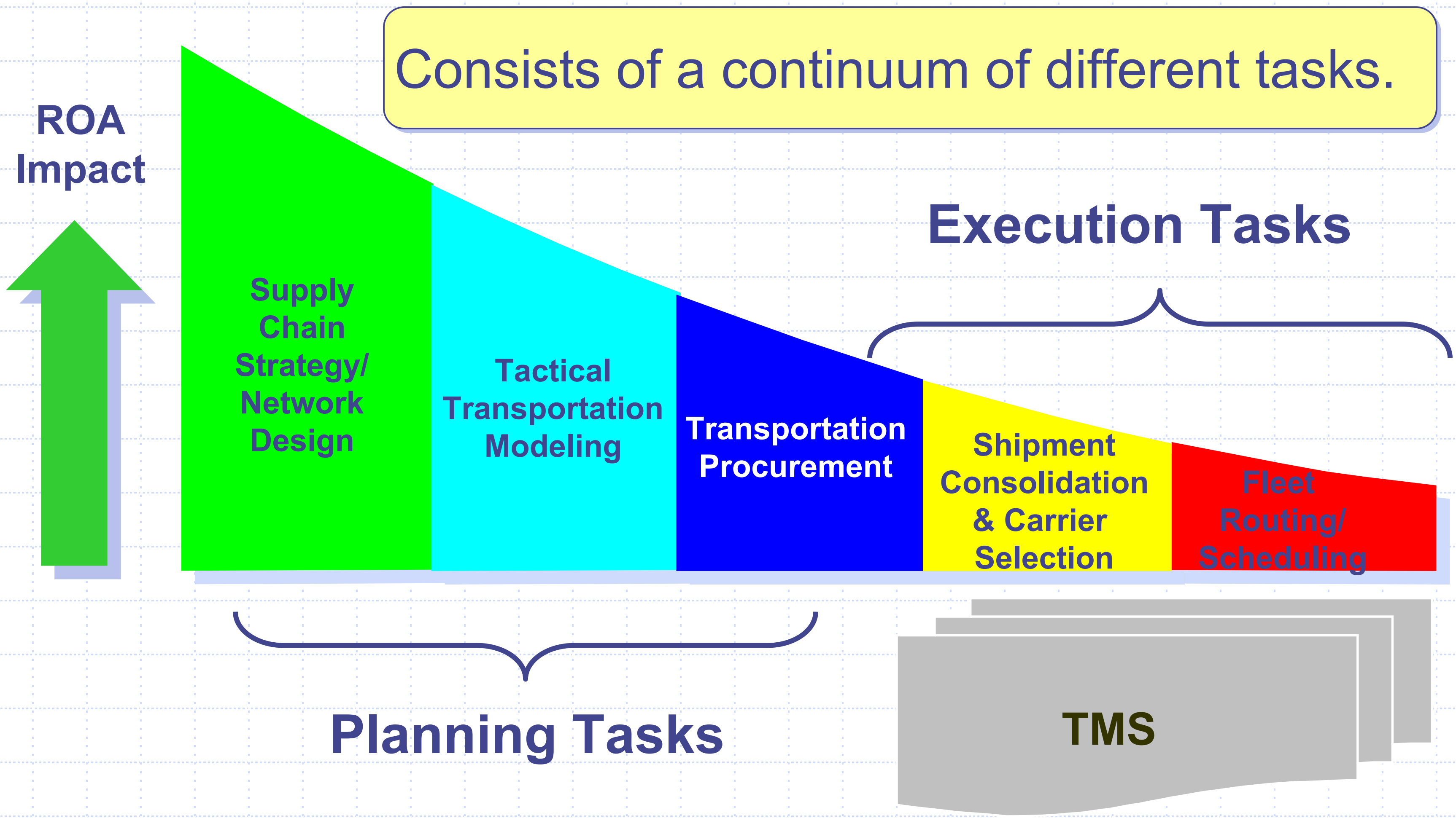
Freight Transportation III
Transportation Management

Carrier Systems 1.224
Fall 2003

Caplice

Transportation Management



Questions Differ Based on Timeframe

Strategic	• What carriers should I partner with and how? • How will seasonality affect my carrier assignments? • Should I use dedicated or private fleets? • Which carriers provided quality service in the past? • Should I use pool points, cross-docks, or multi-stop routes?
Tactical	• How can I quickly secure rates for a new DC/plant/lane? • What lanes are having performance problems? • Which carriers are complying to or exceeding their contracts? • Are site managers are complying to the strategic plan? • Where should I establish a seasonal contract?
Operational	• Which carrier should I tender this load to? • How can I collaboratively source this weeks' loads? • How do I prevent Maverick/Rogue behavior? • Should I use a contract carrier or look at the spot market? • How can I best communicate with my carriers?

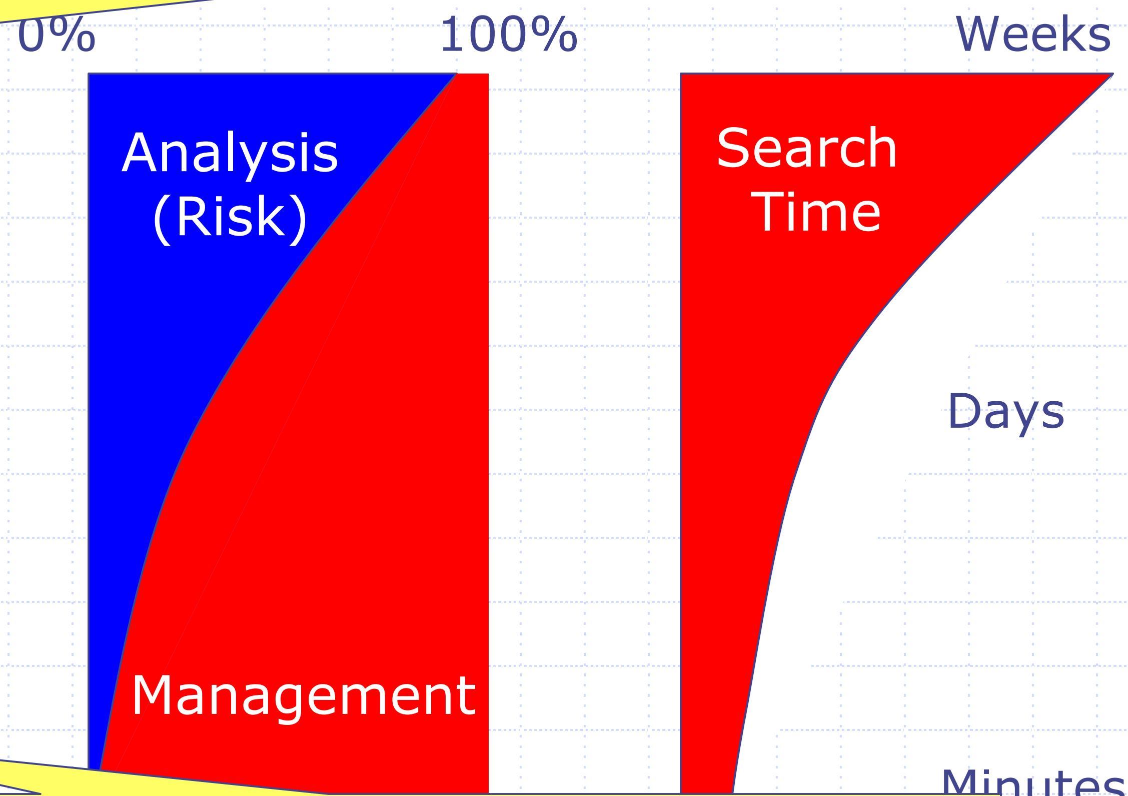
Approaches Differ Based on Timeframe

- Establishing plan & strategy
- Event based engagement
- Non-routine analysis - Value Focus

Strategic

Tactical

Operational

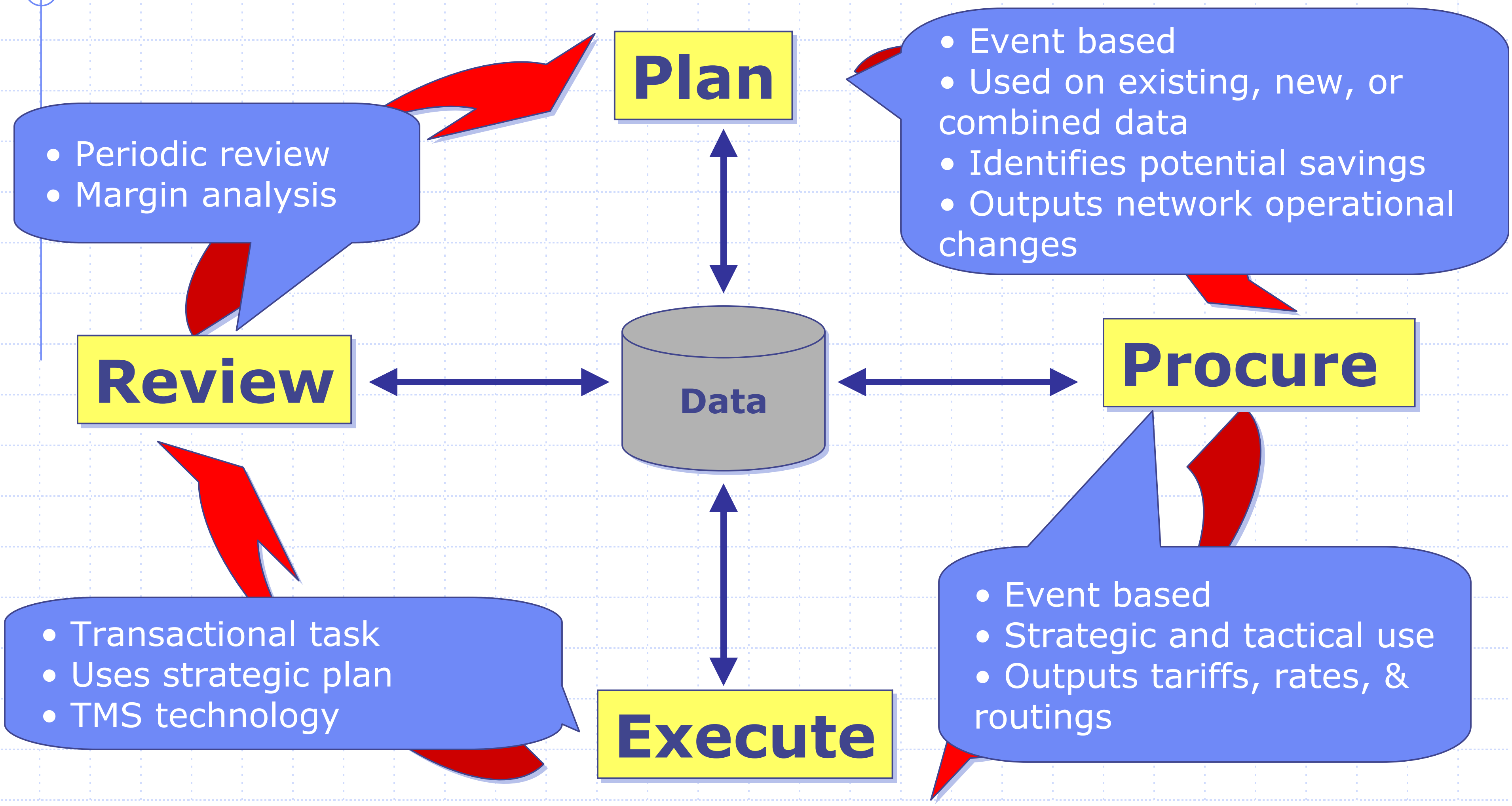


- Executing the strategic plan
- Transaction based rules & processes
- Automated actions - Process Focus

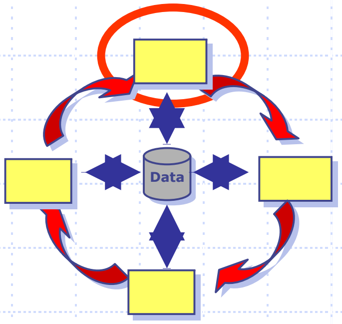
Technologies Differ Based on Timeframe

	Analysis Engine •Optimization •Simulation •Data Analysis	**Communication** •Web-based •File Exchange •Remote Access	**Workflow Software** •Compliance Tracking •Rules Engine •Transaction Processing
Strategic	X	X	
Tactical	X	X	
Operational	X	X	X

Unified Planning & Execution Process

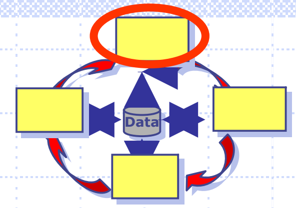


Transportation Planning



- Objective
  - Establish primary transportation modes, contract types, routing options to minimize total expected landed cost
- Key Points
  - Physical network (suppliers, plants, distribution centers) is likely already fixed
  - Plan is run annually with quarterly tweaks
  - Transportation plan limits what you can do in execution
  - Approximate approaches are acceptable, but we have lots of time so why not optimize . . . .

Decisions – Mode Choice



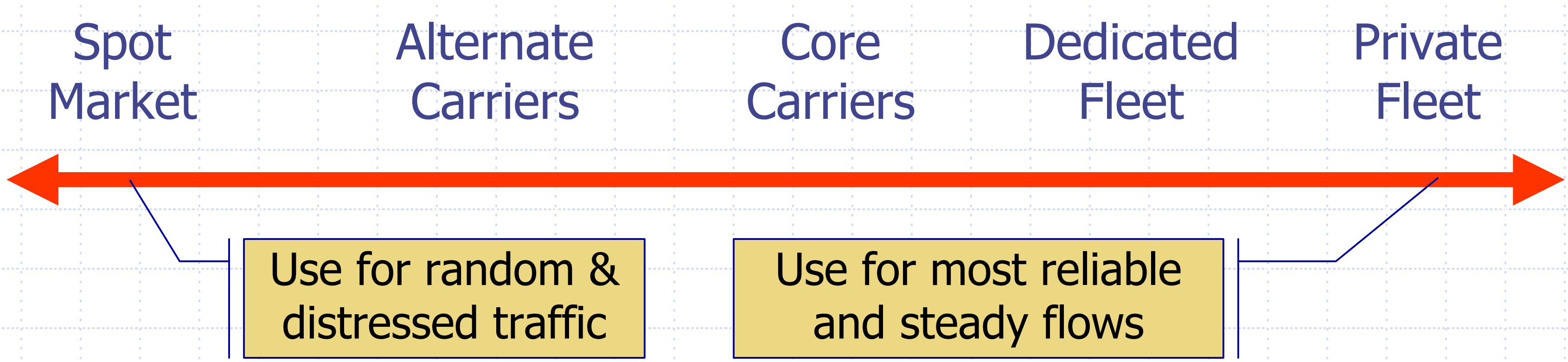
- Mode Choice Criteria
  - Feasibility
  - Service Standards
  - Length of Haul
  - Product Characteristics
  - Shipment Characteristics
- Trade-offs between
  - Service vs Cost
  - Inventory vs Transportation

- Additional Choices
  - Types w/in Modes, e.g. Trucking
    - Truckload
    - Less-than-Truckload
    - Parcel
    - Expedited versus Standard
  - Intermodal / Multi-Modal
  - Dual-Mode Strategies
    - Air & Ocean
    - IM & Truck
    - LTL & TL
    - Air & Parcel

Mode	¢/ton-mile	Transit Time	Reliability (absolute)	Loss & Damage
Rail	2.28	3	4	5
Truck	26.19	2	3	4
Water	0.74	5	5	2
Pipeline	1.46	4	2	1
Air	61.2	1	1	3

Decisions – Contract Type

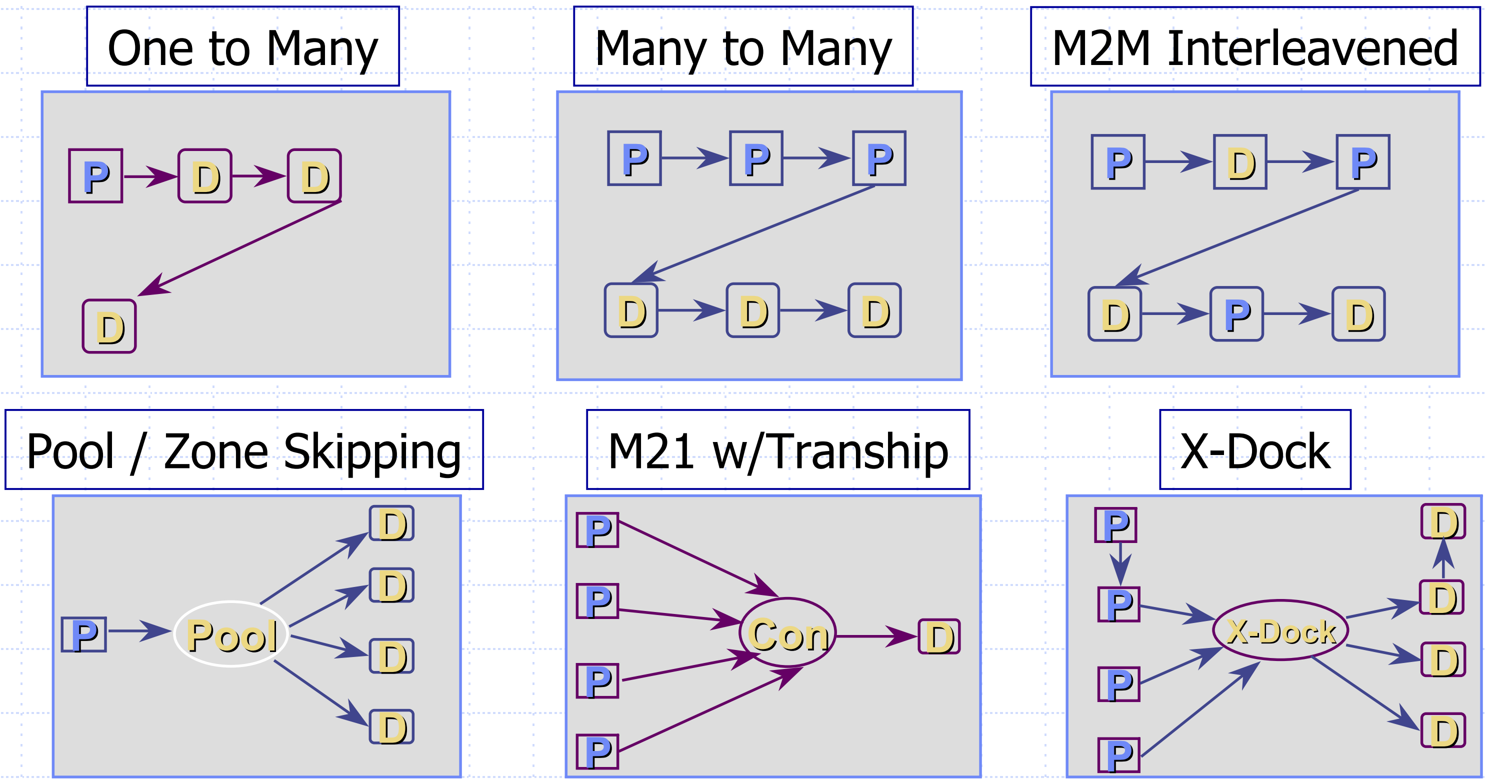
- What type of relationship do you need to establish with your carriers?
- Continuum of relationships from one-off to ownership
  - Ownership of Assets versus Control of Assets
  - Responsibility for utilization
  - On-going commitment / responsibilities
  - Shared Risk/Reward – Flexible contracts



Decisions – Routing Options

- Strategic plan establishes the potential options that can be taken in execution

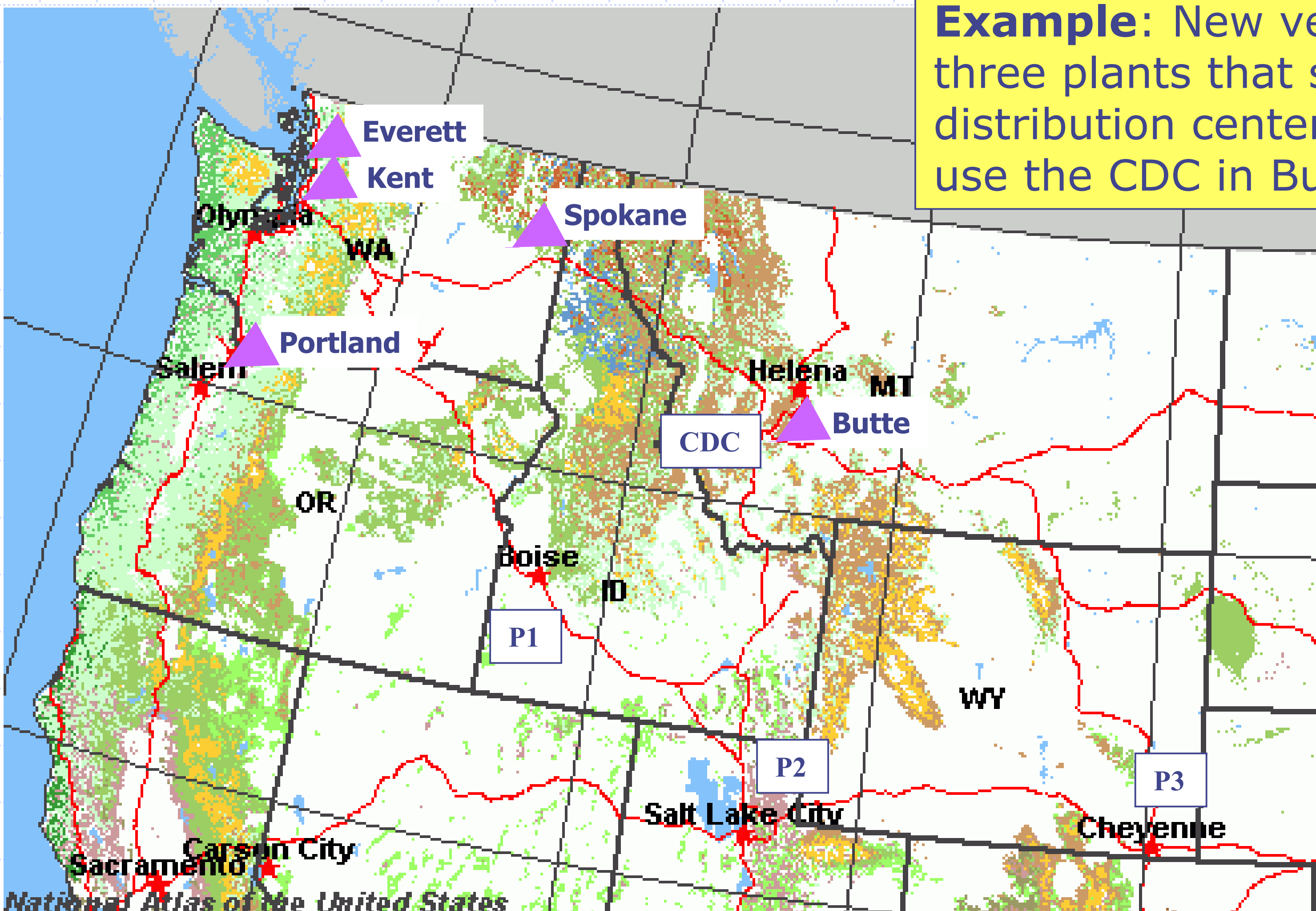
Network Consolidation Archtypes



P - Pickup Location **D - Delivery Location**

Transportation Routing Options

Example: New vendor has three plants that serve four distribution centers and may use the CDC in Butte.



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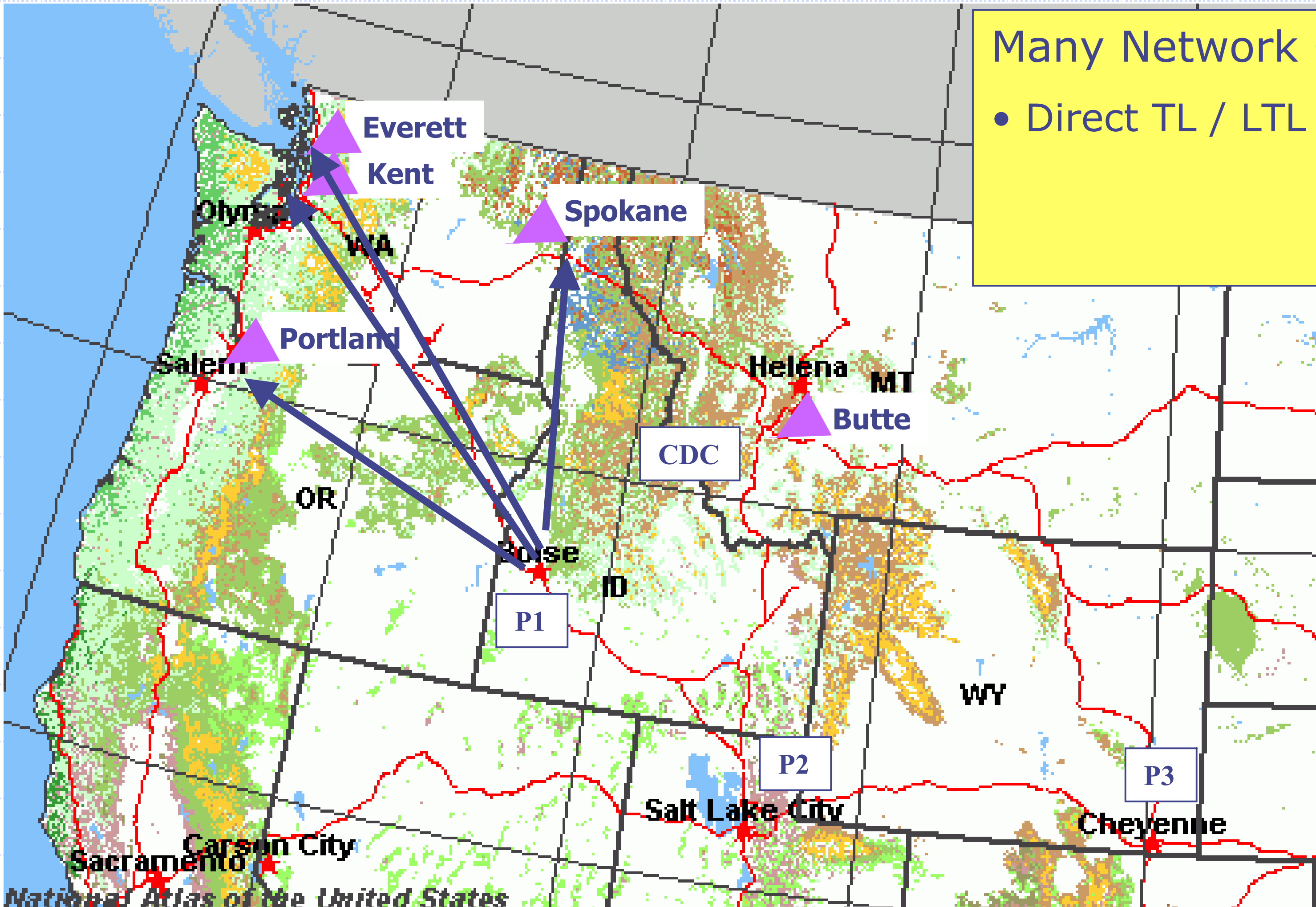
Transportation Routing Options



Many Network Options:

- Direct TL / LTL Moves

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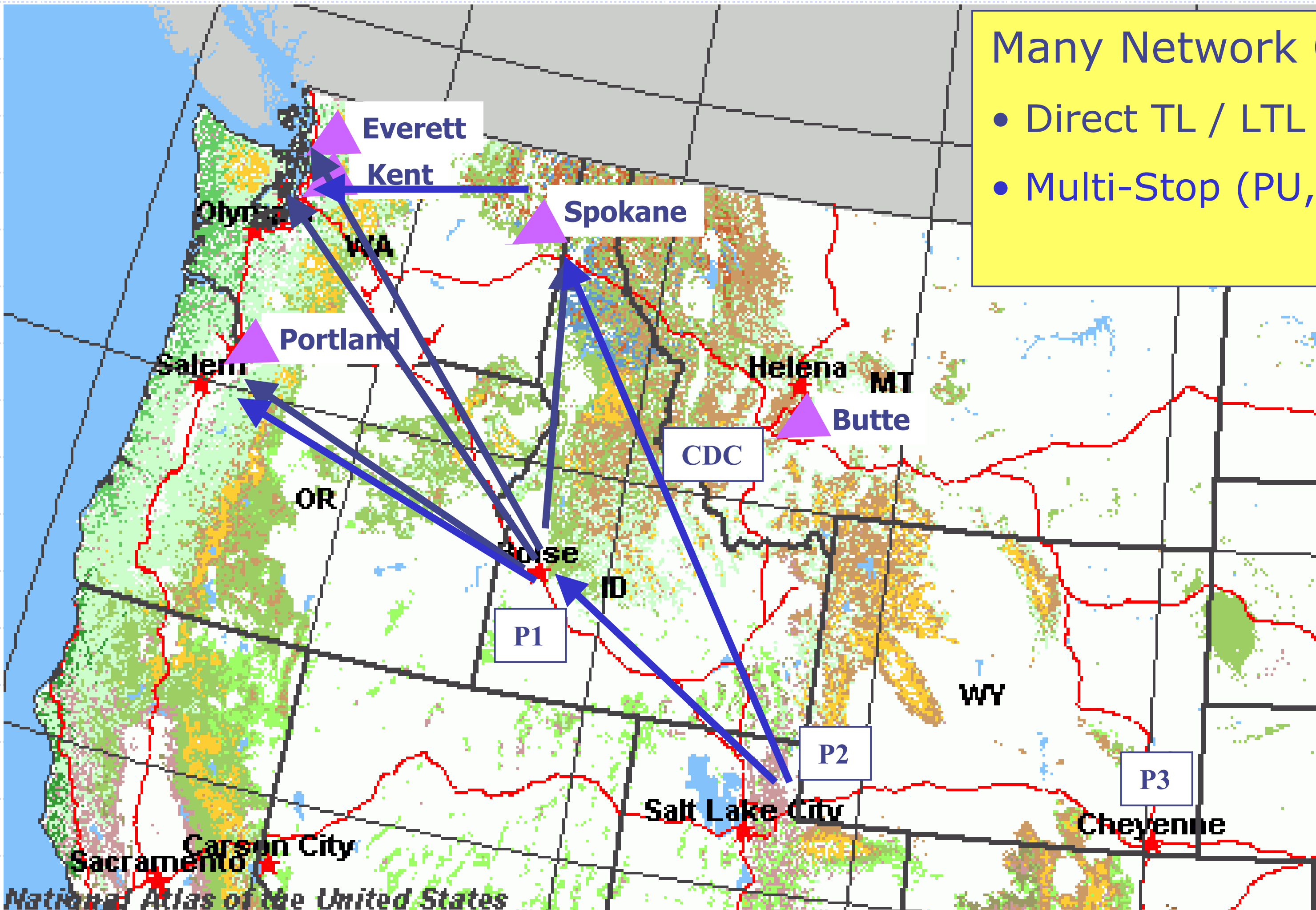
Transportation Routing Options



Many Network Options:

- Direct TL / LTL Moves
- Multi-Stop (PU, DO, Both)

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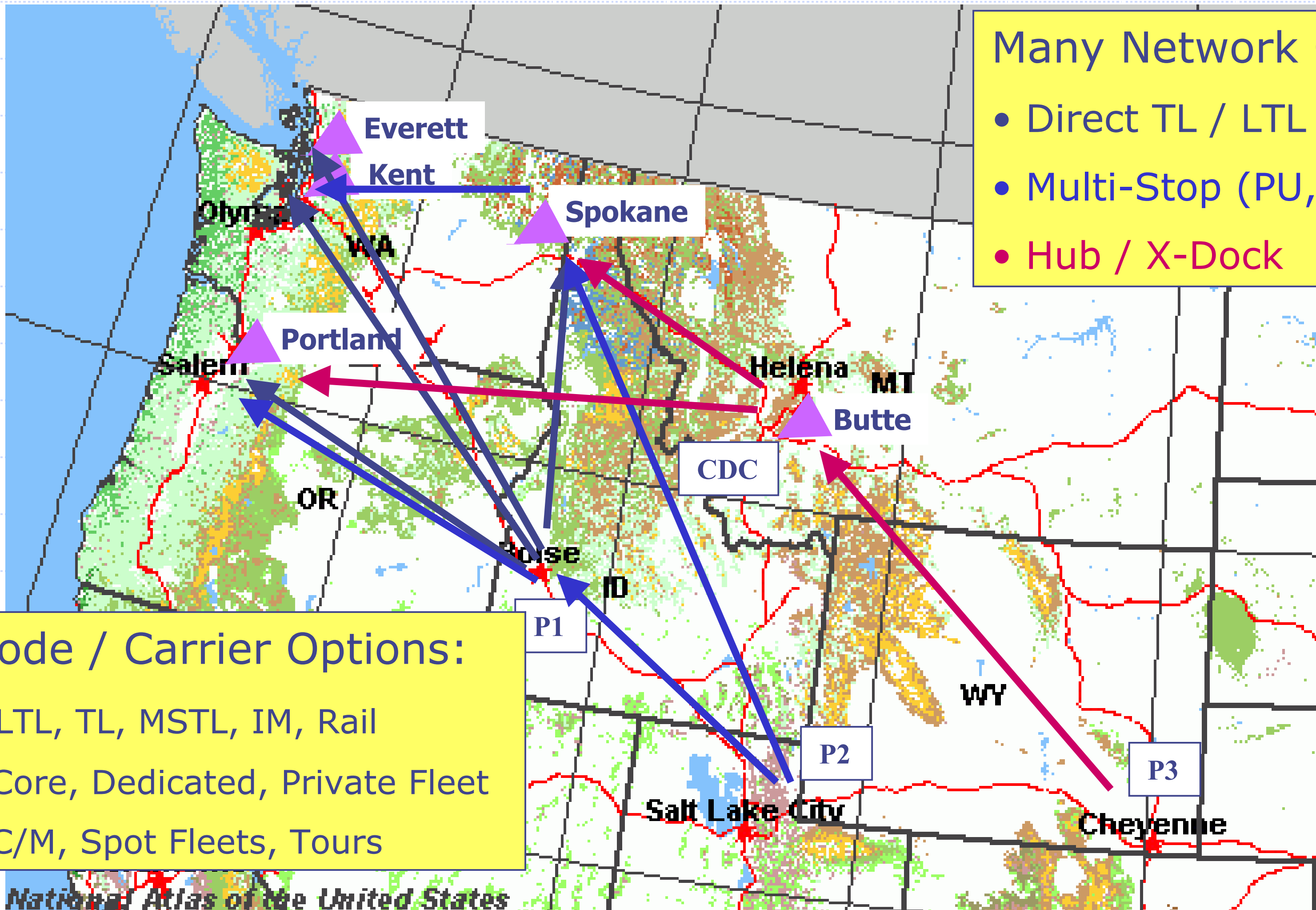
Transportation Routing Options



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Many Network Options:

- Direct TL / LTL Moves
- Multi-Stop (PU, DO, Both)
- Hub / X-Dock

Mode / Carrier Options:

- LTL, TL, MSTL, IM, Rail
- Core, Dedicated, Private Fleet
- C/M, Spot Fleets, Tours

Transportation Modeling

Inputs:

- Demand forecast (transaction level data)
- Carrier tariffs, rates, capacities, & service levels
- Business constraints
- Equipment and facility profiles
- Potential routing / carrier options

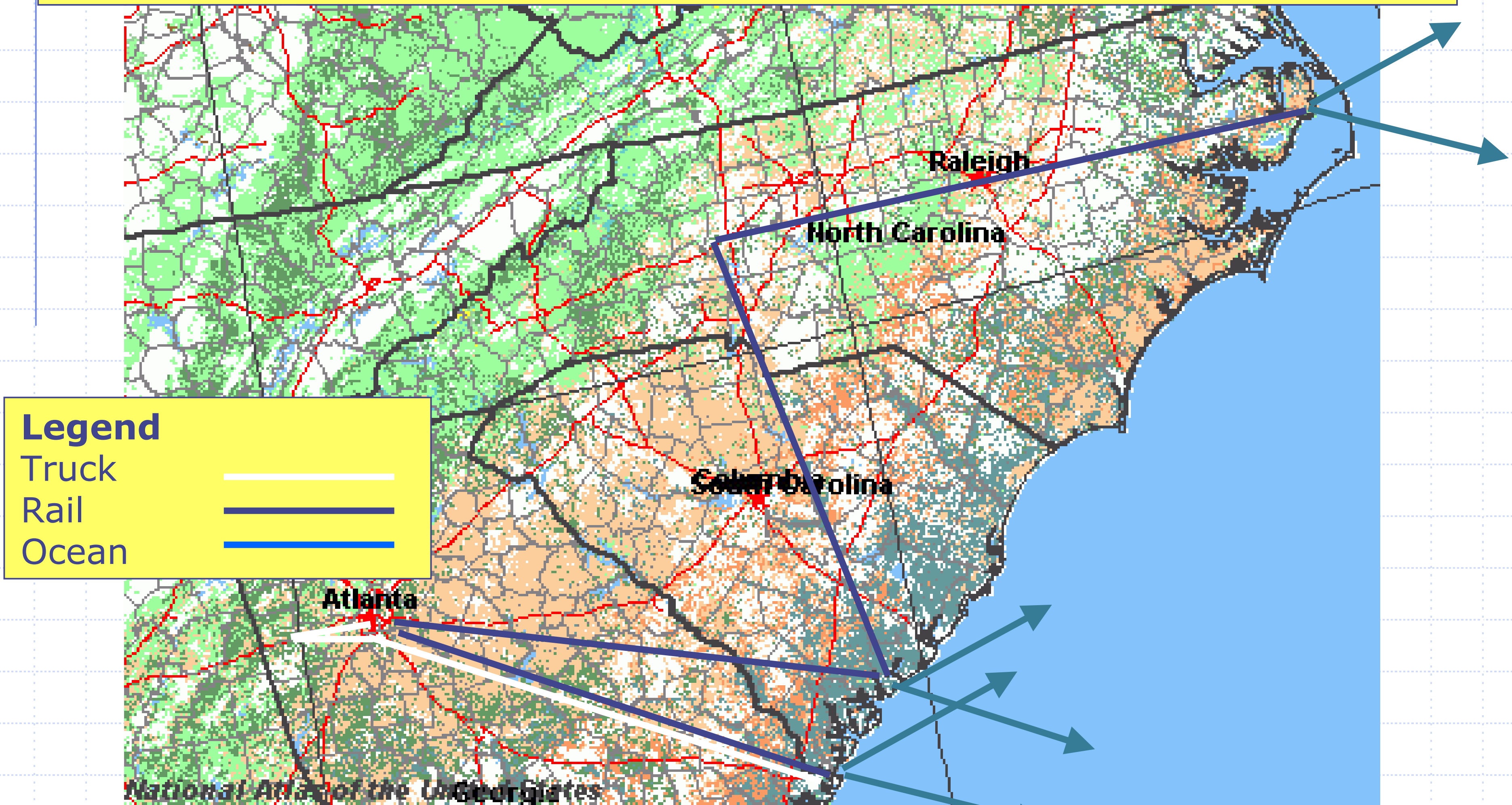
Analytic Engine

Outputs:

- Total transportation costs
- Mode selection
- Fixed routing and itineraries
- Recommended sailings

Transportation Modeling

Example: Two clients ship product to Rotterdam. There are rail and truck options to multiple ports with various ocean carrier options.



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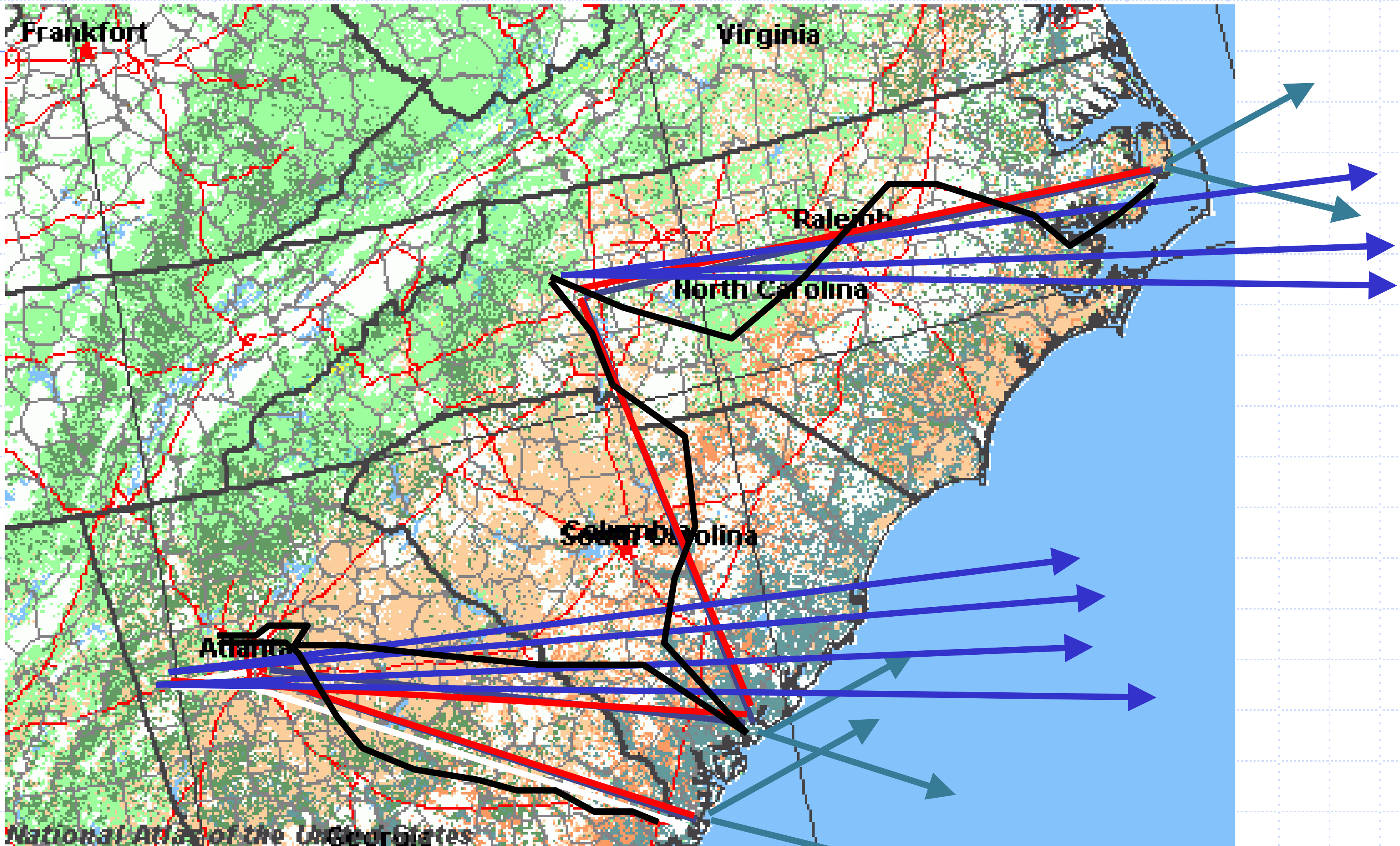
Transportation Modeling



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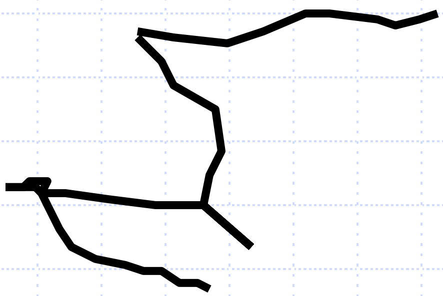
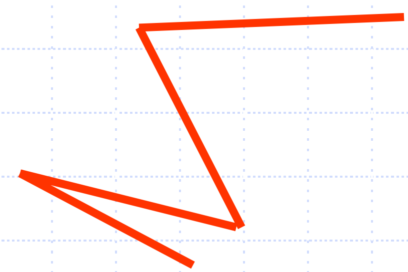
Physical - Operational Service

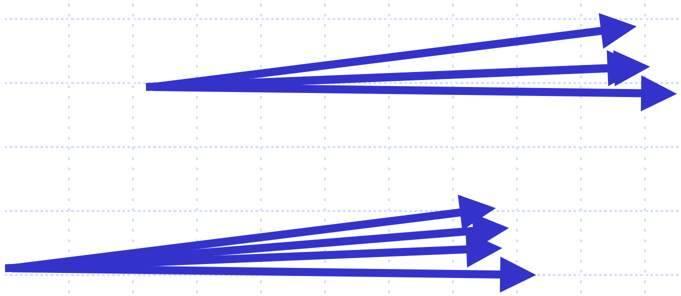
Three Layers of Networks



Physical Network: The actual path that the product takes from origin to destination. Basis for all costs and distance calculations – typically only found once.

Operational Network: The route the shipment takes in terms of decision points. Each arc is a specific mode with costs, distance, etc. Each node is a decision point.



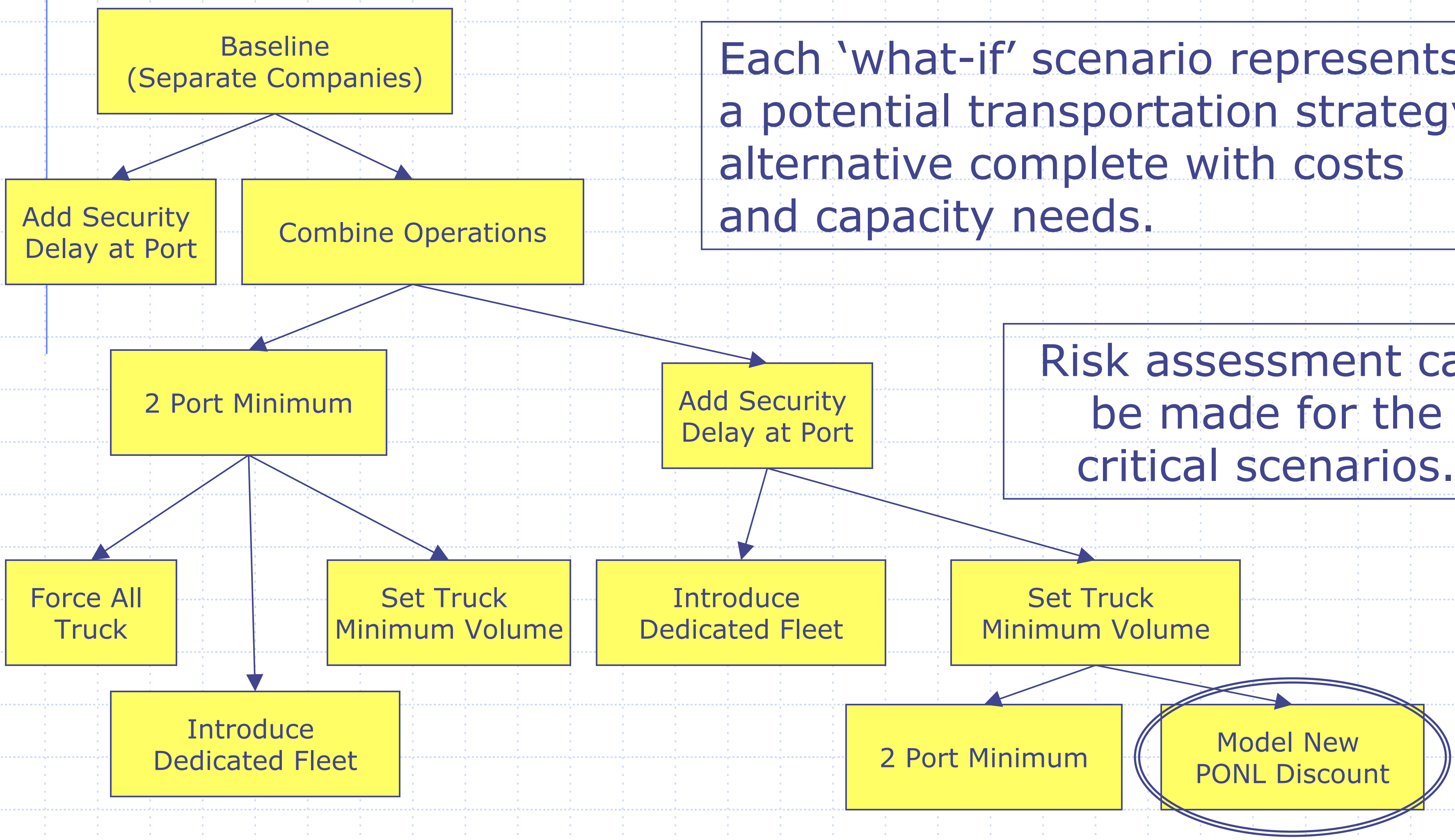


Service Network: A series of paths through the network from origin to destination. Each represents a complete option and has end to end cost, distance, and service characteristics.

Transportation Modeling

- Transportation Options
  - Carrollton ISO tanks can move via truck or rail to Charleston or Savannah
  - Kingsport ISO tanks can move via truck or rail to either Norfolk or Charleston
  - Each port has two sailing schedule options to Rotterdam
- Transportation Modes
  - Each mode is modeled with:
    - Variable & fixed costs
    - Service and capacity levels
    - Sailing schedules (day of week or fixed day)
- Potential Scenarios
  - Run each company separately (Baseline)
  - Run combined operations (leverage volume discount out of Charleston)
  - Introduce new security process at ports – impact of a one day delay
  - Relax delivery windows (measure potential cost reduction)
  - Force a 2 port solution (minimize risk of port closure)
  - Force an all bulk truck solution
  - Explore option of running a dedicated fleet for linehaul or drayage
  - Increase demand by 20% on certain lanes

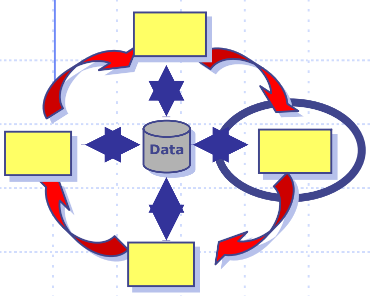
Transportation Modeling



Each 'what-if' scenario represents a potential transportation strategy alternative complete with costs and capacity needs.

Risk assessment can be made for the critical scenarios.

Task: Procurement

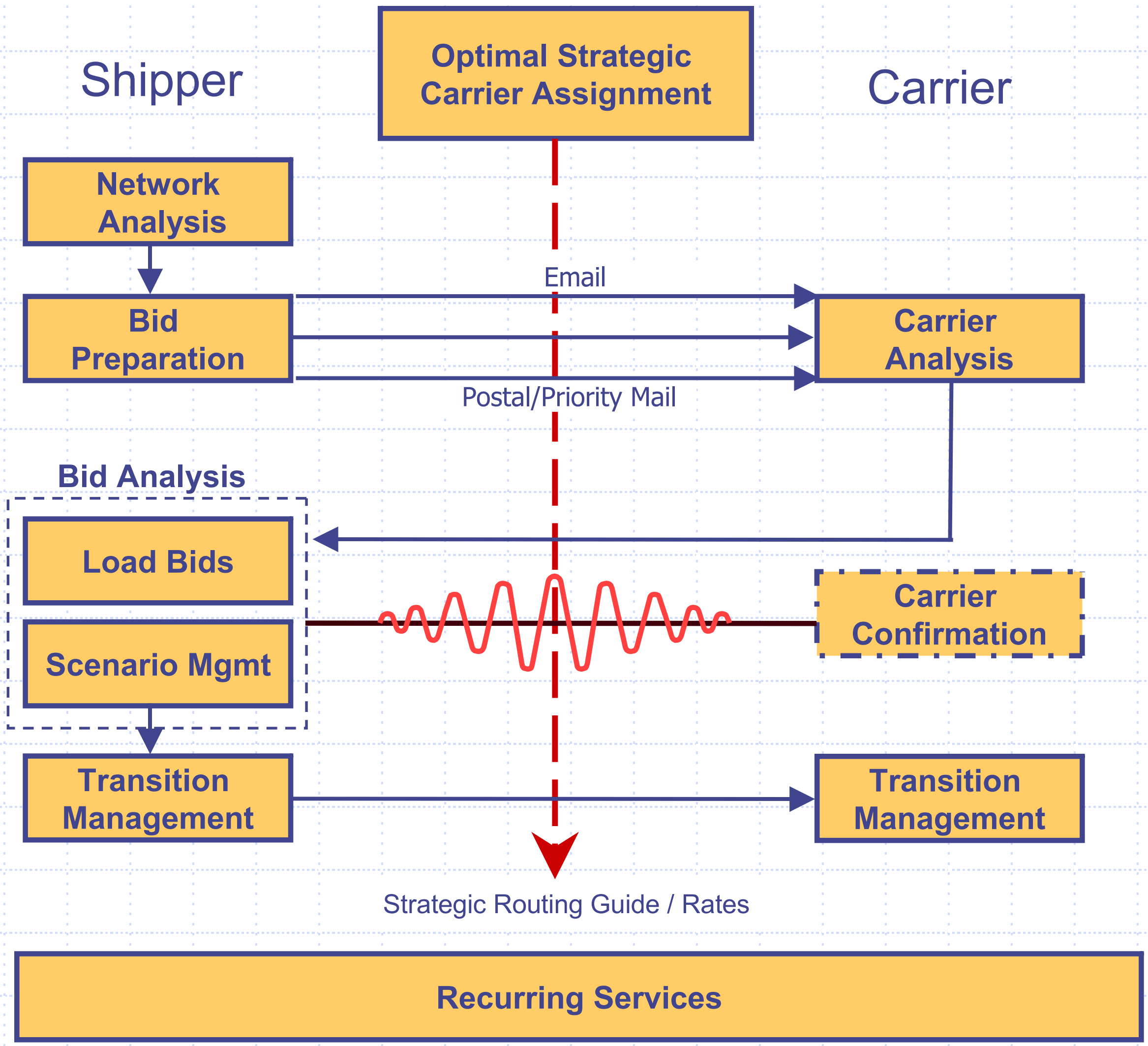


- Multiple Levels of Procurement
  - Strategic
    - Looking at entire or large portions of network
    - Detailed analysis – value focused
    - Encourages use of sophisticated carrier proposals
    - Considers trade-offs between service and cost
  - Tactical
    - Collecting rates for some lanes from a few carriers
    - Minimal analysis – efficiency focused
    - No sophisticated proposals from carriers
  - Execution
    - Collecting spot rates for a specific load
    - Private / public exchanges
    - Considered component of execution system

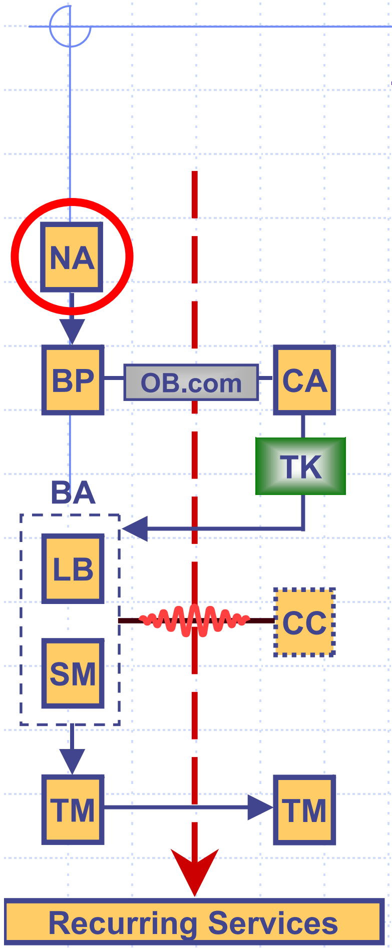
Transportation Is Different

- Multiple controlling economics, not just scale
  - Economies of scope
  - Economies of density
- Multiple dimensions to transportation services
  - Cost alone is very rare (believe it or not)
  - Transit time, loss & damage, EDI, tracking
- Forecasting transportation is difficult
  - Exceptionally disaggregated spatially and temporally
  - Derived demand
- Complex administration
  - Typically decentralized decision making
  - Two tiered buy (contract and tender) not always linked

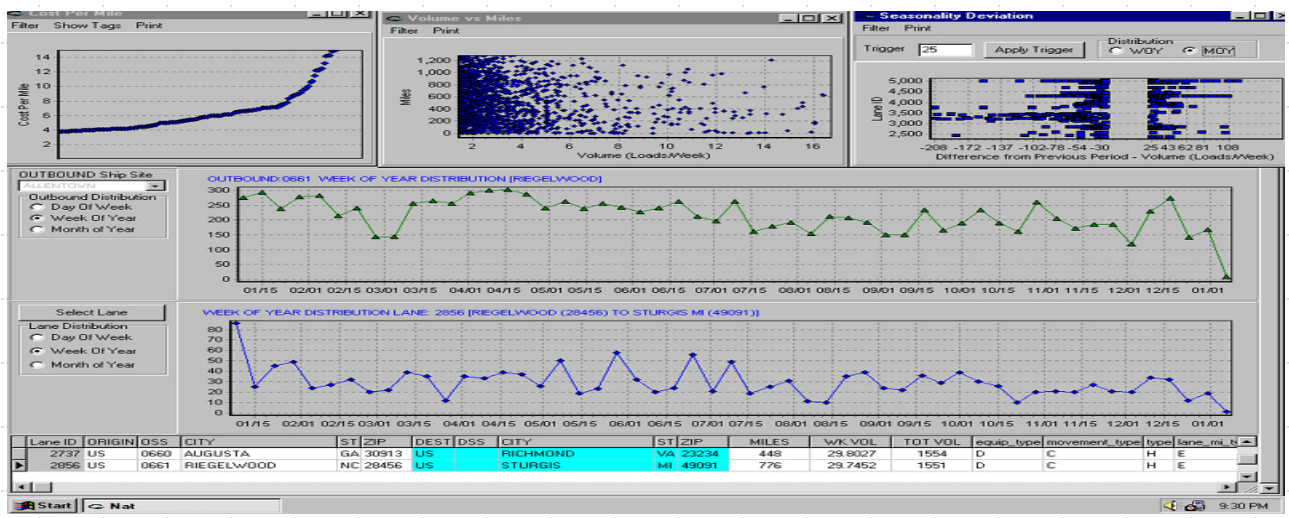
Procurement Process



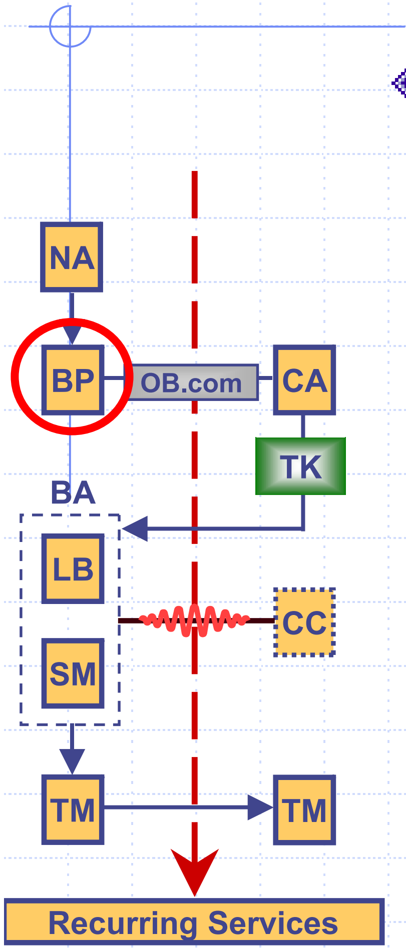
Network Analysis



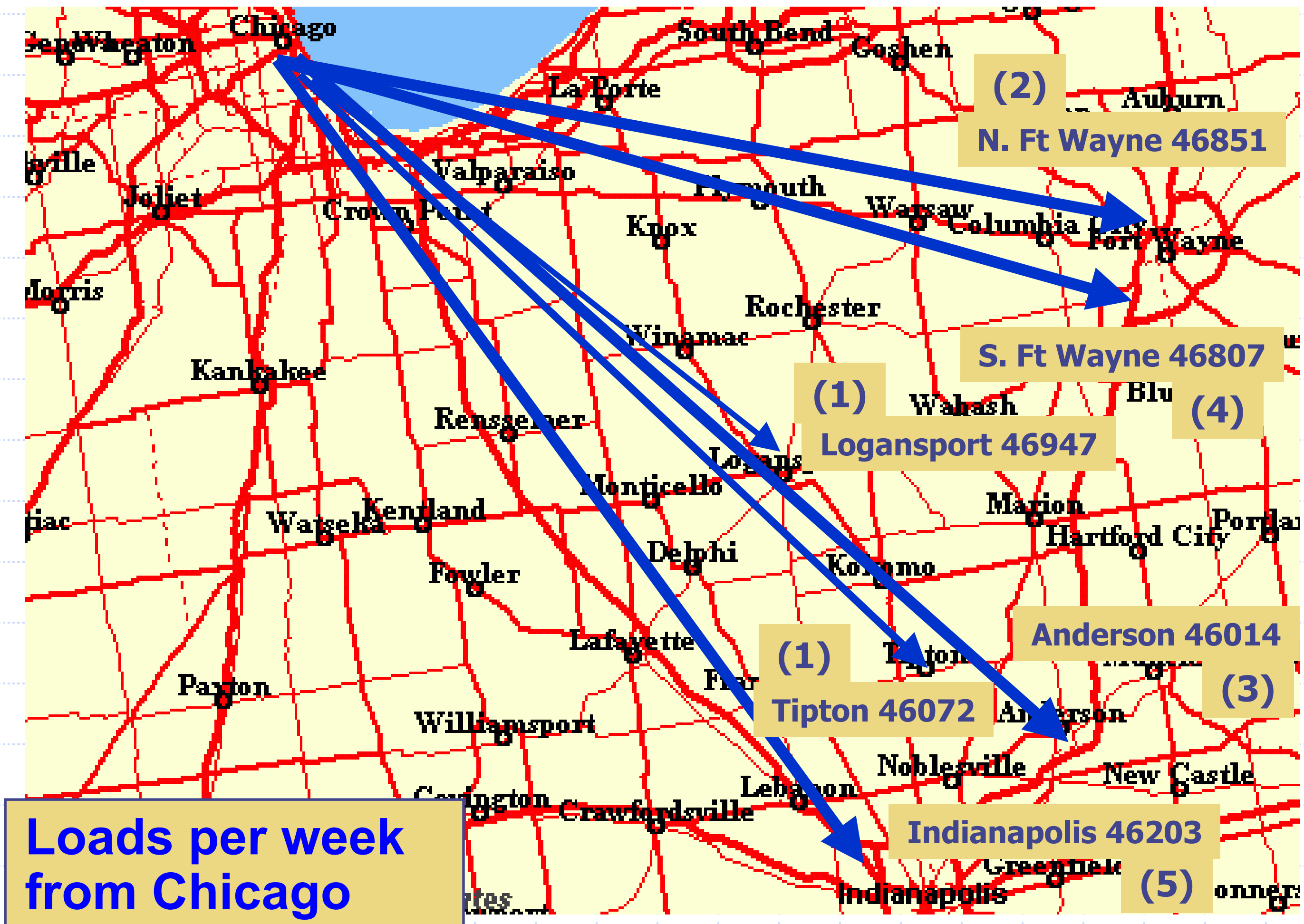
- What is it that you are bidding out?
  - Historical summary & forecasted analysis
  - Carrier performance from historical files
  - Identify high surge lanes
  - Seasonality analysis
  - Identify potential changes to network



Network Analysis



◆ What is a lane?



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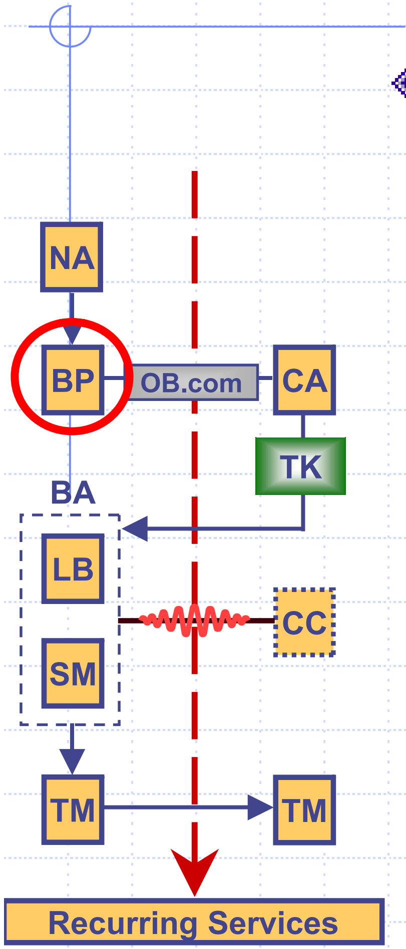

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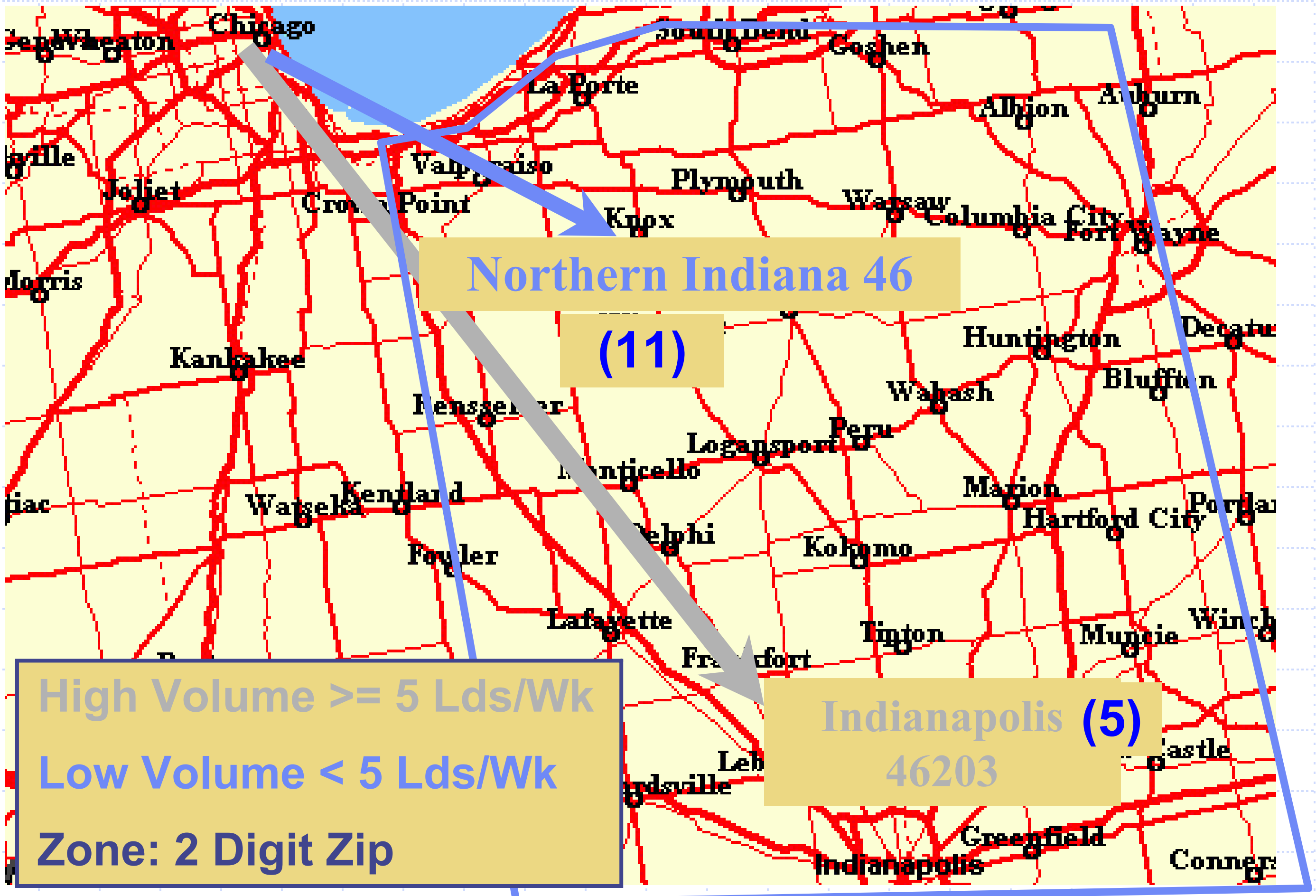

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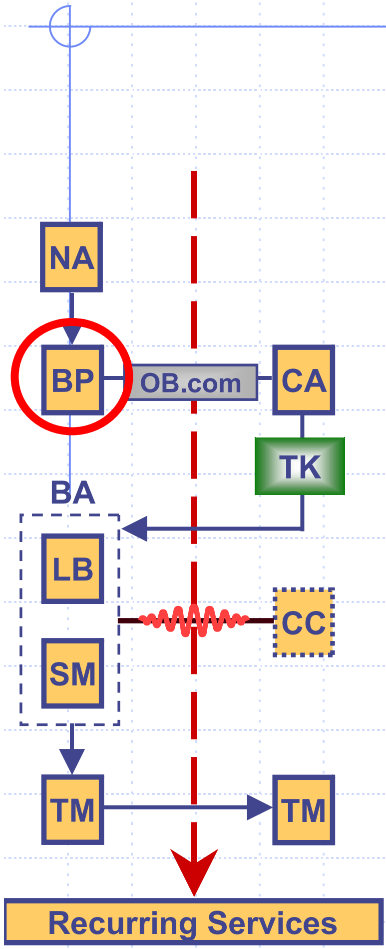
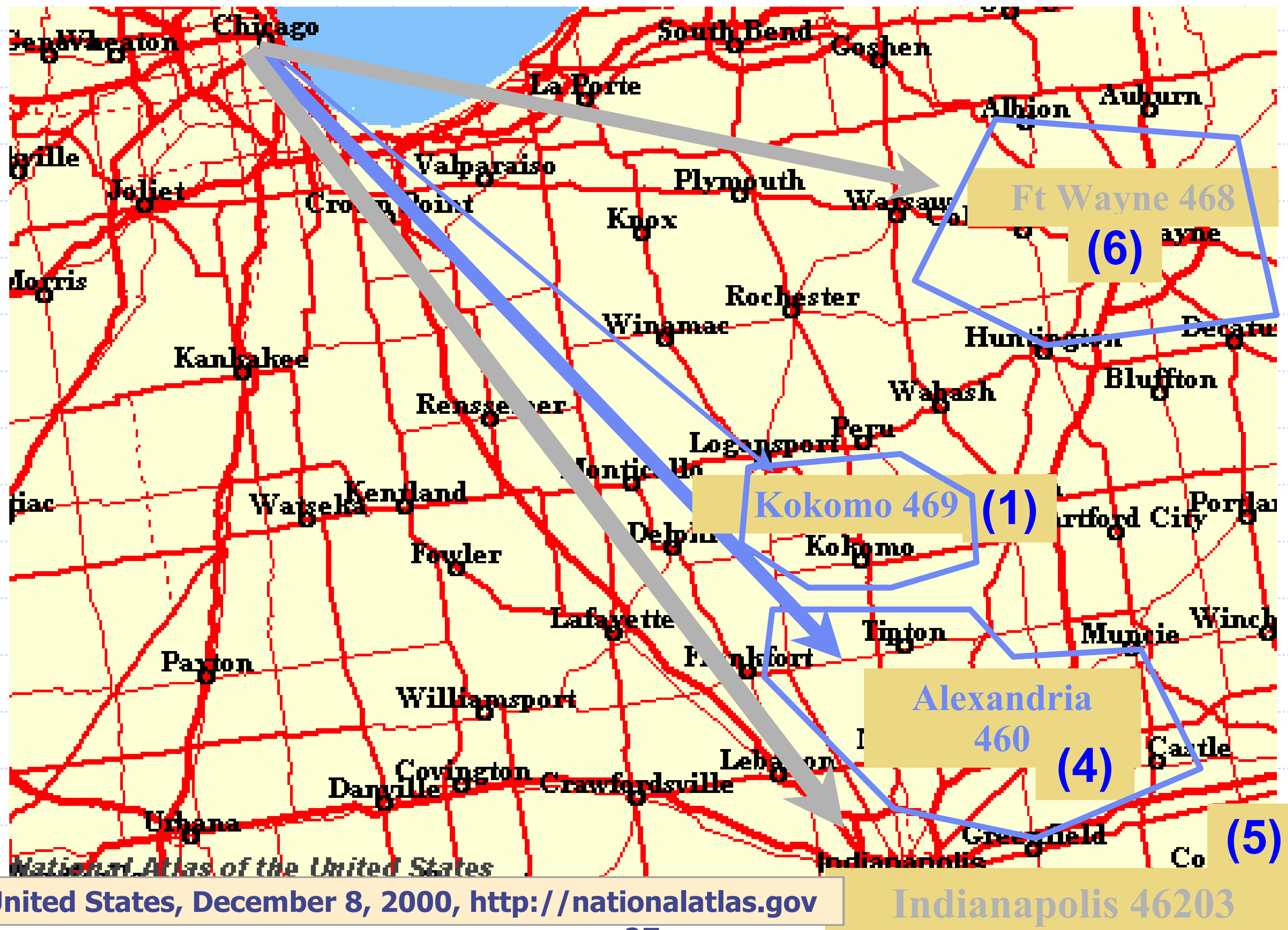


- What is a lane?



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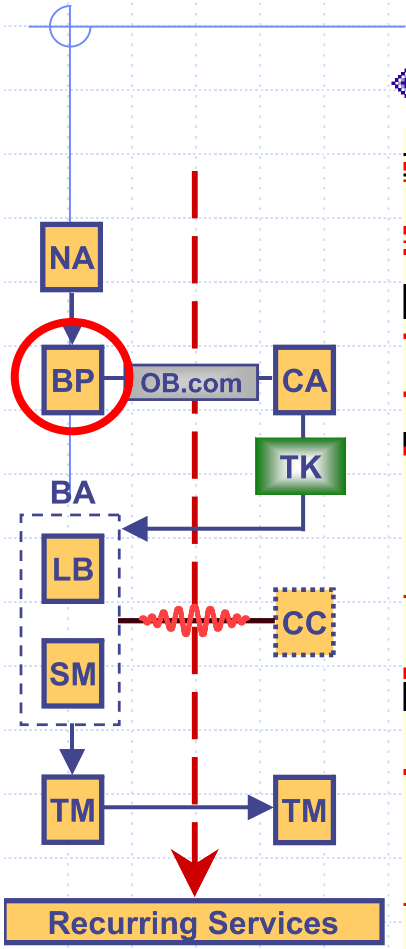
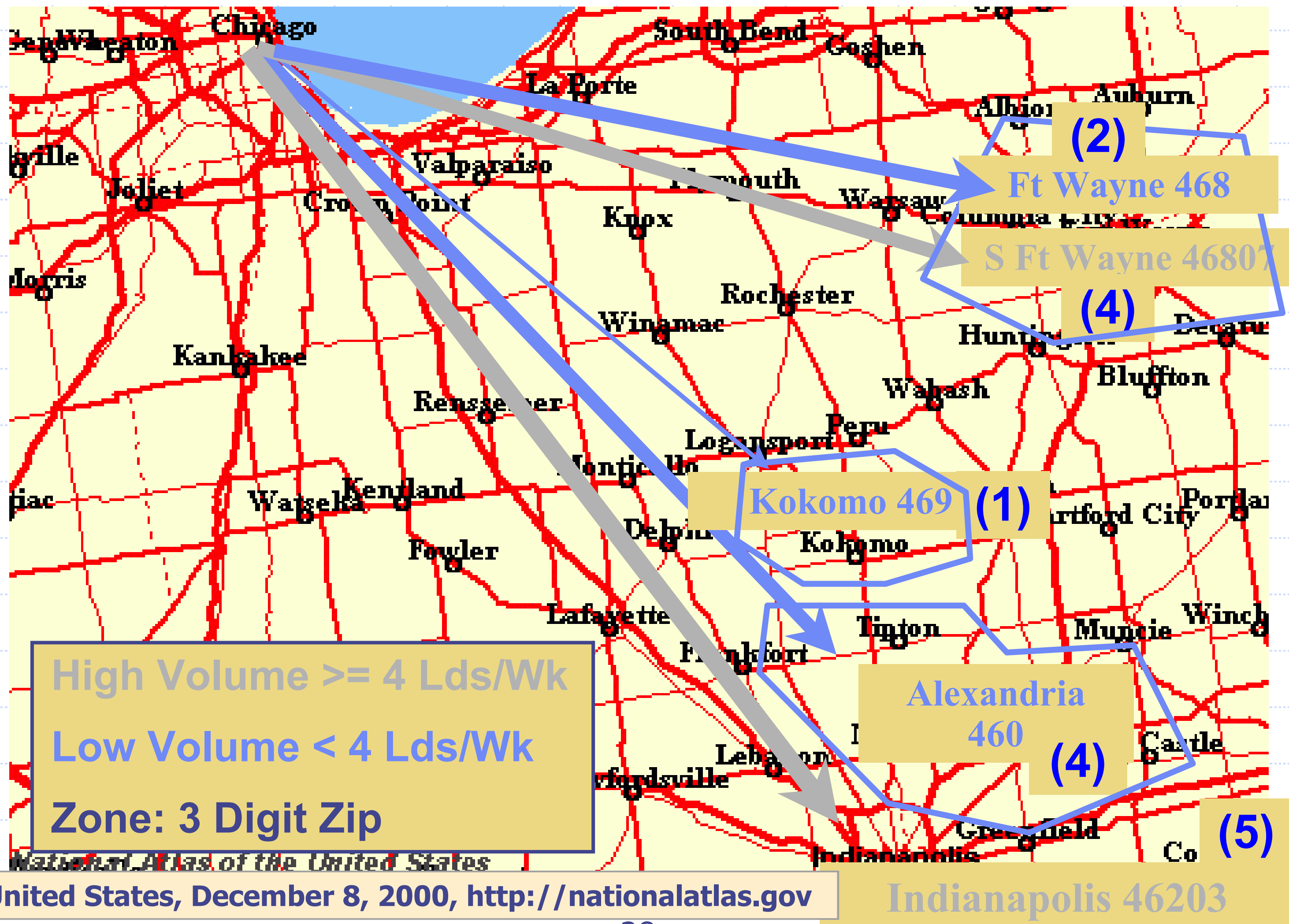


◈ What is a lane?



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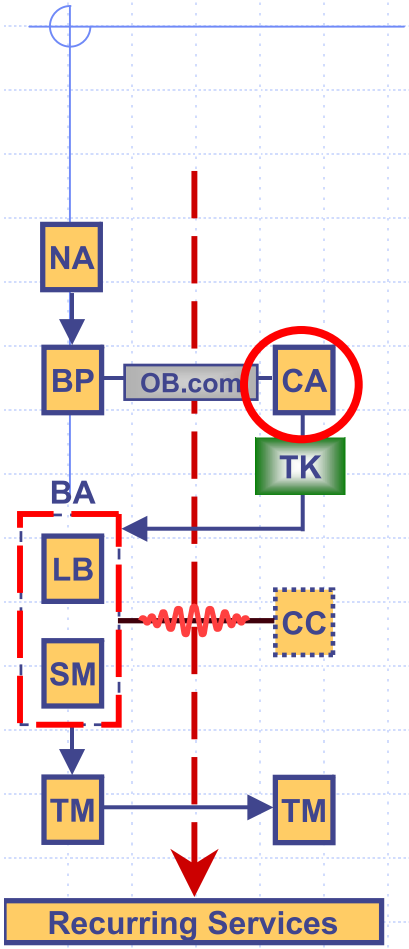
Forecasting

- Forecasting is a prerequisite to any procurement process
- Transportation requirement forecasting is particularly difficult:
  - It requires disaggregate forecasting
    - By lane, season (also weekly, monthly quarterly variations), equipment, type of load (hazmat?)
  - It is volatile
    - Almost any system change will affect transportation needs
    - Most ERP systems do not have an integrated transportation requirement planning module

Consequences of Bad Forecasting

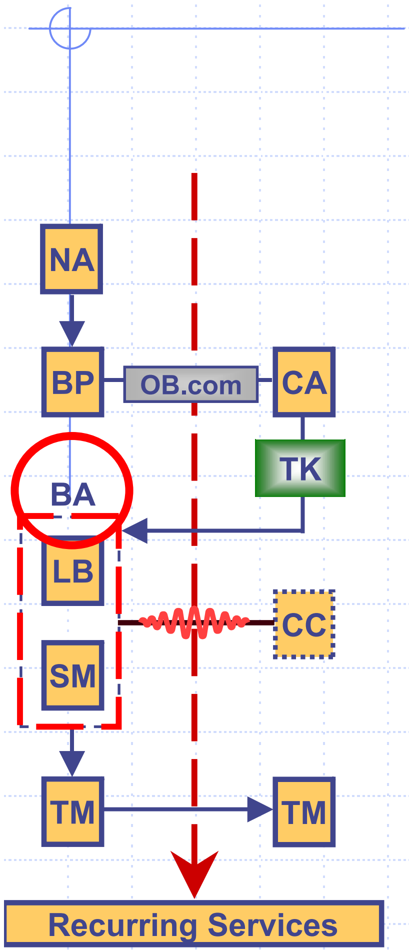
- A good forecast requires a manual process based on network adjustments beyond a statistical forecast
- Continuous contract adjustments are needed throughout the life of the contract
- Contracts are not binding
- Requirements for alternate winners and an exception/rejection management process

Carrier Analysis



- How do carriers determine their pricing?
  - Usually Poorly
- Typical Practice
  - Start with historical rates and modify based on market
  - Sales typically trumps operations
  - GIGO
  - Limited time to analyze
  - Hope to win the business through relationships later (lose the bid, win the business)

Bid Analysis

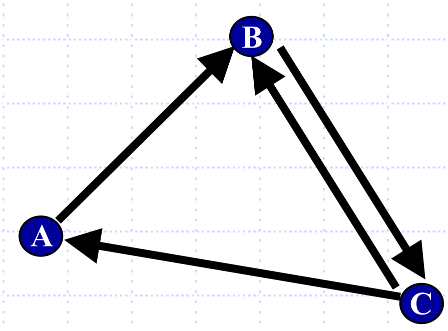


- Which carriers to assign to which lanes?
- Heart of procurement process
  - Receiving significant attention
  - GIGO
  - Only a piece of the process
  - Excellent optimization does not guarantee success

Traditional Practice

- Information exchange:
  - Shippers give aggregated volume estimates (by lane, origin, region, system), based on last year.
  - Carriers submit lane rates (per mile or per move).
- Assignment mechanism:
  - Lane-by-lane analysis.
  - Low bid wins.
  - Spreadsheet analysis.

Fig.1 A Simple Network with Four Lanes



	Carriers	
Lane	**Best**	**Fast**
A→B	$ 500	$ 525
B→C	$ 500	$ 475
C→A	$ 500	$ 525
C→B	$ 475	$ 500

Traditional Practice

- Information exchange:
  - Shippers give aggregated volume estimates (by lane, origin, region, system), based on last year.
  - Carriers submit lane rates (per mile or per move).
- Assignment mechanism:
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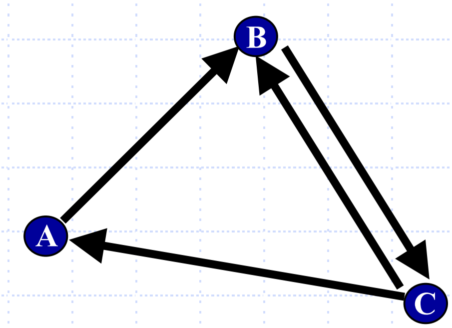

	Carriers	
Lane	Best	Fast
A→B	$ 500	$ 525
B→C	$ 500	$ 475
C→A	$ 500	$ 525
C→B	$ 475	$ 500

Tradtional Practice

- Information exchange:
  - Shippers give aggregated volume estimates (by lane, origin, region, system), based on last year.
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- Assignment mechanism:
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  - Spreadsheet analysis.

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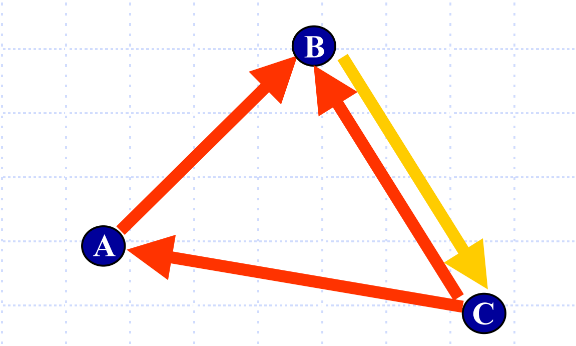
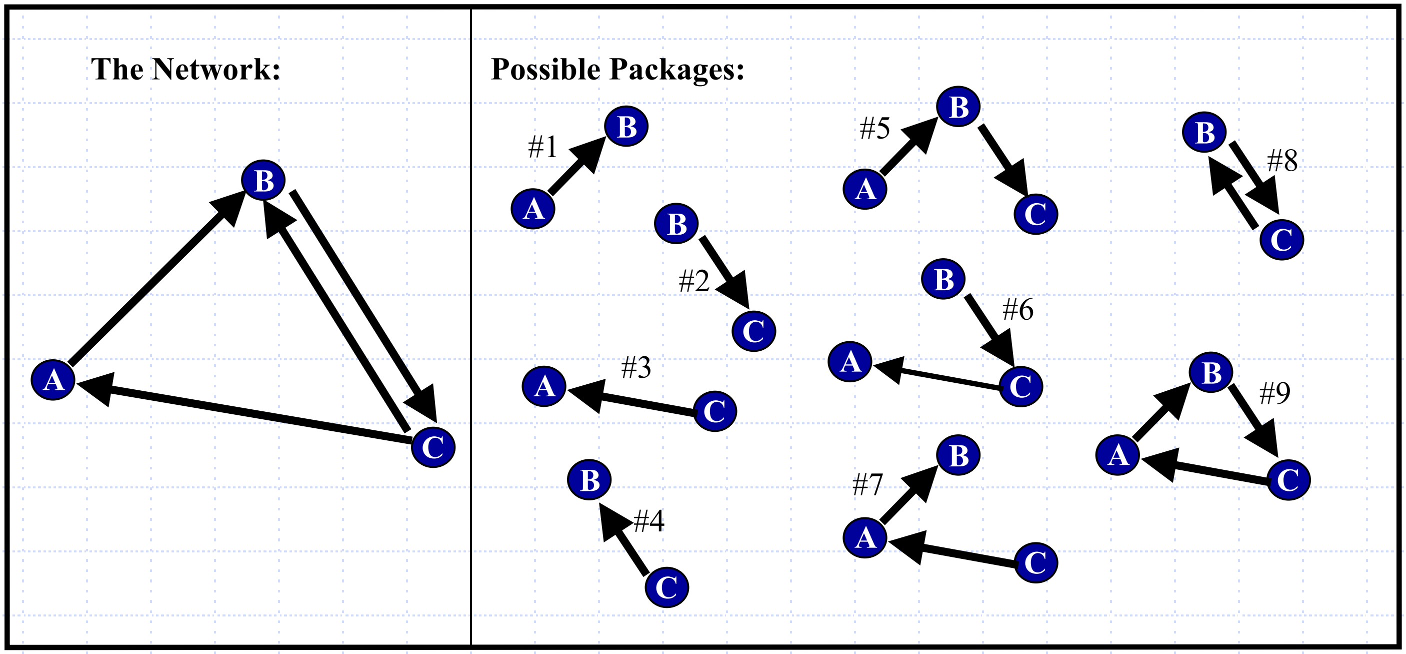


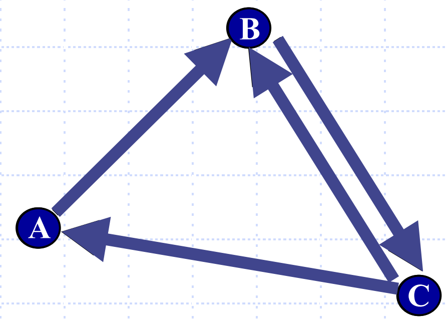
	Carriers	
Lane	Best	Fast
A→B	$ 500	$ 525
B→C	$ 500	$ 475
C→A	$ 500	$ 525
C→B	$ 475	$ 500

Combinatorial Bidding

Fig.2 A Network Example with Nine Bid Packages



Packaged Bids



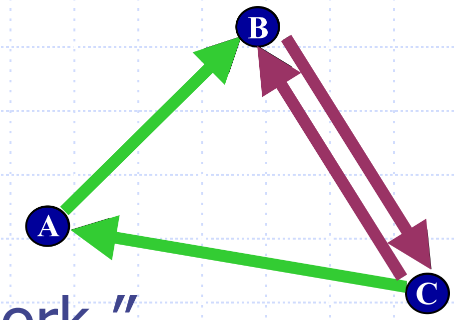
	Carrier "Best"									Carrier "Fast"								
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#1	#2	#3	#4	#5	#6	#7	#8	#9
A→B	1				1		1		1	1				1		1		1
B→C		1			1	1		1	1		1			1	1		1	1
C→A			1			1	1		1			1			1	1		1
C→B				1				1					1				1	
Bid	500	500	500	475	975	950	975	900	1325	525	525	475	525	1000	925	925	900	1375

\$1325 + \$475 = \$1800

Multi-attribute Procurement

- Transportation *service* involves more than price (two types of attributes):
- Lane attributes
  - Solution: use "generalized cost" with proper weights for LOS and other attributes in the optimization
- System attributes
  - Solution: introduce constraints reflecting the business rules that one wants to impose

System Constraints



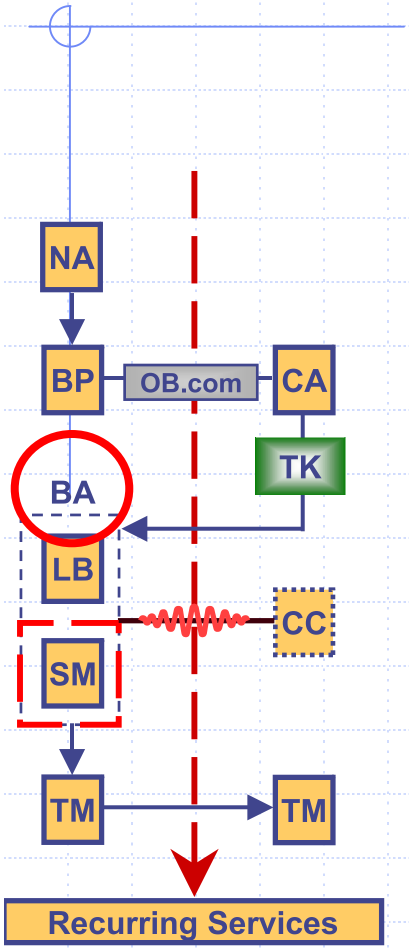
"More than one carrier serving the network."

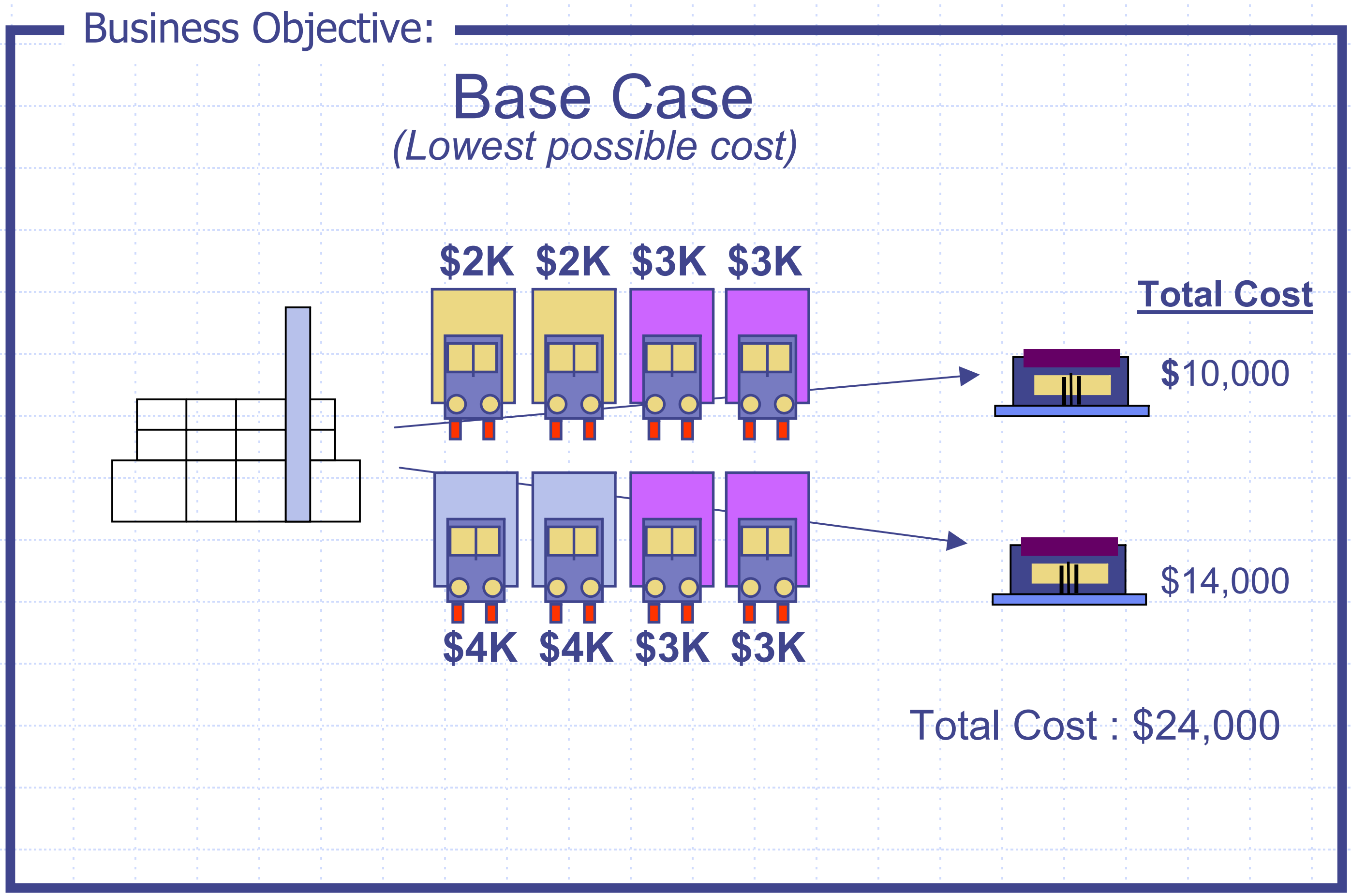
	Carrier "Best"									Carrier "Fast"								
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#1	#2	#3	#4	#5	#6	#7	#8	#9
A→B	1				1		1		1	1				1		1		1
B→C		1			1	1		1	1		1			1	1		1	1
C→A			1			1	1		1			1			1	1		1
C→B				1				1					1				1	
Bid	500	500	500	475	975	950	975	900	1325	525	525	475	525	1000	925	925	900	1375

Re-running the optimization with additional constraints: "what if" analysis

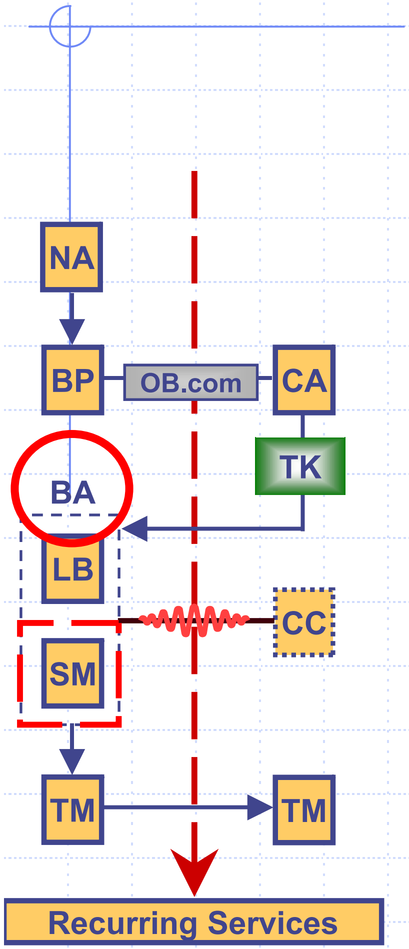
$900 + $925 = $1825

Scenario Management





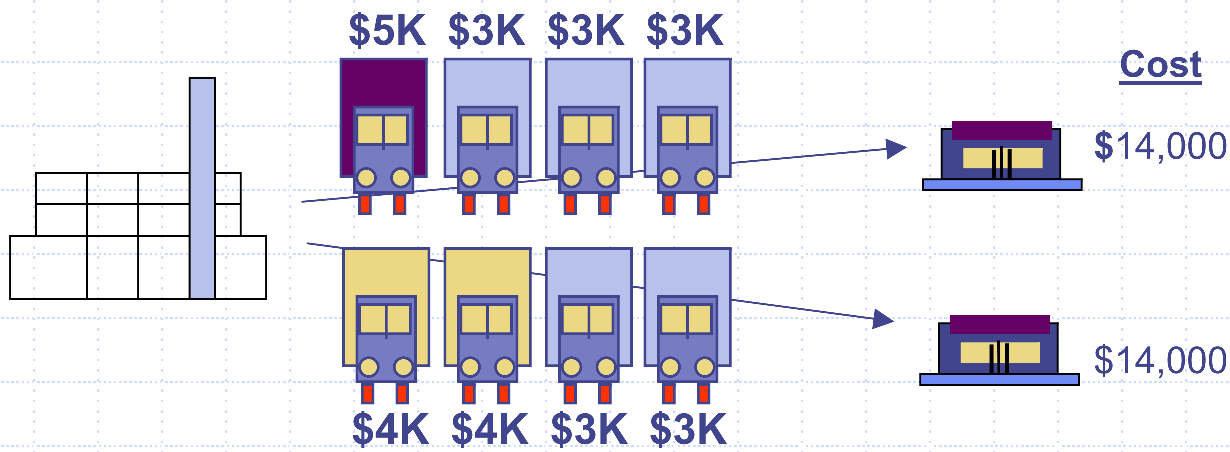
Scenario Management



Business Objective:

Limit Number of Carriers

(No more than 2 carriers)



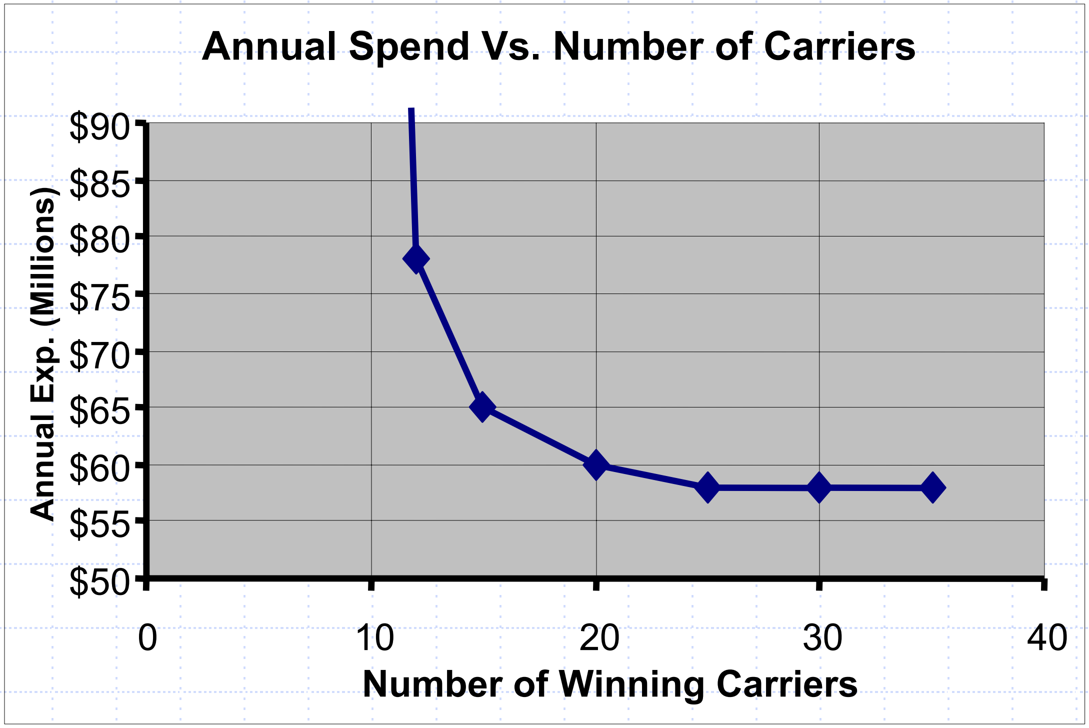
Total Cost : $28,000

Basecase : $24,000

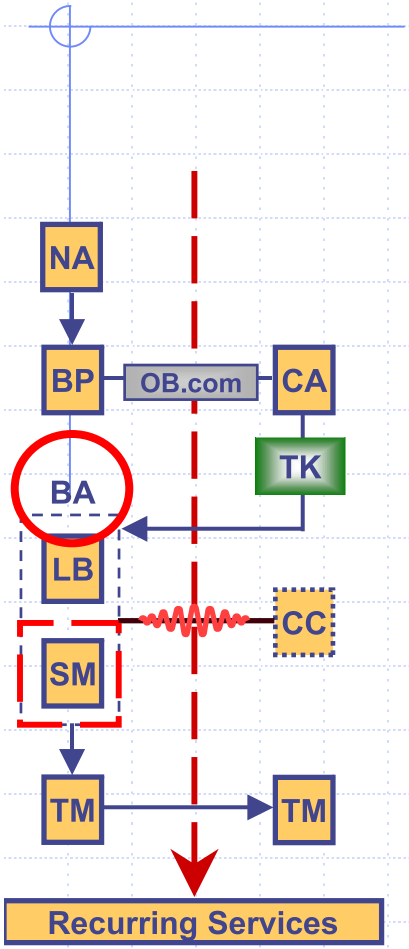
Cost of this Business Objective: **$4,000**

Scenario Management

- Core Carrier Requirements
- Lost Opportunity Cost
  - Limiting the number of carriers constrains opportunities.
  - Result: higher cost solution
  - The question: is it worth it?



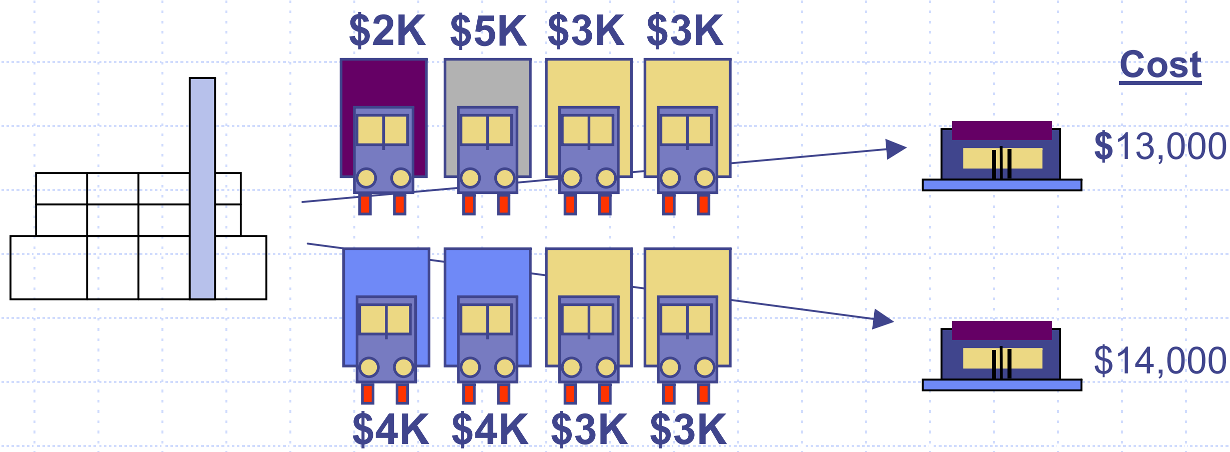
Scenario Management



Business Objective:

Limit a Carrier's Capacity

(Red can win no more than 1)

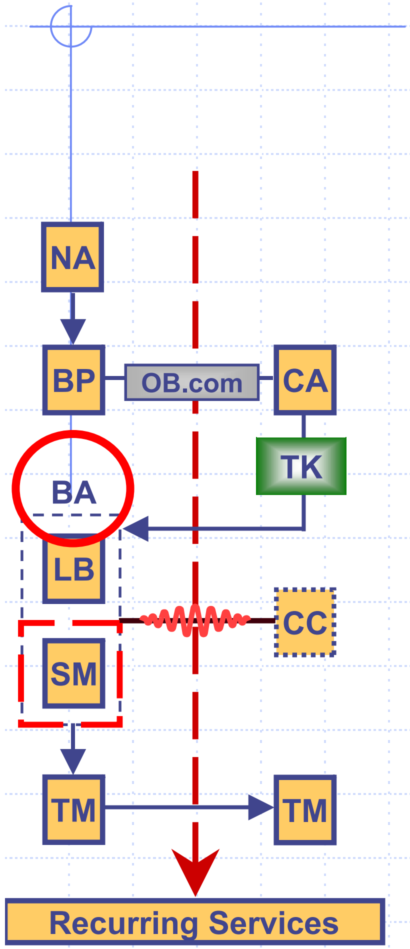


Total Cost : $27,000

Basecase : $24,000

Cost of this Business Objective: **$3,000**

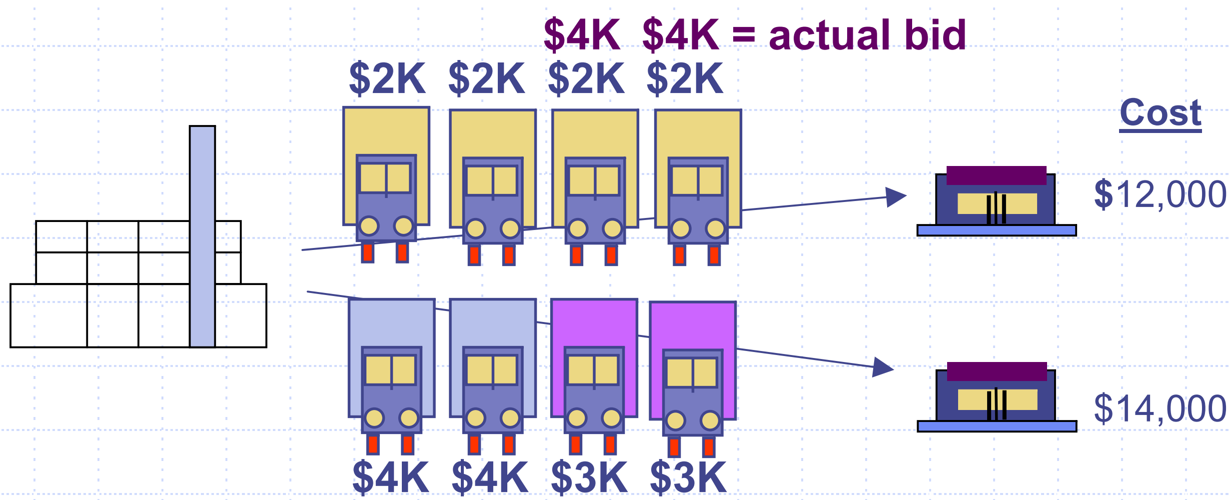
Scenario Management



Business Objective:

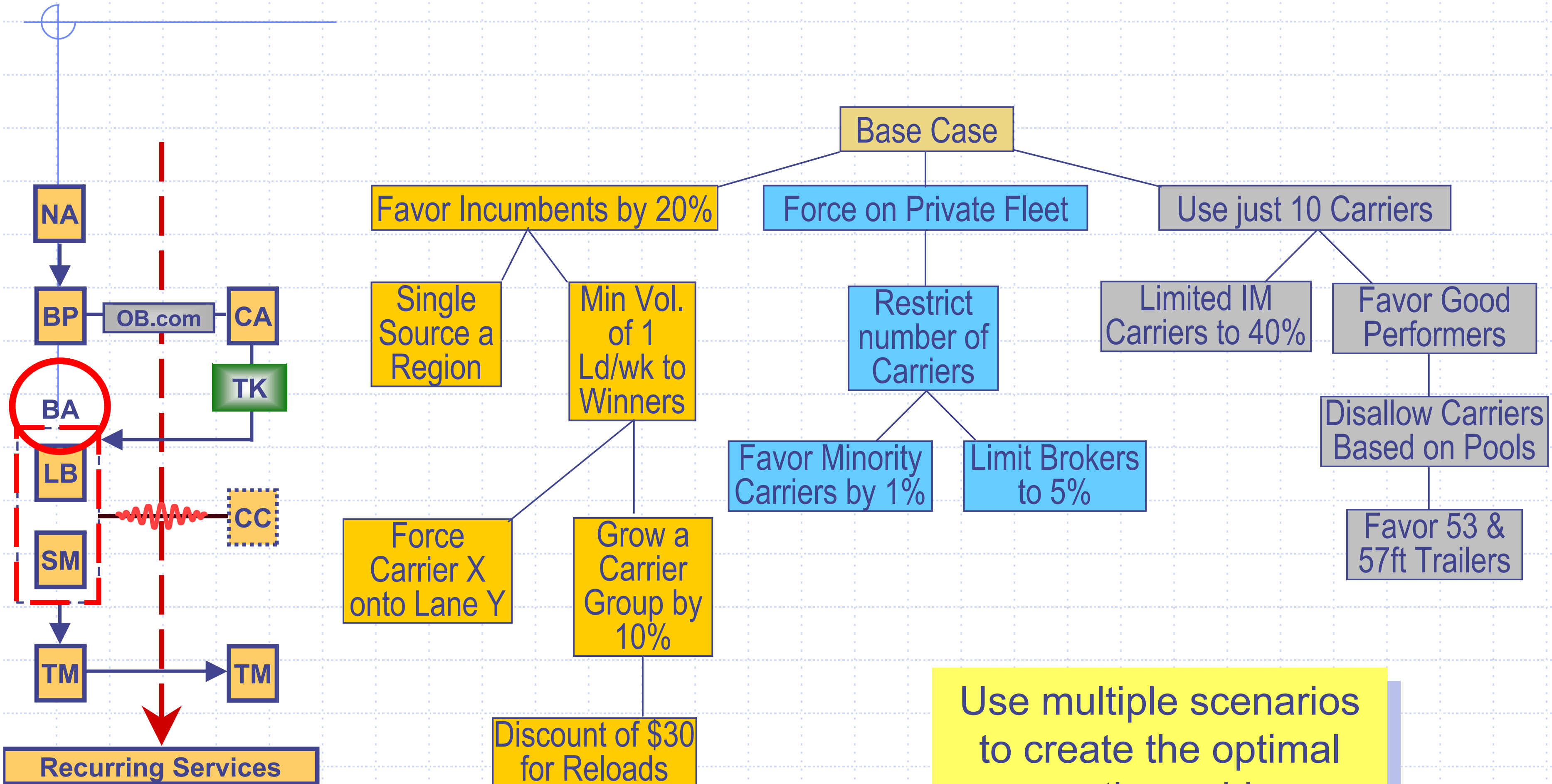
Favor "Good" Carriers

(Discount carriers with 99% on time by 50%)



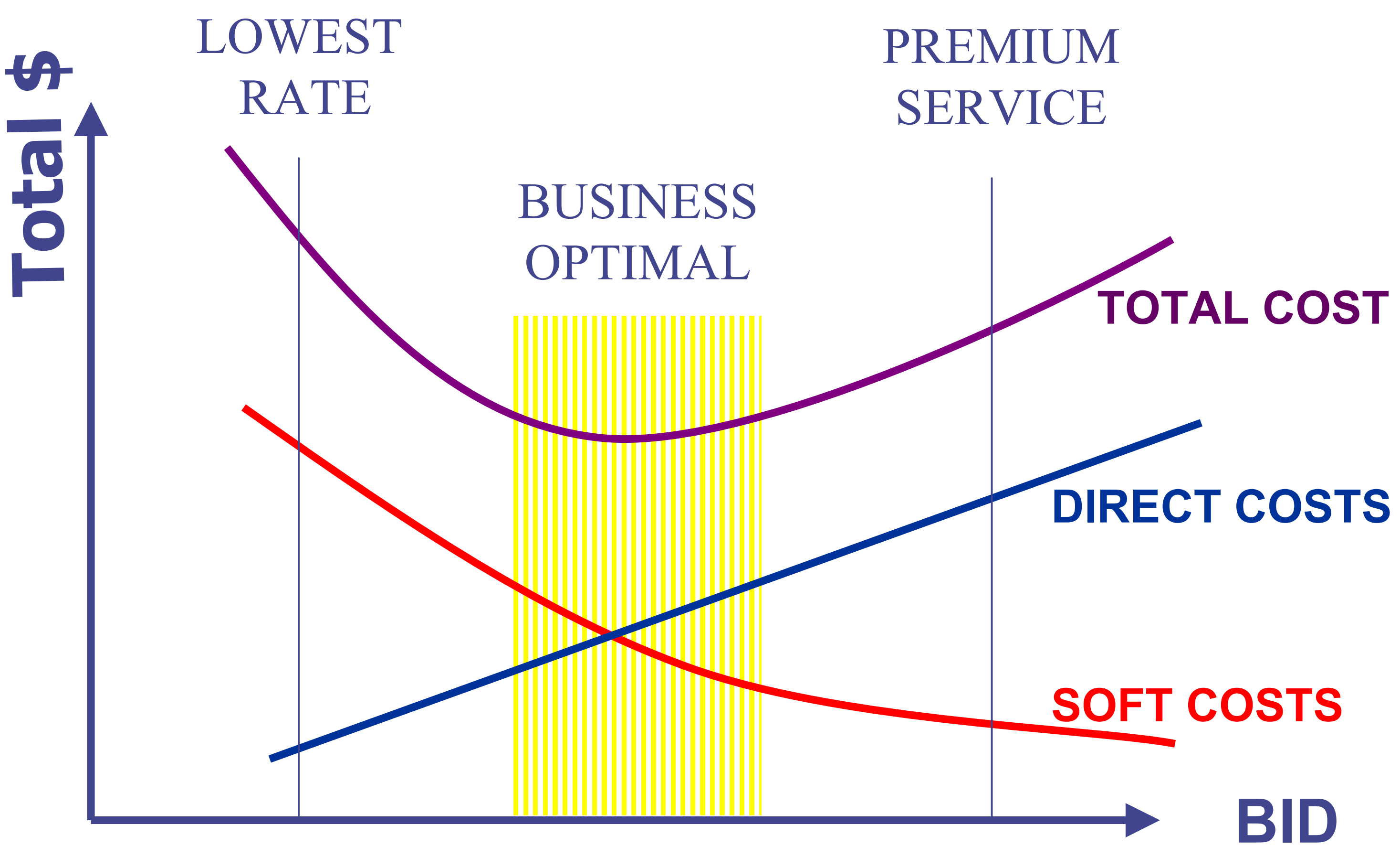
Total Cost : $26,000
Basecase : $24,000
Cost of this Business Objective: **$2,000**

Scenario Management



Use multiple scenarios to create the optimal routing guide

Scenario Management



DIRECT COSTS – LANE BY LANE CONTRACTED RATES
SOFT COSTS – SERVICE LEVELS, DAMAGE, CARRIER MGMT……

OBB Companies

Transportation Procurement History:

- First optimization based bid – Reynolds Metals 1990
- First combinatorial bid – Sears 1993 (Ledyard et al)
- First commercial software – PTCG 1997
- As of 2003 –
    - >10 software vendors in space
    - >100 companies run >200 OBBs
    - >$20 billion of annual spend
    - Savings range – 2% to 20%
    - TL, LTL, Ocean, Air

Lessons

Transportation is Different

- Strong economies of scope (requires conditional bidding).
- Multi-attribute evaluation process (requires generalized "costs" and system constraints).
- A difficult forecasting problem (non-binding contracts).
- A burdensome administrative challenge (requires a single round process).

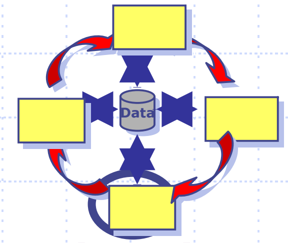
Optimization-based Conditional Bidding

- Allows carriers to achieve better economics.
- LOS can be handled rigorously.
- External conditions can be incorporated.
- Allows for special forecasting methods.
- Allows one-round process - preferred to multiple rounds (but requires optimization).
- Automated administrative process.

Lessons

- Need for a contract-augmenting procedure
- Need for tender-rejection management
  - Replace "dialing for diesels"
- Need for TMS that can execute sophisticated bid results (e.g., Surge pricing)
- Some conditional bid results are surprising
- But: <u>it works</u> – especially with intelligent scenario management and wise carrier management

Task: Execution



- Move products from initial origin to final destination is most cost effective manner while meeting service standards
- Most shippers use software systems (Transportation Management Systems)
- TMS works within strategic plan, procured carriers, and real-time information

PLAN: Create Shipments from Orders

EXECUTE: Select and tender to Carriers

MONITOR: Visibility of the status of Shipments

RECONCILE: Audit invoices and pay for Transportation

How Does a TMS Generate Value?

PLAN → EXECUTE → MONITOR → RECONCILE

Visibility

- Improved communications efficiency with all trading partners
- Reduced levels of safety stock inventory.
- What is the current status of your PO's/orders/shipments?

Automation

- Reduces resources, cost, and time to accomplish activities
- Allows user to manage the exceptions
- Minimizes maverick/rogue behavior and human error

Decision Support

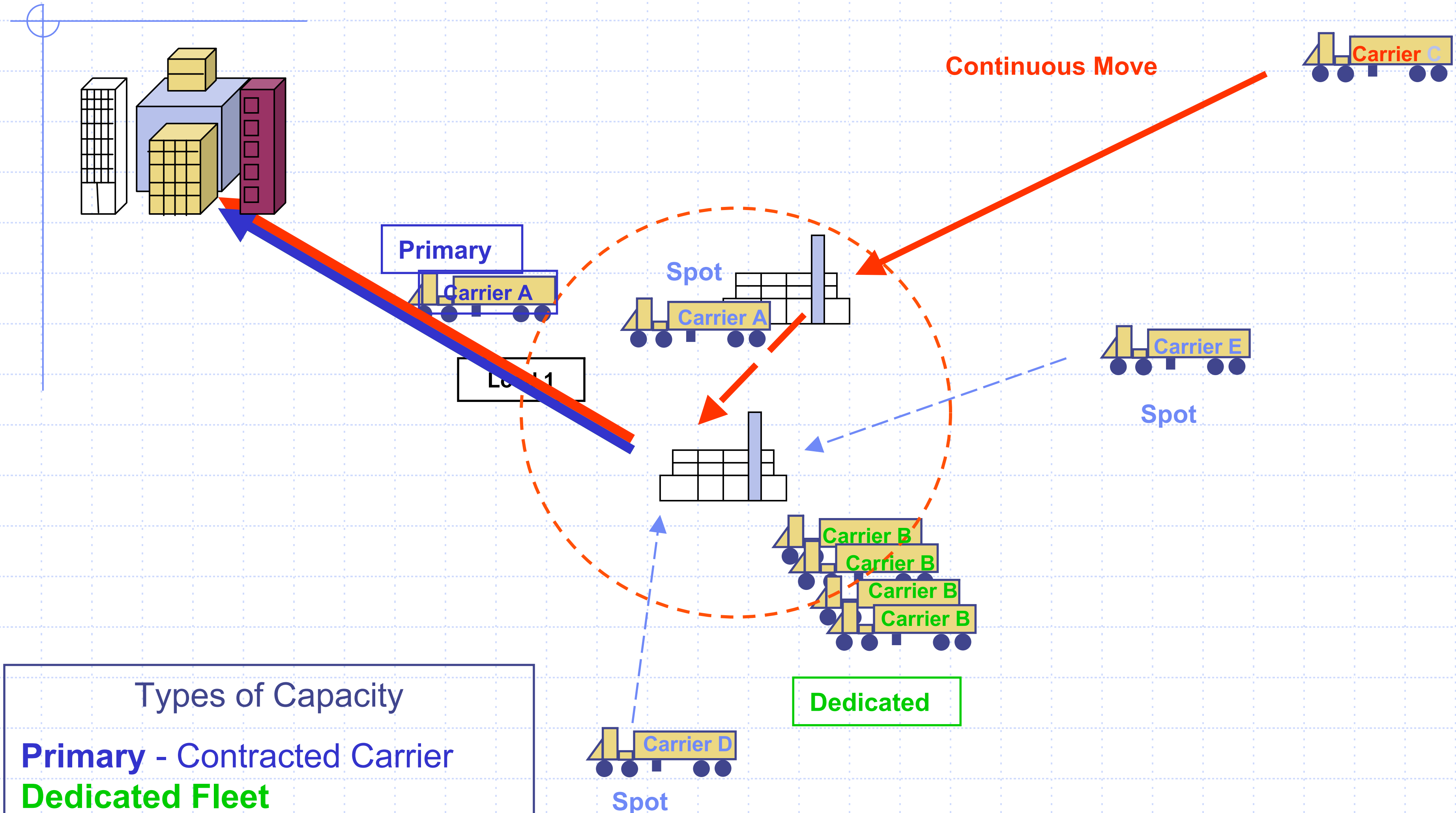
- Provides dramatic cost reductions and efficiency gains
- Make the 'business optimal' decision at every stage of the process
- Assist logistics professionals in making decisions

Execution Considerations

- Considerations
  - How do orders drop? Batched vs Continuous?
  - How much time is allowed between drop and must-ship? Weeks? Days? Hours? Minutes?
  - What percentage of orders change after release?
  - How do they change? Quantity? Mix? Destinations? Timing?
  - What is the length of haul?
  - How many orders are “in play” at any time?

- Key Decision Support Decisions
  - Carrier Selection
    - Routing and Rating
    - Routing Guide Compliance
    - Continuous Moves
  - Consolidation & Routing
    - Postponement of shipments in time
    - Vehicle consolidation (LTL to TL, Parcel to LTL)

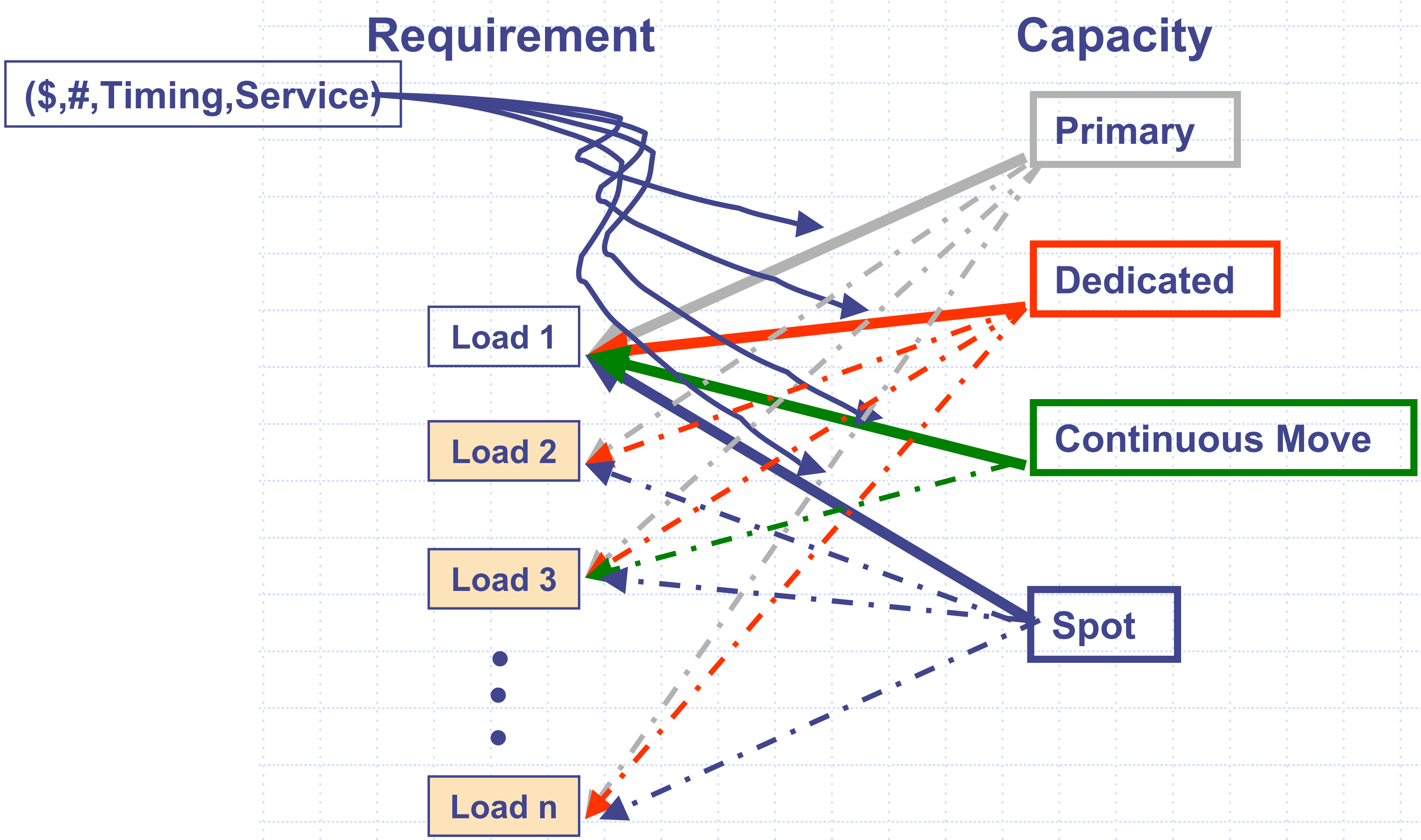
Carrier Selection



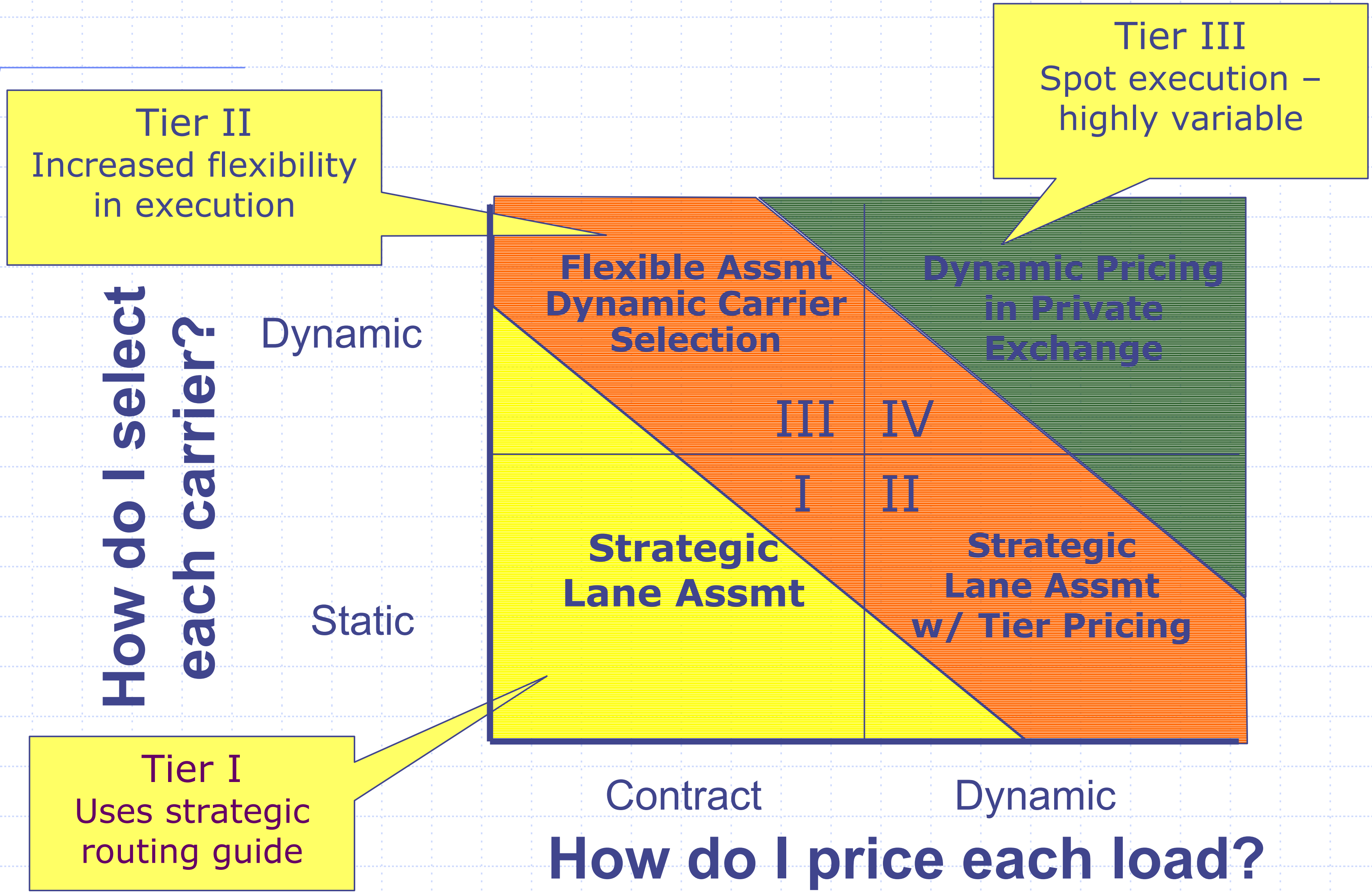
Types of Capacity

Primary - Contracted Carrier
Dedicated Fleet
Continuous Move
Spot Carrier

Carrier Selection

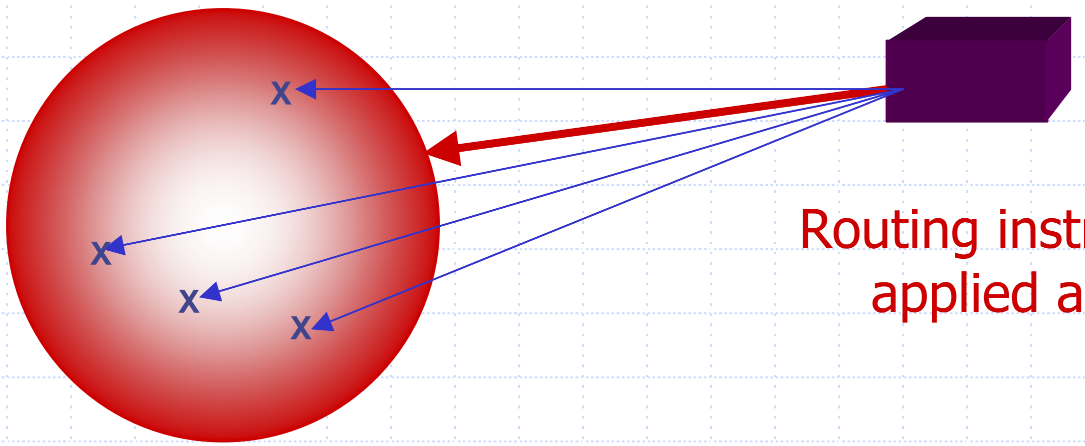


Approaches Must Be Linked



Note on Rating vs Routing

- Separation of Rating Engine and Routing Guide
  - Older systems do not make this distinction
  - Carrier selection (routing guide) hardwired into rating engine
  - Limits the flexibility and potential new carrier options

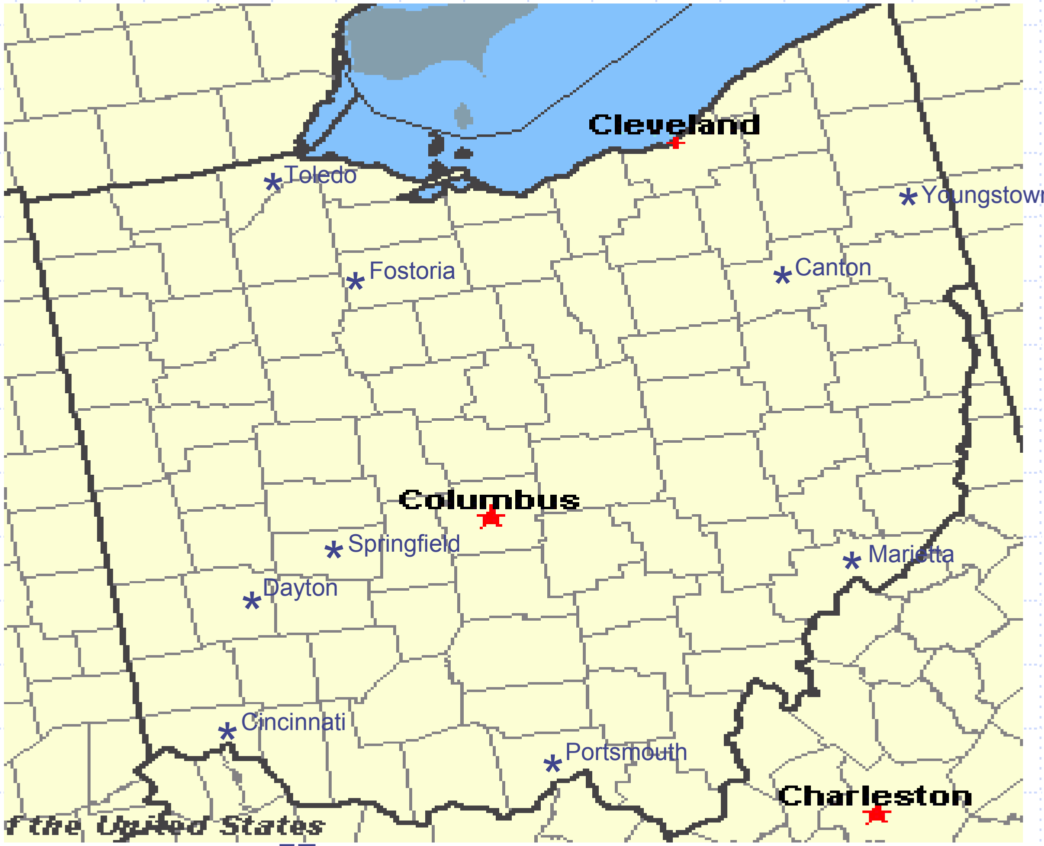


Routing instructions can be applied at an aggregated level

Rates can be applied to individual fine grained OD pairs

Consolidation & Routing

- Find lowest cost routing of orders through consolidation in time, on vehicle, or through facilities.
- Most TMS software contains consolidation or optimization modules



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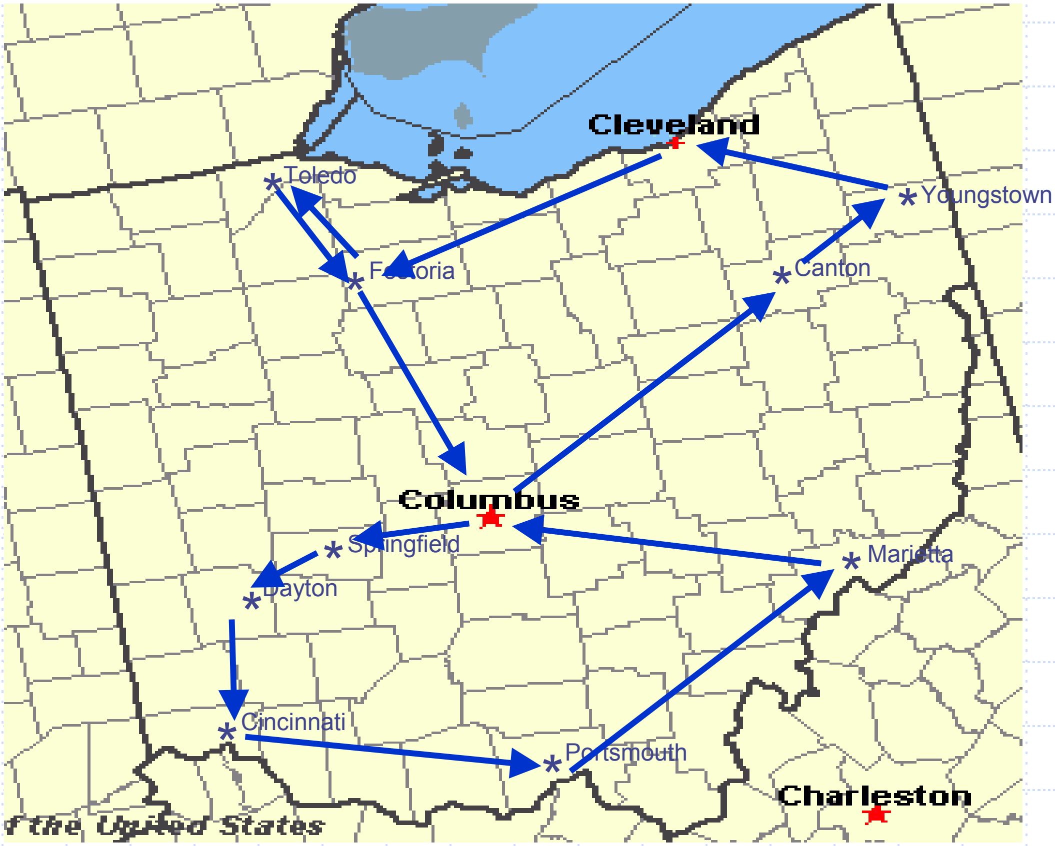
Multiple Vehicle Scheduling Algorithm

MILP, Set Covering, Column Generation

	Route 1	Route 2	Route 3	....	.....	Route M	
	C1	C2	C3	....	....	Cm	
Stop A	1	0	0	1	0	1	1
Stop B	1	1	0	0	1	0	1
Stop C	1	1	1	1	0	0	1
Stop D	0	1	1	0	1	1	1
Stop E	0	0	1	1	0	0	1
Stop F	0	0	0	0	1	0	1
Stop G	0	0	0	0	0	1	1
...	0	0	0	0	0	0	1
..	0	0	0	0	0	0	1
Stop N	0	0	0	0	0	0	1

- Each Row represents one of the N stops
- Each Column represents a generated vehicle route and its cost
- Each matrix coefficient, a_{ij}, is {0,1}, identifying the stops on the j'th route
- Define Z_{ij}, {0,1}, "1" if Stop "i" is on Route "j" , else "0"
- Define Y_j, {0,1}, "1" if the sum of Z_{ij} >0 , i=1,n ; else "0"
- Minimize: the sum of $C_j Y_j$, , j=1,m
- Subject to: the sum of a_{ij} Z_{ij} =1, j=1,m; for all i

Optimal Routing Solution



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Heuristic Approach – Savings

Clarke-Wright Algorithm

1. Serve each stop with direct out and back
2. Find savings for each pair

   $S = D_{OA} + D_{OB} - D_{AB}$

3. Combine loads that increase savings and $< V_{MAX}$

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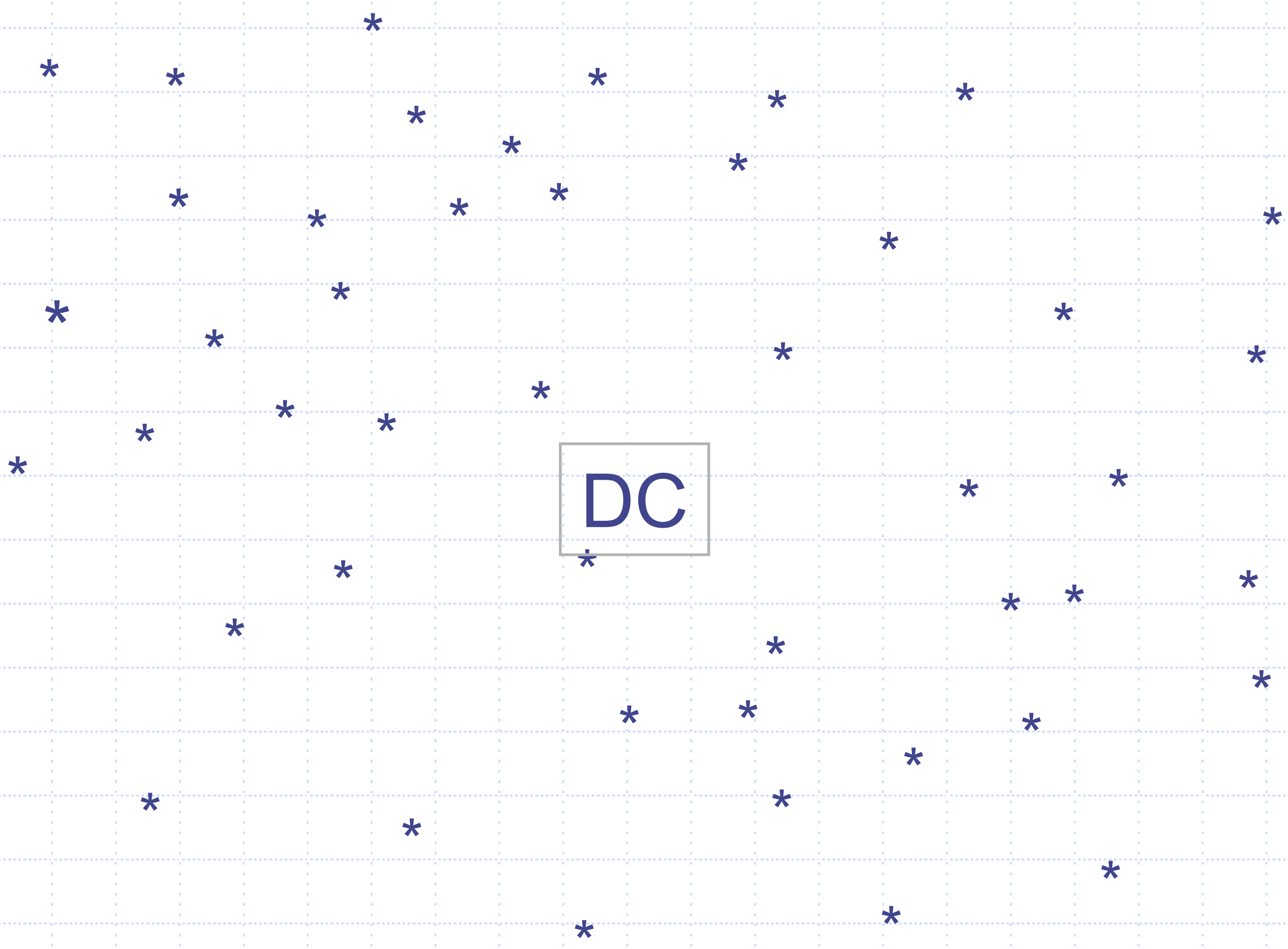
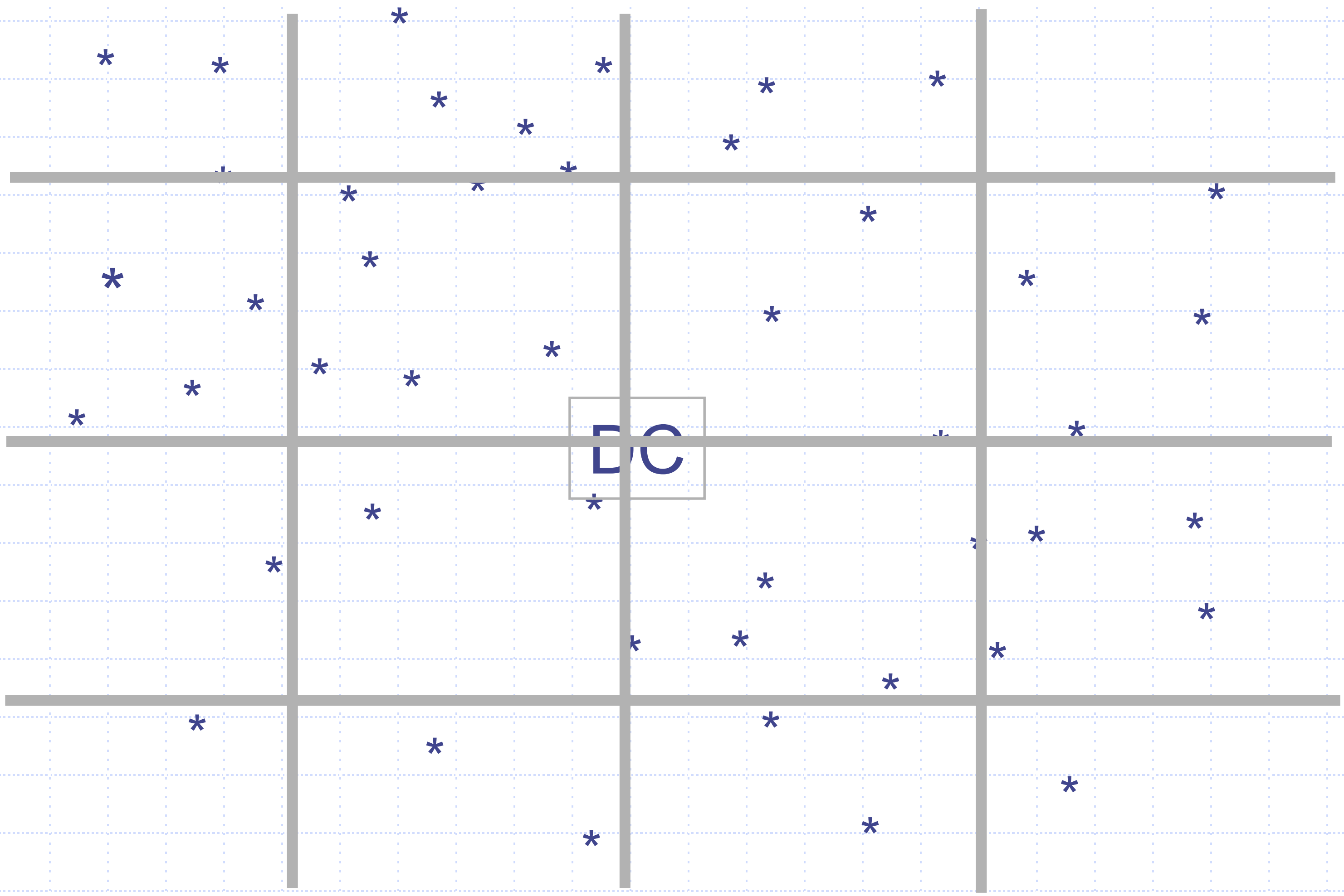
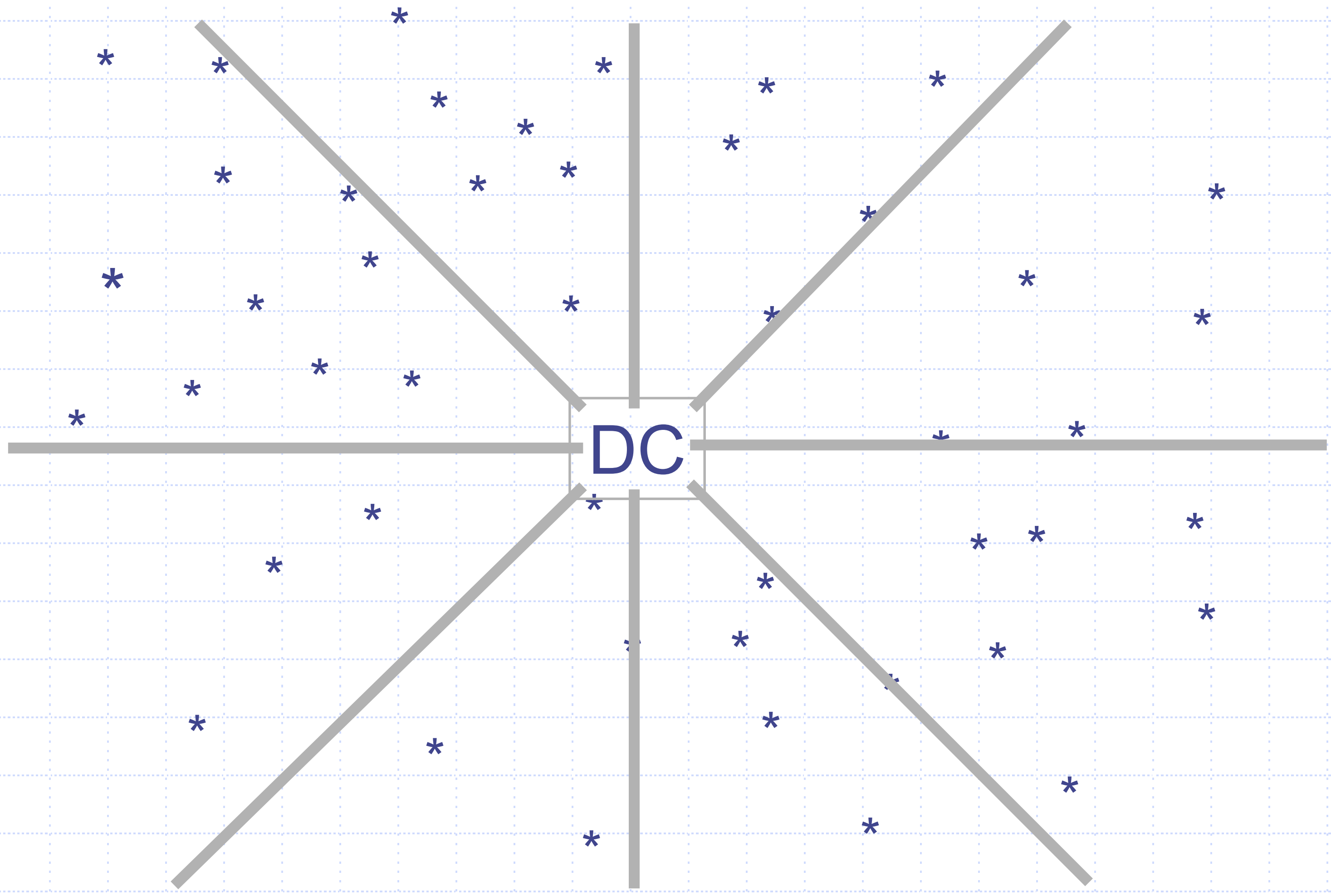
Heuristic Approach – Cluster & Sweep



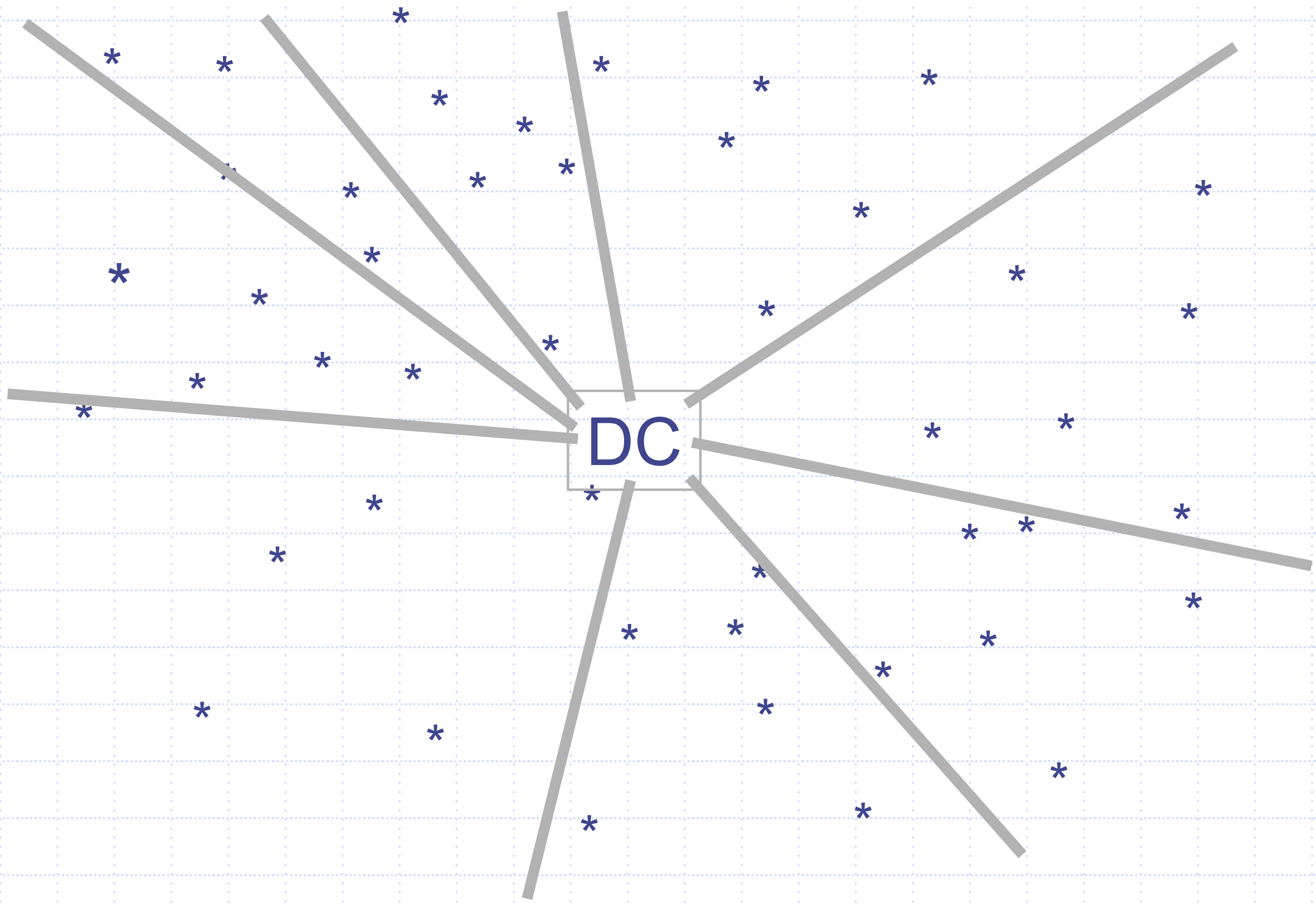
Heuristic Approach – Cluster & Sweep



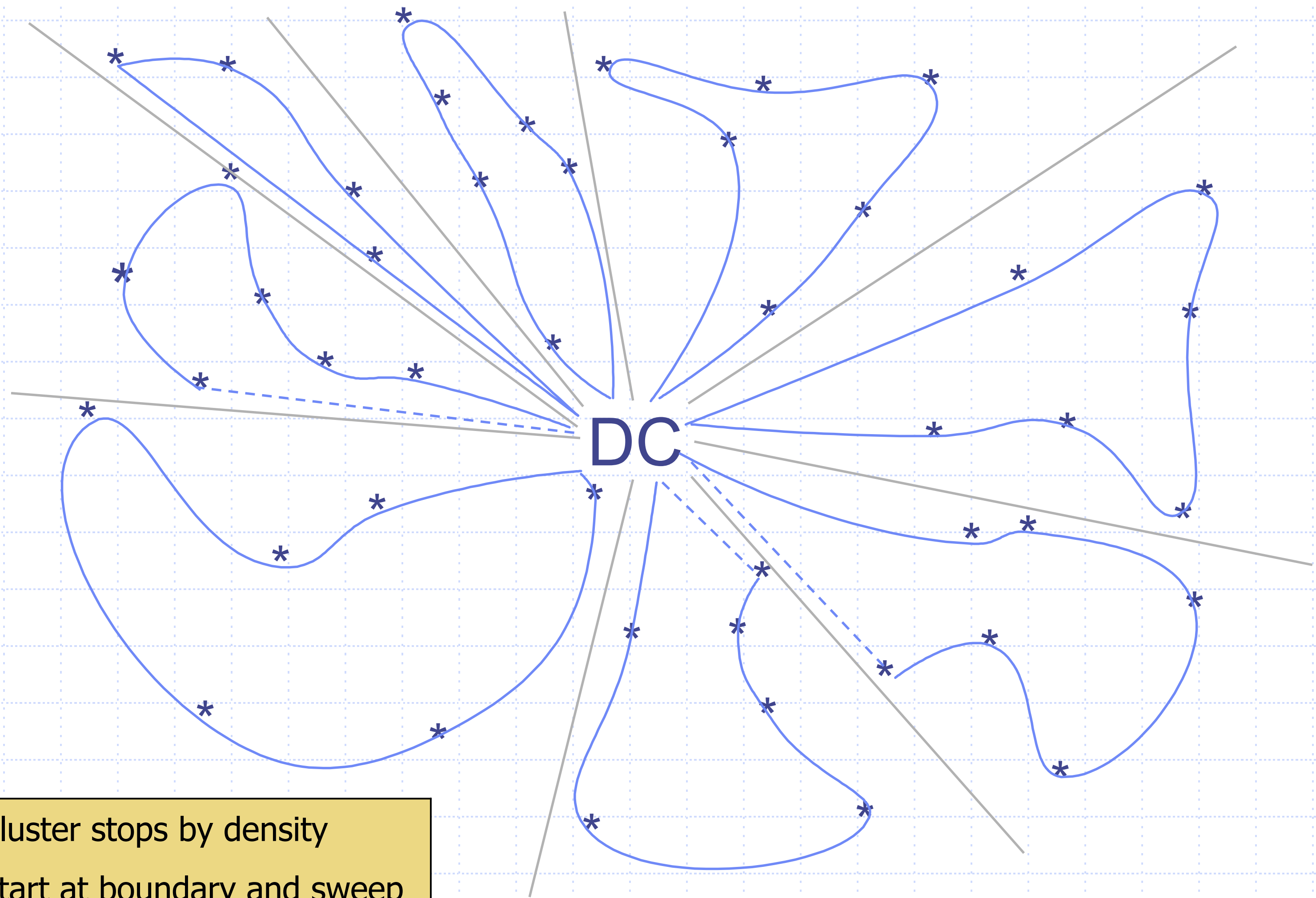
Heuristic Approach – Cluster & Sweep



Heuristic Approach – Cluster & Sweep



Heuristic Approach – Cluster & Sweep



1. Cluster stops by density
2. Start at boundary and sweep CW adding stops until $=V_{MAX}$

Regardless of Approach

- Rules of Thumb
  - Good routes are "rounded", not "star shaped"
  - Good routes don't cross themselves or others
  - Good sectors are "pie shaped", not "checker board"
  - Good solutions "look like a daisy“
- Good Practice Tips
  - Always use a Preview-Analyze-Review methodology
  - Periodically visit the internal logic within the TMS
  - Never discount the salty expert who has been doing this longer than you've been alive
  - Identify all special conditions (customer A must be delivered to first) and then validate or reject them

Questions