Case Study

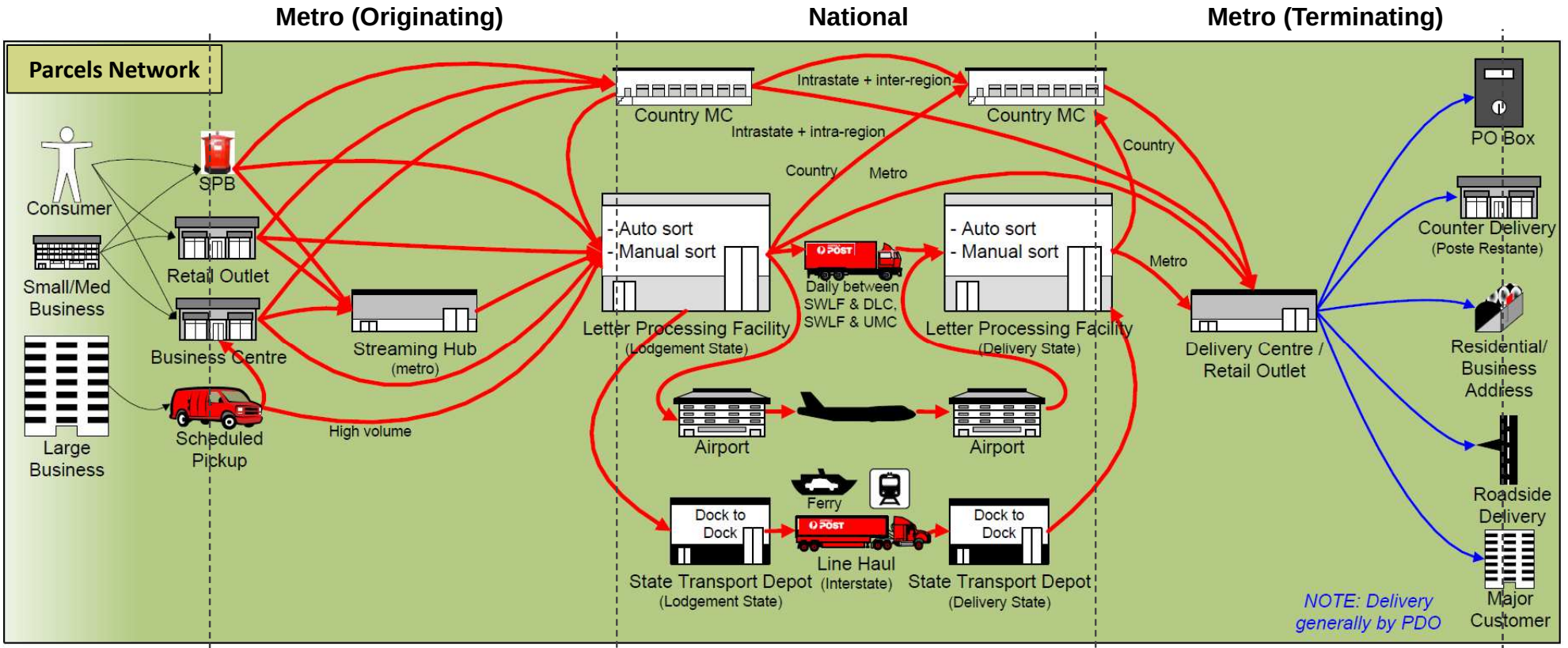
Australia Post – Parcel Delivery Network Redesign

Biarri Applied Mathematics Conference, 12-13 November 2012

Biarri was engaged to provide modelling support for the redesign of Australia Post's parcel delivery network

- Australia Post operates two largely distinct delivery networks
  - Letters network
  - Parcels network
- Over a six month timeframe in 2012, PwC conducted a major redesign of Australia Post's Parcels network
- Biarri was engaged by PwC to develop "end to end" network models which would provide a quantitative basis for the redesign
- The network models were also to be provided in the form of web tools for Australia Post's ongoing use

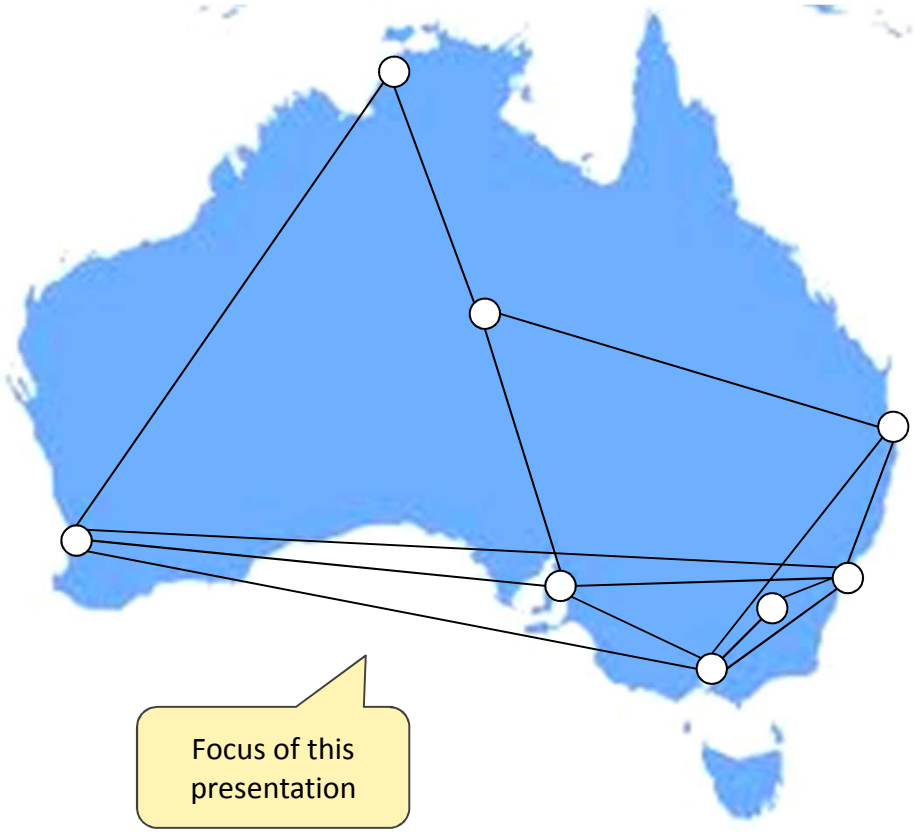
Software models were required to assist network design decision making at the national network level as well as the metro level



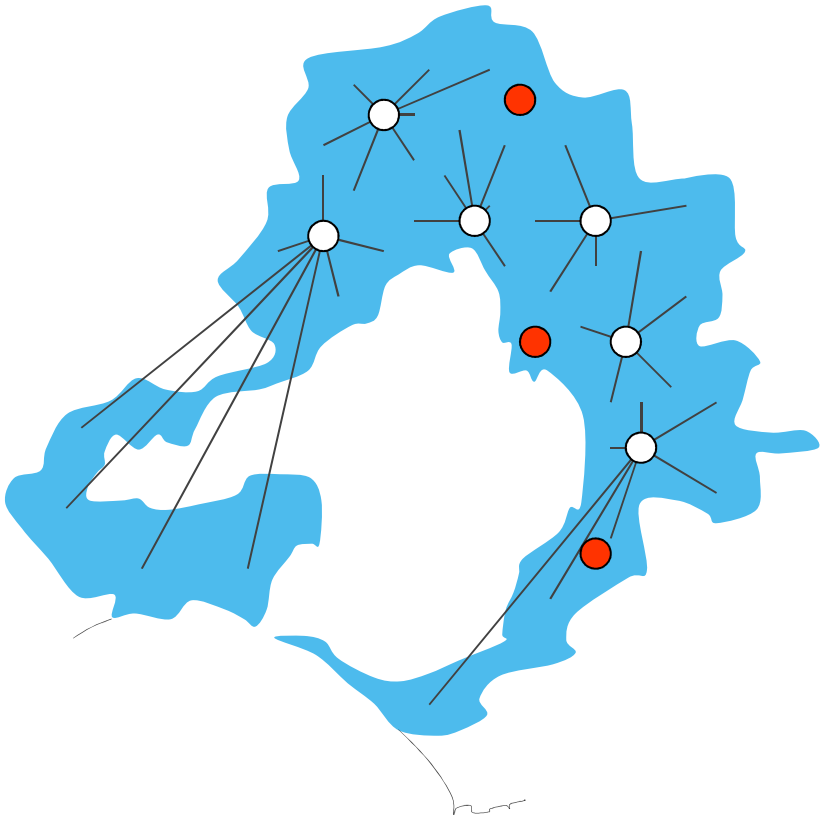
Business Problems:			
	• How many hubs should there be? • How big should each hub be? • Which hubs should service which postcodes?	• How big should the proc. facilities be? • What modes of transport should be used? • What transport timings? • What trans-shipments should be made?	• How many DCs should there be? • How big should each DC be? • Which DCs should service which postcodes?

A “network flow” model was built to model national parcel flows while a “facility location” engine was built to support network design within each metro area

National: Network Flow



Metro: Facility Location / Hub Selection

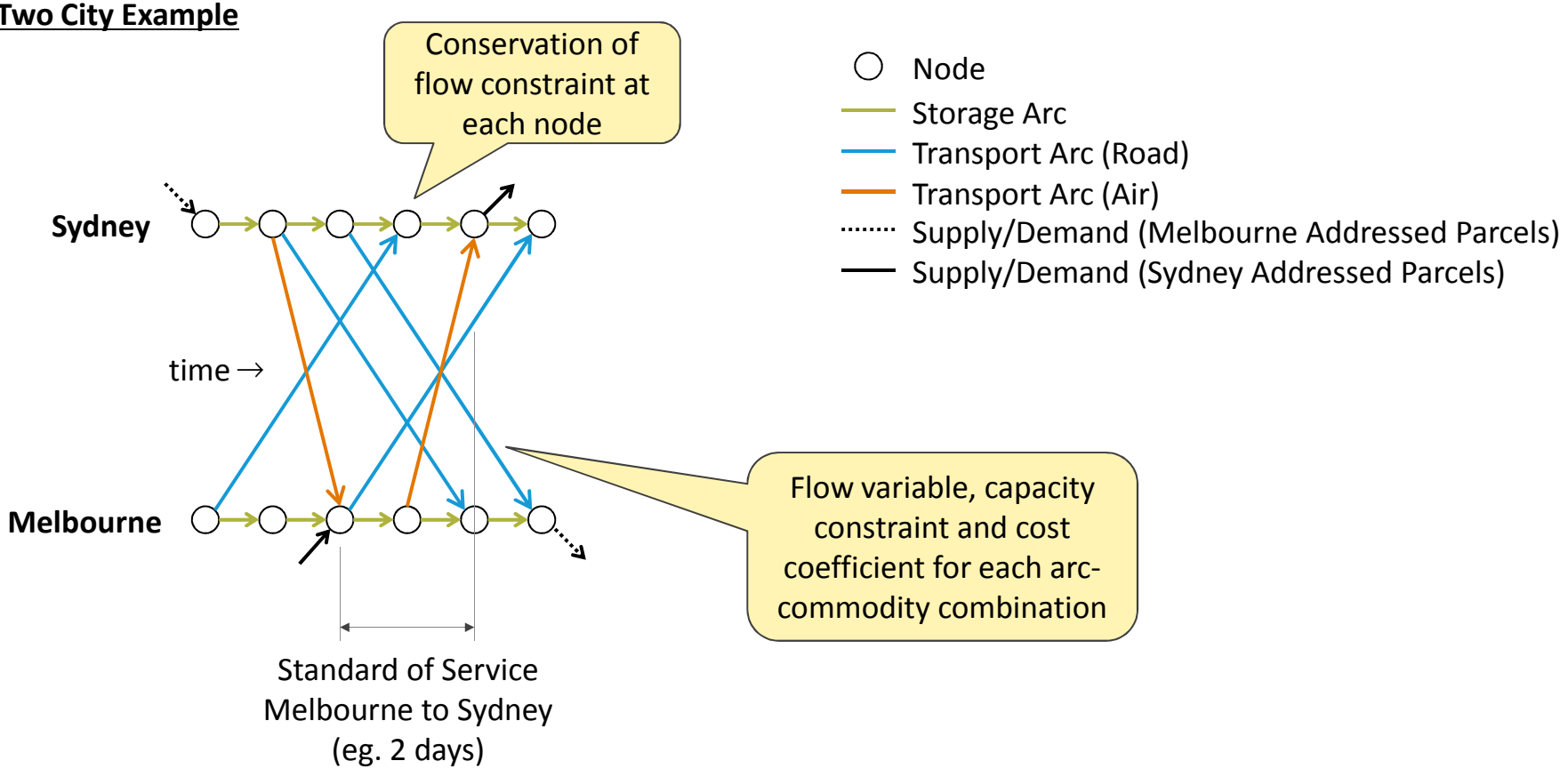


The parcel delivery network could have been modelled by either a discrete event simulation or a network flow system

Feature	Discrete Event Simulation	Network flow model (with LP solver)
Optimization	Needs to be explicitly added/coded	Global optimization inherently available
"Accessibility"	Quantities are realistic	May need a non-integral "unit of measure"

The national network was represented as a network flow system over both space and time

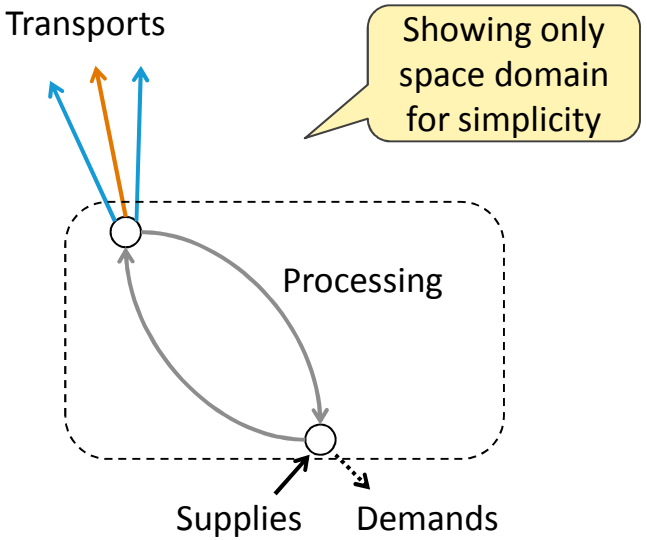
Simplified Two City Example



Application of a network flow model to the Australia Post parcel delivery network was complex

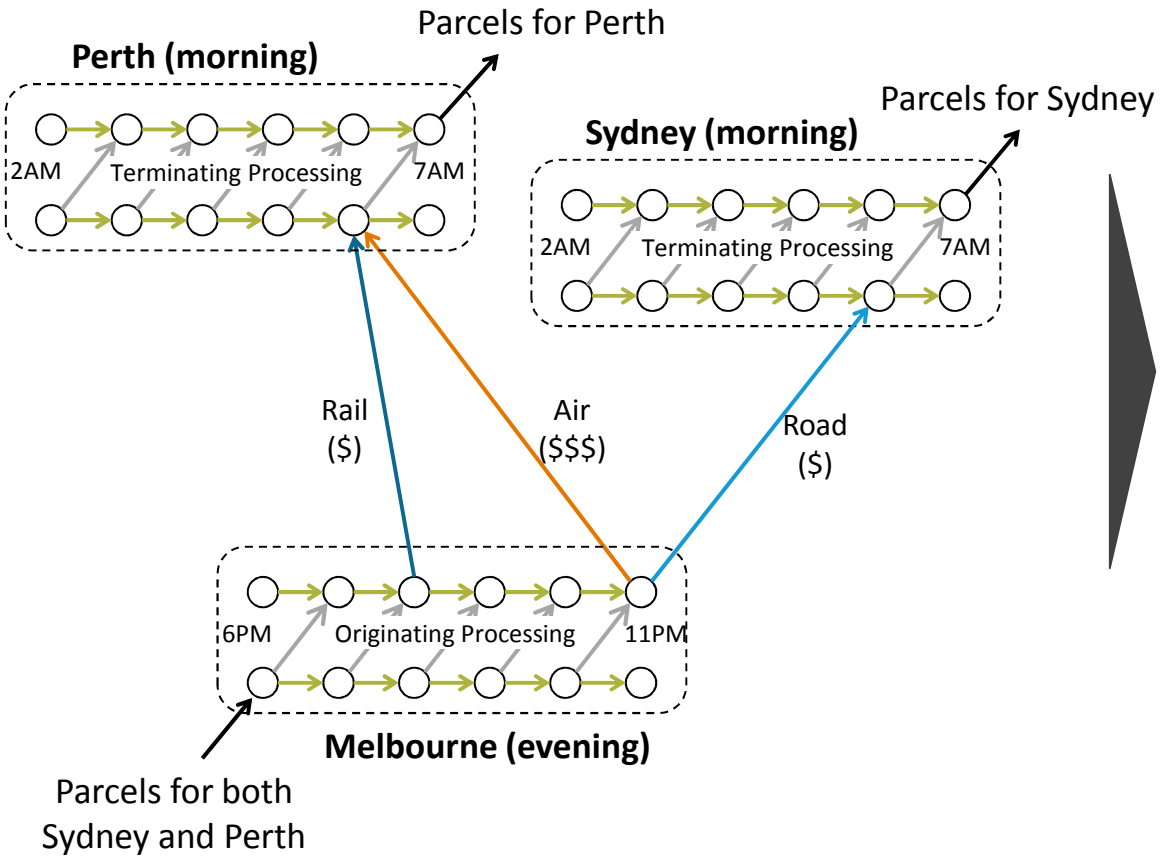
Application to Australia Post Parcels Network

- Eight cities, each represented as two locations with capacitated “processing” arcs between (see below)
- Hourly time step over three weeks; supplies at 5pm, demands at 7am
- Transport arcs for road, rail, air and sea
- Distinct commodity for each product type, destination and due date
- Slack variables for unused supply / unmet demand
- Network “pruning” to reduce size of problem
- Commercial solver to determine minimum cost solution



The mathematics of the network flow model can see into the future and cheat by prioritising the sorting process according to destination

Simplified "Crystal Ball" Example



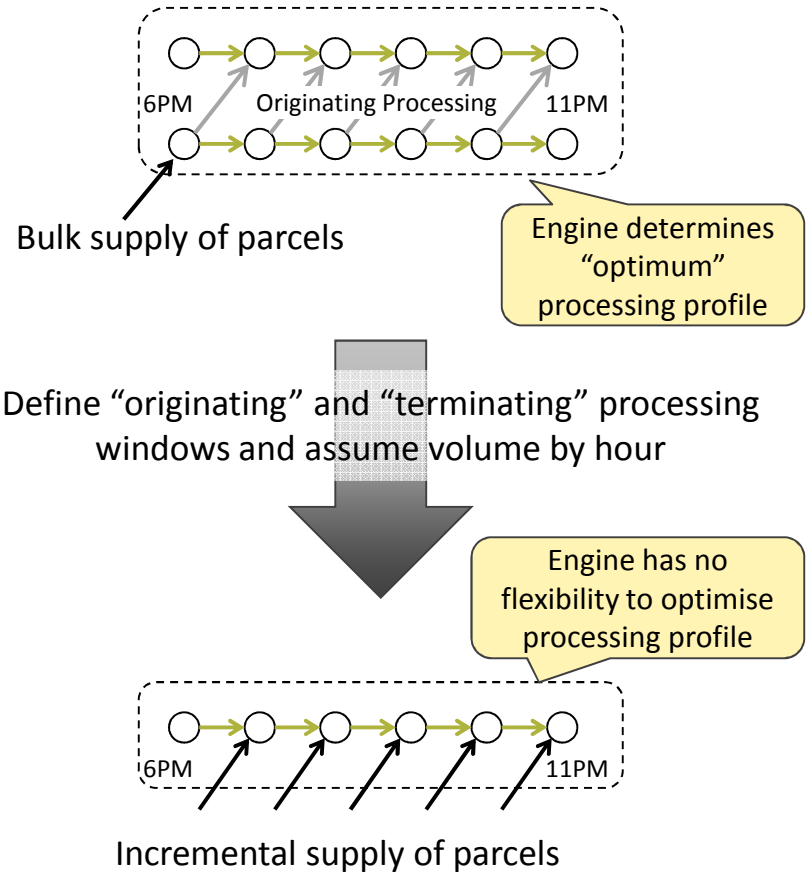
- Parcels lodged in Melbourne can be transported to Perth by rail (cheap) or air (expensive)
- The rail link departs Melbourne at 8PM while the air link departs at 11PM
- Optimum "solution": sort all parcels bound for Perth in the hours of 6-8PM and send by train, then sort the Sydney parcels by 11PM
- But, in the real world, it is only through sorting that we discover which parcels are bound for Perth
- The model would send all Perth parcels cheaply by rail but reality requires that they are sent by air

The maths has a crystal ball that we do not have in reality... It can cheat!

Constraining which parcels are processed at which times/locations avoids the “crystal ball” problem but restricts the power of the engine

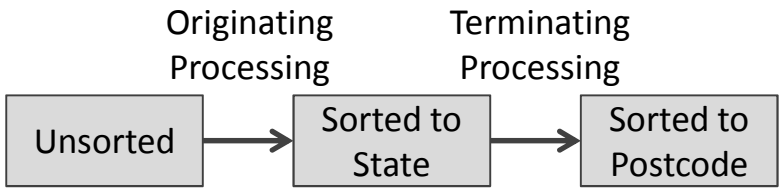
- Initially, the project team solved the “crystal ball” problem by removing processing decisions from the scope of the mathematics
- “Originating” and “terminating” processing windows were defined and hourly processing volumes were assumed
- Parcels were supplied into the model incrementally to reflect parcels exiting the originating sorting process
- Similarly, parcels were demanded incrementally to reflect parcels entering the terminating sorting process
- While this fixed the immediate problem, it restricted the flexibility of the mathematics
- The customer was not happy!

A better solution was required



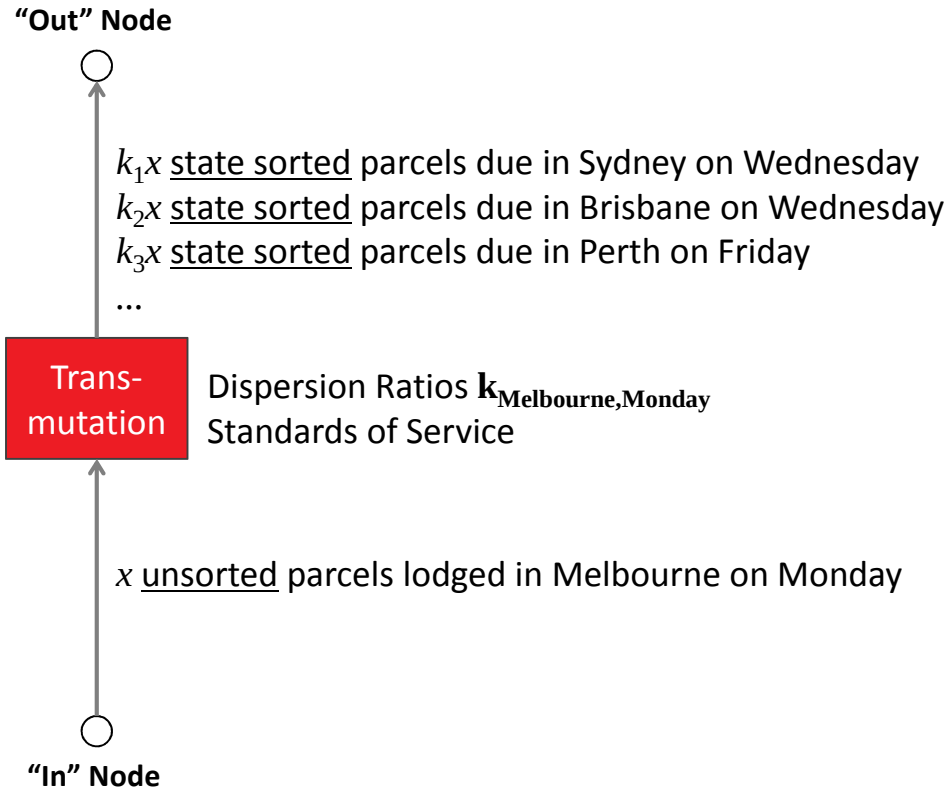
The crystal ball problem was solved ultimately by augmenting the mathematical formulation to support "transmutation" of commodities in the network

- Information about parcels' destinations ("sort level") increases as they progress through the network:



- Decisions made by the engine must be based on parcel destination information that is known in reality
- The project team enhanced the network flow mathematics
  - Distinct commodities were defined to represent parcels at each sort level
  - Parcels were transmuted from one sort level to another, ensuring dispersion ratios[1] were obeyed
- This empowered the engine to optimise which parcels to process where/when while obeying real world limitations (no "crystal ball")

"Crystal Ball" problem solved



1) "Dispersion ratios" define what portion of parcels from each lodgement city are addressed to each destination

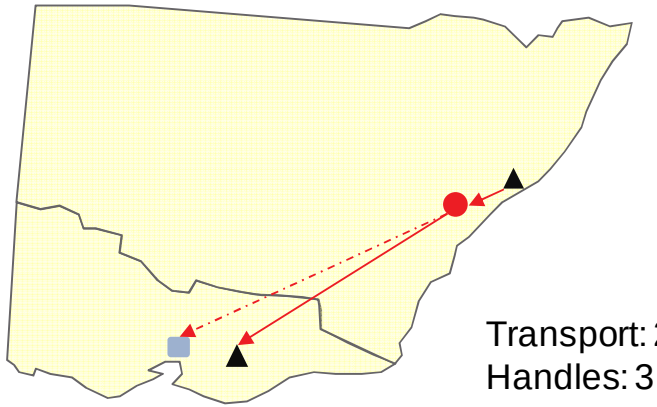
As a result of implementing transmutation in the network flow system, the model provided powerful insights which led to major network design decisions

Addition of a Super Hub

Product Flow: Alexandria > Preston

2 transports with Sydney superhub (If No Capacity @ MPF)

1. Alexandria-> Sydney superhub
2. Sydney superhub > Preston



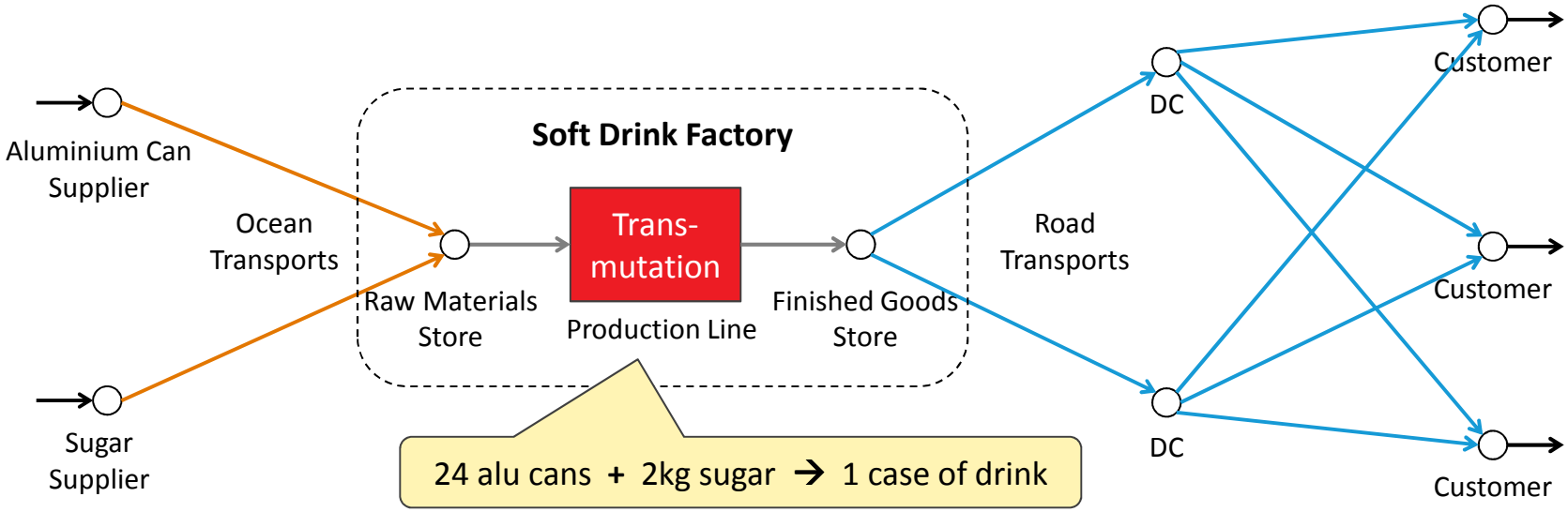
Transport: 2
Handles: 3

- The broader network design team identified an opportunity to introduce a “super hub” into the network
- The super hub would act as an overflow processing facility for the Eastern states
- Lower number of handles but potentially higher transport costs
- With transmutation, the network model was able to determine the optimum way to use the super hub
- Analysis of the results showed that the benefits of a super hub were outweighed by the increase in transport costs

The design team restricted their analysis to non super hub scenarios

A network flow model equipped with transmutation can be used to support business decisions around other types of real world systems such as manufacturing supply chains

- A supply chain network with a manufacturing process, where raw materials are converted into finished goods, can be optimised using a network flow model with transmutation
- Below is a simplified example based on a supply chain for carbonated beverages
- This can help solve complex business problems such as:
  - Optimum raw material inventory levels given customer demand for finished goods
  - Best order frequency and mode of transport from raw material suppliers



Questions?

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