# Terminologies

This would be clearer if a network diagram and a sample timetable.

* Train: a physical rolling stock
* Trip: one run of a train from start to end stations
* Route: a list of particular stations from start to end of a trip. It means each trip run on a particular route of the network. In some rail network, it’s called a line.
* Service plan: a set of routes and its frequencies.

# Line planning model

## Identify routes and frequencies

### Purpose:

Find the service routes and frequency of train for timetable scheduling.

### Scenario:

Simple network with single line with no branches.

### Parameters:

* Number of Stations: 10 stations to start with
* Turn-back location: 4 locations => 6 possible routes
* OD matrix
* Array of Links: element = [origin, destination, distance]
* Flow on each links
* Max # of services on each link
* Array of train capacity: 1 to start with
* Array of train cost per meter
* Transfer and operation weight to combine multiple objectives to into 1 function

### Variables:

* Service Plan: Number of service running on each possible route
* Train plan: what train running on each possible route with assumption that each route only run 1 type of train

### Constraints

1. Not exceed link capacity
2. Meet flow demand

### Objectives:

* Minimize travelling distance
* Minimize # of interchange passenger

## Extension 1: differentiate between turn-back and terminate station

### Purpose:

Find the service routes and frequency of train for timetable scheduling.

### Scenario:

Simple network with single line with no branches.

### Parameters:

* Number of Stations
* Turn-back location: train need to turn-back to form another trip
* Terminate location: train can terminate the trip and park in stabling yard
* OD matrix: include demands in both directions
* Array of Links: element = [origin, destination, distance]
* Flow on each links in both direction: array of [2, LINKS]
* Max # of services on each link in both directions
* Array of train capacity: 1 to start with
* Array of train cost per meter
* Transfer and operation weight to combine multiple objectives to into 1 function

### Variables:

* Service Plan: Number of service of each train type running on each possible route

### Constraints

1. Not exceed link capacity
2. Meet flow demand
3. End trip of each train type is equal to start trip of the same type at each turn-back stations

### Objectives:

* Minimize travelling distance
* Minimize # of interchange passenger

## Extension 2: Include rolling stock constraints

### Purpose:

Find service routes, frequencies and rolling stock requirements for high level service planning which will be used for timetable scheduling in the later stage. To answer the questions below:

* What is the number of each rolling stock type required to run this optimal plan?
* What is the best possible plan for existing set of rolling stock?

### Scenario:

Network with branches is used. Pakenham and Cranbourne is a good and simple case study where train come to Flinders Street station and back.

### Assumptions:

* Each route run can have trip of different train type
* Unlimited stabling capacity which mean that no limit of trains to begin or terminate their journey at stabling locations

### Parameters:

* Number of Stations:
* Turn-back locations: where the train can turn-back but not begin/terminate the trip
* Stabling locations: where train can turn-back and begin/terminate the trip
* OD matrix: both inbound/outbound
* Array of Links: element = [origin, destination, distance].
* Flow on each links
* Link capacity: max # of services on each link
* Array of train capacity: passenger capacity of each train type operated
* Array of train cost per meter: running cost of each train type operated
* Transfer and operation weight to combine multiple objectives to into 1 objective function

### Variables:

* Service Plan: Number of service running on each possible route
* Train plan: what train type running on each possible route
* Rolling stock requirement: how many train of each type needed to run the choose service plan. This could be the objective function or part of objective function which need a weight coefficient constant.

### Constraints

* Link Capacity: number of trips on each link does not exceed link capacity
* Meet flow demand: enough trips to cover demand flow
* Rolling Stock must begin or terminate at stabling location: given each train running on 1 route only, at least 1 end of a trip

### Soft constraints: which can turn to be an objective

* Rolling stock constraint: if service plan needs to be operable with existing set of rolling stocks.

### Objectives:

* Minimize travelling distance
* Minimize # of interchange passenger

# Rolling stock scheduling

## Schedule timetable with given service plan

### Purpose:

Given the number of routes and frequencies during a fix time period, schedule the trips with departure and arrival time. By connecting trips, the rolling stock requirement can be identified to see if existing rolling stock set can run the proposed service plan.

### Scenario:

Network with branches is used. Pakenham and Cranbourne is a good and simple case study where train come to Flinders Street station and back.

### Assumptions:

* Each route run can have trip of different train type
* Unlimited stabling capacity which mean that no limit of trains to begin or terminate their journey at stabling locations.
* FUTURE: stabling limitation and fix set of rolling stock

### Parameters:

* Number of Stations
* Routes and frequencies
* Array of Links: element = [origin, destination, distance] and duration
* Headway requirement (safety)

### Variables:

* Trip with travel time
* Trip connection ===> rolling stock requirement

### Constraints

* Headway

### Objectives:

* Find a satisfied timetable

# Support tool to create input data

* Modify OD matrix: Relocate demand to sub network: if only focus on particular lines of the network, there’re no need to have full OD matrix. Depending on the origin and destination, it needs to relocate demand to origins and destinations outside the sub-network to the interchange stations.
* Contract intermediate links: There’s no need to keep middle link between turnback/stabling locations. The max flow can be used for contracted link. For example, route from station 1 to 4, there 3 links, 1-2, 2-3, 3-4, which can be contracted to a single link 1-4 and flow is the max flow of 3 middle links.