Australasian Transport Research Forum 2019 Proceedings
30 September – 2 October, Canberra, Australia
Publication website: http://www.atrf.info

Using netgraphs as an aid for planning urban transit ferry networks

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Abstract

This study examines the application of netgraphs to urban transit ferry networks, using Sydney Ferries as a case study. Netgraphs are a commonly used tool for planning periodic rail networks, providing a strategic visualisation of line connections and network capacity. The study identified desirable modifications to standard practice in notation to make netgraphs more useful for a ferry system, including treatment of all stops as nodes, adding the vessel crossing point as an extra event category and labelling berths at nodes. These changes were necessary because of the importance of minimizing or eliminating berthing conflicts in ferry network planning.

1 Introduction

Many elements are involved in planning a ferry system, including the design of vessels, wharves, the passenger exchange process and scheduling. This work is necessary to minimise costs, ensure service reliability and integrate ferry services within the total public transport offering.

Strategic planning of the network is a critical first step, but this and the other planning tasks in a multi-line ferry system can be extremely complex. It is even more difficult if variations in the marine environment or speed requirements necessitate the use of different vessel classes on different lines or line groupings. This is turn affects the vessel/ wharf interface, the speed of passenger exchange, flexibility of crewing and the cost of training and maintenance. Scheduling services to avoid berthing conflicts are also likely to be more difficult.

Practices followed elsewhere in the public transport field can help make the ferry planning task easier. For example, integrated periodic (regular interval) timetabling improves connectivity and efficiency in complex urban transit ferry systems (Sandell, 2015, 2017).

Netgraphs are a commonly used tool in rail planning to provide a graphical representation of periodic timetables (Schittenhelm Nielsen & Landex, 2013, p.23). Netgraphs supplement a two dimensional network map with the dimension of time. They show the frequency of services on each line and arrival and departure times at nodes, giving a strategic overview of connectivity. Lines are coloured to distinguish train classes. Preparing a netgraph helps eliminate flaws in a network not evident from the timetable itself.

The purpose of this study was to test the use of netgraphs in planning complex urban transit ferry networks and to identify any modifications needed to address issues peculiar to ferry operations.

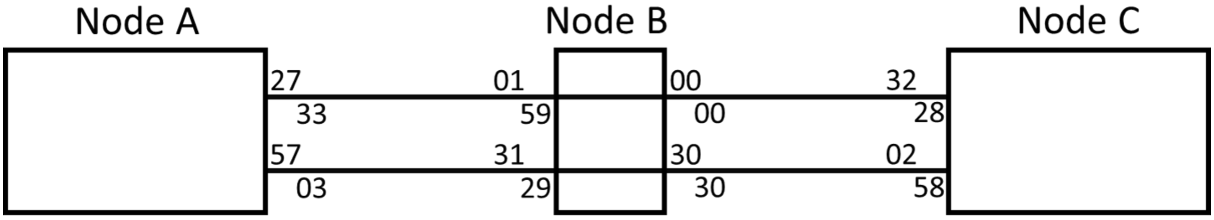
2 Methodology

While there are no strictly prescribed rules for netgraphs, a standard set of practices have developed for notation (Michl, Drabek & Vavra, 2017, pp.44-45). These include:

1. Network nodes are named. A node is typically either a terminus or intermediate stop where passengers can transfer to another line or make an intermodal connection.
2. Edges correspond with a public transport line. A line is used to represent travel in both directions. The representation of the line indicates the service interval. A single line denotes a one hour interval; a 30 minute interval is represented by two lines. Line colour is used to show the class of train/vehicle.
3. Time descriptors at nodes show the minute arrival and departure events.

The example in Figure 1 (modified from Michl, Drabek & Vavra) shows three nodes on a 30 minute interval train line. Following standard practice, arrival and departure times are distinguished by the distance of the descriptor from the node box. The arrival time is immediately adjacent, while the departure time is set back from the node.

Figure 1: Netgraph representation of 30 minute interval public transport line with three nodes



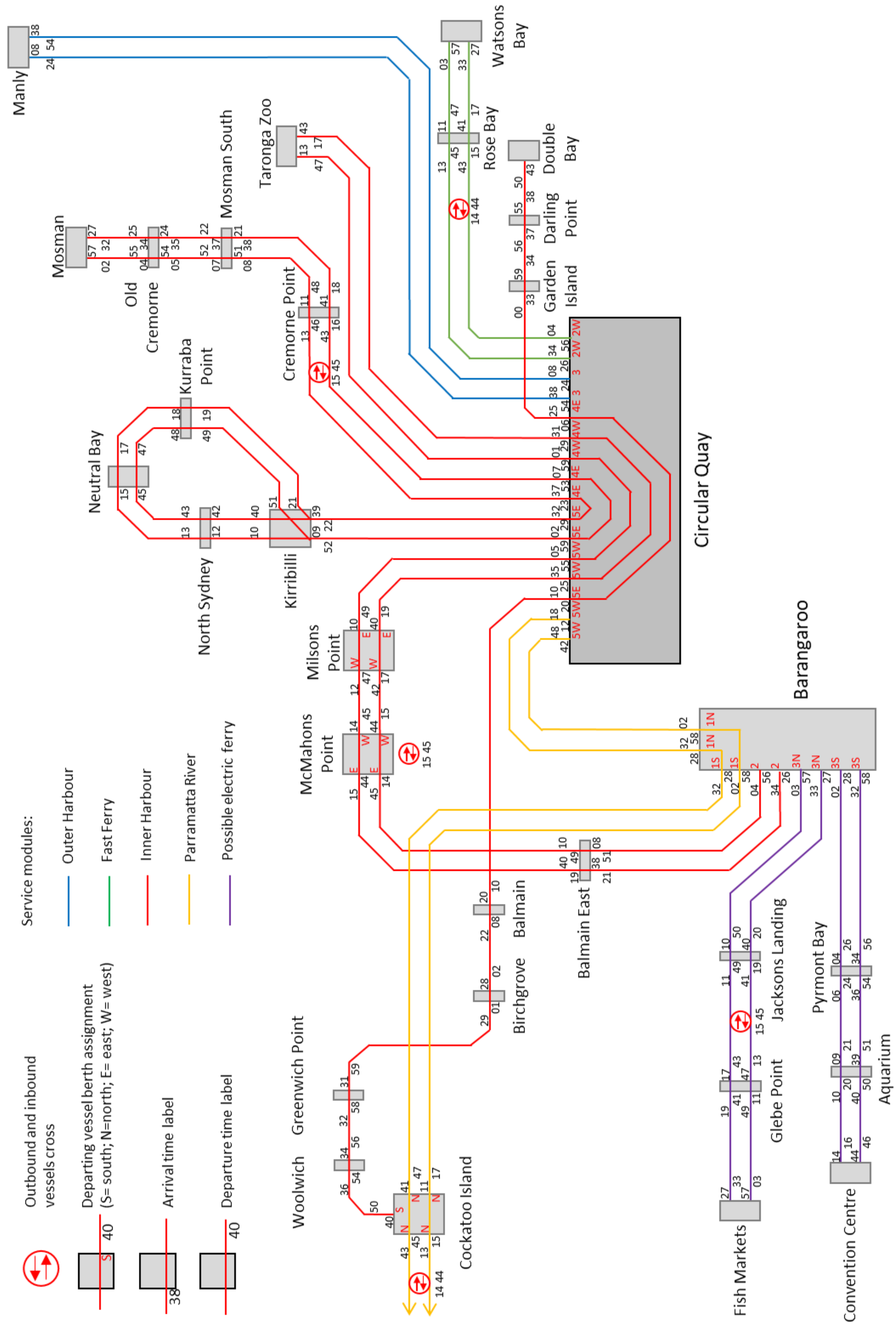
While this format could be followed for any mode, some enhancements are needed for planning a ferry network, where berthing conflicts are a critical issue and a systemic cause of delays. Typically only one berth is available at each stop for vessels travelling in both directions. In addition, the time required for a stop at a wharf is longer than a train or bus dwell. Without some modification to standard netgraph practice, systemic berthing conflicts in a ferry network could be hidden and may fail to be addressed.

A netgraph was prepared for Sydney Ferries as a case study (Figure 2). To make the exercise as realistic as possible, no changes were made to current stopping patterns or frequencies, except two new lines were added as possible extensions in Darling Harbour and the Bays Precinct. For simplicity, the netgraph represents the week-day off peak timetable only.

As the current timetable is not strictly periodic, an integrated regular interval timetable was developed especially. This maximises attractive transfer points in the network. Six of the nine lines terminating at the main terminal, Circular Quay, were scheduled with convenient transfer waits, but because only six berths at Circular Quay are assigned to the Sydney Ferries franchise, the remaining three lines were scheduled to operate off pulse.

All four lines intersecting at Barangaroo are on a pulse timetable with transfer waits of between four and seven minutes.

Figure 2: Netgraph representation of Sydney Ferry network (off peak with periodic timetable)



The network represented by the netgraph comprises five discrete service modules:

1. Outer Harbour (Manly Ferry), displayed as a blue lines.
2. Watsons Bay fast ferry, displayed as a green lines.
3. Inner Harbour lines, displayed as red lines.
4. Parramatta River line, displayed as yellow lines.
5. Darling Harbour/ Bays Precinct, a possible new module represented by purple lines. Owing to speed restrictions and other constraints, these lines need to be operated by a separate vessel class, which could be an all electric ferry.

To show whether the timetable is causing berthing conflicts, all stops were treated as nodes with time descriptors. In addition, berths were labelled separately where a ferry stop or terminal had more than one berth face. The berth label is adjacent to the departure time descriptor only.

Another improvement was to add vessel crossing locations as events, highlighted by a red circle enclosing opposing red arrows. In all cases, these were able to be located in open water except one event at McMahons Point where two berths are available to accommodate the inbound and outbound vessels simultaneously.

3 Findings and Discussion

The study demonstrated that a netgraph can be a valuable tool for strategic planning of a waterborne transport network with a periodic timetable. Preparing a netgraph does not in itself make better connections or more reliable services, but as a step in an iterative planning process, it can highlight where adjustments are needed to eliminate berthing conflicts, correct a missed timed transfer opportunity or modularise the network to allow customisation of the vessel/wharf interface.

Labelling berths on a netgraph helps the network planner avoid berthing conflicts at a node where multiple lines intersect, but this is not a substitute for other planning tools. For example, a time and distance graph highlights berthing conflicts very plainly on individual lines. But time and distance graphs do not provide a visualisation of how lines impact on each other as they do in Sydney Ferries, especially at Circular Quay and Barangaroo. Using both tools together achieves the best possible outcome.

As a means of demonstrating timed connections, a netgraph is less effective than other approaches for at least two reasons:

- Even for an experienced planner, not all poor connections will be obvious from a visual scan of the arrival and departure time labels on a netgraph.
- The time range that can be considered “attractive” for transfer waits depends on the distance between the points of disembarkation and embarkation. For example, a passenger who has arrived at Jetty 2 from Watsons Bay, with the intention of transferring to the Cockatoo Island ferry at Jetty 5 must walk 280 metres. At a walking speed of 4 kmph, that is a total of about four minutes, compared to just a few seconds for a passenger who only needs to cross from one side of a pontoon to the other. It is not possible for a netgraph to make allowance for these differences.

A matrix of lines intersecting at each main terminal with colour coding to highlight good, moderate and poor connections, with allowance for variation in walking distances between vessels, would offer a better overview of the attractiveness of transfer waits.

By using line colour to represent vessel class, the opportunities for customising wharves to vessels were evident. One example is Jetty 2 at Circular Quay, where the Watsons Bay ferry berths on the western side and Manly Fast Ferry berths on the eastern side. Both lines use vessels with similar specifications, so there is the possibility of customising the passenger exchange process at this jetty for faster loading in a future upgrade.

While the netgraph in this case study was limited to the Sydney Ferries franchise, it would be desirable in future work to include the non-subsidised ferry operators as they share some wharves with Sydney Ferries and present a berthing conflict risk. Including connecting bus services would also be a useful addition.

4 References

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