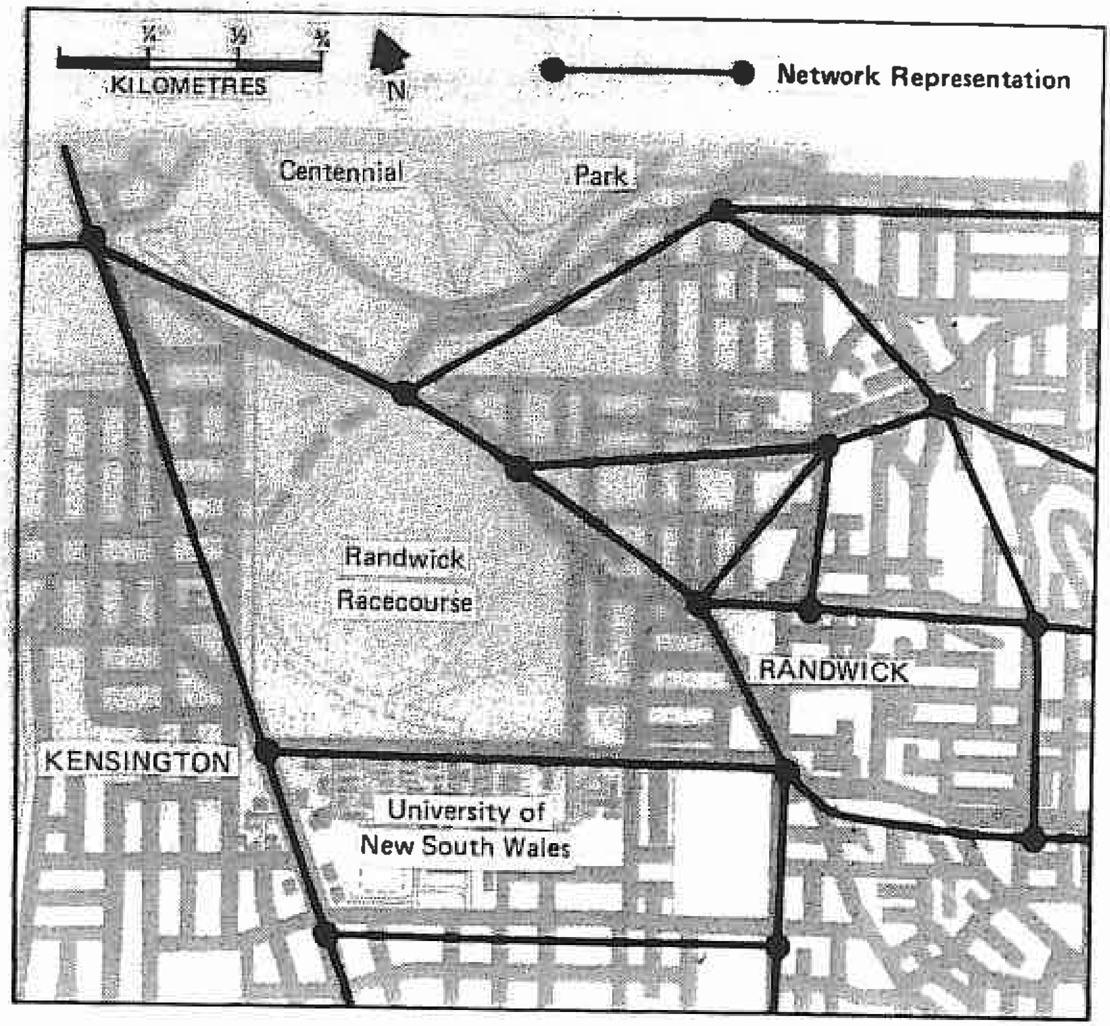

Figure 2.3: Transport Network Representation of Roads in Randwick, Sydney

links and nodes (unlabelled) superimposed. The network is a simplification because only the main traffic thoroughfares are included, and many of the road alignments are straightened. Of course, more streets could be included, although computational costs increase; this is often necessary in transport system management studies (Chapter 8) or in detailed local area planning exercises (Chapter 9).

2.3.2 Link Transport Impedances

The only feasible way of representing the complex operational characteristics of different transport modes is to construct mode-specific networks and to specify the average link travel time or cost as the measure of difficulty of getting along each link. Many of the simple worked examples in this book use link travel times because the concept is straightforward, but current UK practice involves the specification of 'generalised cost' for each link.

'Generalised cost' involves three terms: money (M), travel time (T) and the value of time (v). Expressed in monetary units, 'generalised cost' is:

$$G_c = M + v\,T \tag{2.12}$$

and, expressed in units of 'equivalent' time, is:

$$G_t = T + M\,/\,v \tag{2.13}$$

where

G_c = 'generalised cost' in monetary units; and
G_t = 'generalised time' in 'equivalent' time units.

Advice from the UK Department of Transport is to use 'generalised time' in making traffic forecasts because incomes might change, and to use 'generalised cost' at the transport plan evaluation stage (Goodwin, 1978, Table I, pp. 284-5).

The 'generalised cost' of a public transport journey is:

$$G_c = \phi\,D + v\,T_a + v\,T_w + v\,T_v + \delta \tag{2.14}$$

where

G_c = 'generalised cost' of a journey by public transport;
D = journey distance;
T_a = travel time to get to and from public transport in minutes;
T_w = waiting time in minutes;
T_v = in-vehicle travel time in minutes;
ϕ = fare, per unit of distance;
v = monetary value of time, cents/minute; and
δ = an optional 'penalty' parameter to reflect intangible costs.

Walking and waiting time is usually counted as double, thereby reflecting travellers' perceptions of inconvenient walks or lengthy waits (Jones, 1977, p. 40). As noted by Bonsall (1976), fare structures may be more complex then the simple linear structure in equation (2.14) and suggestions are made for incorporating stepped and complex functions.

Similarly, the 'generalised cost' of a journey by motor car is:

$$G_c = \psi\,D + v\,T_v + C \tag{2.15}$$

where terms are defined above, except for:

G_c = 'generalised cost' of a journey by car;
ψ = vehicle operating costs per unit distance; and
C = costs of parking (or tolls).

Standard values for the parameters in equations (2.14) and (2.15) are recommended unless reliable local data are available (McIntosh and Quarmby, 1970). The monetary value of time is the traveller's hourly wage rate plus any overheads for business travel, although this is challenged (Hensher, 1977a), and 20 per cent of the wage rate for all other journey purposes. The method of estimating the value of travel time is described elsewhere (Beesley, 1973, pp. 151–86; Stopher and Meyburg, 1976, Chapter 4).

For example, consider the following simple calculations of the 'generalised cost' of a bus journey over a route distance of 2 km, at an average running speed of 15 kph. Bus headways are 10 minutes, so the estimated waiting time is 5 minutes, and the actual walking time is 2 minutes at both ends. Out-of-vehicle time 'counts' double. Assume the following parameters: ϕ = 5 cents per km, ν = \$1.20 per hour (2 cents per minute), and δ = 6 cents. Therefore

$$G_c = (5 \times 2) + 2 \times (2 \times 2) + 2 \times (2 \times 5) + (2 \times 8) + 6 = 60 \text{ cents.}$$

The 'generalised time' of this journey in equivalent time units is 30 minutes.

2.3.3 Traffic Flow-dependent Travel Times

Link impedances are influenced by the amount of traffic using the transport facility, as explained in the previous chapter, and the modelling of link transport impedances attempts to include this relationship. Although travel times along the same route are often highly variable, even for similar road traffic flow conditions, modelling assumes an overall average traffic flow-dependent function. Desirable theoretical properties of traffic flow-dependent travel times (or cost) functions are listed by Blunden (1971, pp. 81-2):

(a) the intercept on the travel time axis is clearly defined as the 'zero-flow' travel time (or the reciprocal of the mean of the free speed distribution);
(b) the curve is monotonically increasing, initially at a gentle gradient, at least until saturation flow is imminent; and
(c) the curve becomes asymptotic to the saturation flow ordinate (capacity) under 'steady-state' system conditions.

Many mathematical functions are suitable but the following are the most likely to be encountered in transport studies. The first function fulfils all three theoretical requirements (Davidson, 1966); and was used in section 1.4:

$$T_Q = T_0 \frac{1-(1-\lambda)\, Q/Q_{max}}{1-Q/Q_{max}} \tag{2.16}$$

where

T_Q = travel time at traffic flow Q;
T_0 = 'zero-flow' travel time;
Q = traffic flow, vehicles per hour;
Q_{max} = saturation flow, vehicles per hour; and
λ = level of service parameter.

The level of service parameter is related to the type of road, road widths, the frequency of traffic signals and pedestrian crossings and parked vehicles (Menon *et al.*, 1974). In the absence of authentic data, Blunden (1971, p. 84) suggests λ values of from 0 to 0.2 for motorways, from 0.4 to 0.6 for urban arterials, and from 1 to 1.5 for collector roads. A method for estimating zero-flow travel times, saturation flows and the level of service parameter is described by Taylor (1977). Akcelik (1978), in an attempt to avoid the computational problems associated with infinite travel times when traffic flow equals saturation flow, draws a tangent at the point on the curve which represents 'critical' traffic flow and that part of the tangent connecting the point with the vertical saturation flow ordinate is the modified traffic flow-dependent travel time relationship.

The traffic flow-dependent travel time relationship widely used in US transport studies is the general polynomial function:

$$T_Q = T_0\, \{1 + \alpha(Q\, /\, Q_{max})^{\eta}\} \tag{2.17}$$

where

T_Q = travel time at traffic flow Q;
T_0 = 'zero-flow' travel time;
Q = traffic flow, vehicles per hour;
Q_{max} = 'practical capacity' which is defined as three-quarters of saturation flow; and
α, η = parameters.

This function has been verified empirically for North American driving