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Bus network redesign for inner southeast suburbs of Melbourne, Australia

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Abstract. Public transport is the most effective mode of transport in the era of climate change and oil depletion. It can address climate change issues by reducing urban greenhouse gas emission and oil consumption while at the same time improving mobility. However, many public transport networks are not effective and instead create high operating costs with low frequencies and occupancy. Melbourne is one example of a metropolitan area that faces this problem. Even though the city has well-integrated train and tram networks, Melbourne's bus network still needs to be improved. This study used network planning approach to redesign the bus network in the City of Glen Eira, a Local Government Area (LGA) in the southeastern part of Metropolitan Melbourne. The study area is the area between Gardenvale North and Oakleigh Station, as well as between Caulfield and Patterson Stations. This area needs network improvement mainly because of the meandering bus routes that run within it. This study aims to provide recommendations for improving the performance of bus services by reducing meandering routes, improving transfer point design and implementing coordinated timetables. The recommendations were formulated based on a 'ready-made' concept to increase bus occupancy. This approach can be implemented in other cities with similar problems and characteristics including those in Indonesia.

1. Introduction

Public transport is the most effective mode of transport in the era of climate change and oil depletion. Public transport can address climate change issues by reducing greenhouse gas emission and oil consumption while at the same time improving people's mobility [1]. Public transport is effective because it can carry many passengers with different destinations from anywhere in one trip. Therefore, it is essential that a reliable public transport system or network be developed. Network planning is one example of approaches that enhance the performance of public transport and can be implemented in any urban areas with different densities [2]. In network planning, the design of the network determines how public transport can run effectively. The idea of this 'ready-made' concept is how to produce maximum public transport services by utilizing minimum infrastructure (lines) and resources [2].

Network planning has been implemented in several North American and European cities. It is evident that this kind of multi-destination approach has performed better than the direct route approach [2]. The European Verkerhrsverbund (EVV) is an example of a good implementation of public transport network planning. This model integrates timetables of different transit modes and provides integrated public transport services in every part of the cities especially in the low-density areas where the transit frequency is low [3]. Furthermore, the integration of the grid system of the existing arterial roads

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network and the development of public transport networks has also been implemented in Toronto and Vancouver, Canada [4, 5].

Nonetheless, network planning has not been implemented in Melbourne. Radial routes are the predominant structure of public transport network in the city [2]. Melbourne's bus routes are tailor-made, which may lead to high operating costs and low frequencies [6, 7]. This study aims to formulate a set of recommendations to improve bus networks in Melbourne's inner southeast suburbs. The grid street pattern of many areas of Melbourne enables the adoption of the multi-destination network from the Squareville concept [2]. In the last part of this paper, lessons learned from Melbourne's context is briefly linked to TransJakarta, a BRT system in Indonesian capital city of Jakarta.

2. Literature Review

The Squareville Model. Squareville is a model that illustrates how the network effect works [2]. Fig. 1 shows that grid network (right) can provide more transit services than radial network (left and middle) in the same area. The picture on the left-hand side shows ten bus routes running north to the south. These bus lines provide less than 10% of the total assumed trips assumed generated in this city. The picture in the middle depicts double frequencies implemented on the ten bus lines.

Based on the traditional transport demand modelling, doubling the frequency of a line will create 50% increase in demand. However, the cost of doubling the frequency will increase more than 50%. In that case, doubling the frequency is not efficient to do. The figure on the right-hand side illustrates the network effect that is generated by 20 bus lines running north-south and east-west in the city.

This model can directly serve roughly 20% of the total trips generated, and even 100% of the total trips if people are willing to transfer. The elasticity of demand for this model will be 550%, which is significantly than the traditional one (50%). This model will be able to cater for more than a five-time increase in demand. This model also suggests that transfers are an important part of this concept as it enables the provision of anywhere-to-anywhere trip.

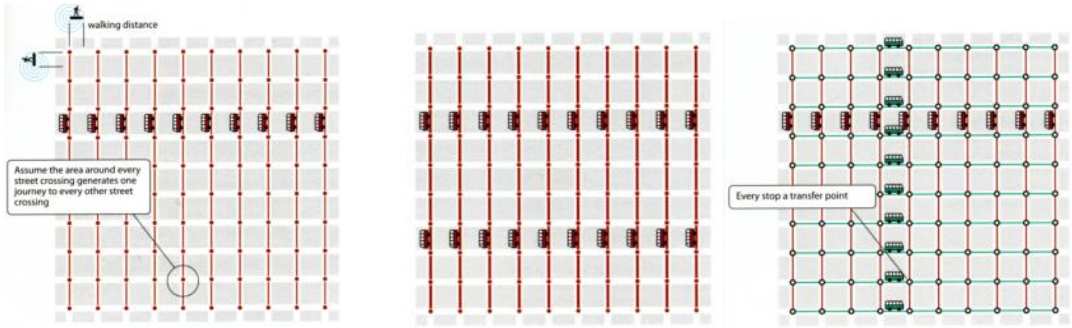


Figure 1. The network effects illustrated by Squareville Model [2]

3. Methods

The study area is located in the City of Glen Eira, an LGA in the inner southeast part of Metropolitan Melbourne, between Gardenvale North and Oakleigh Station, and between Caulfield and Patterson Stations. This area needs network improvement mainly because of the meandering bus routes that run within it (625, 626, 701 and 822). In terms of land use, residential area is predominant in this study area.

The analysis consists of two parts. The first one is the description of existing service supply and the second one is the quantification of service supply within the study area. The first part discusses key trip generators, meandering routes and statistics of bus patronage. This analysis utilises the online database from Public Transport Victoria (PTV) website. The second part is the calculation of the existing service kilometer. This combines the data of route lengths from the Glen Eira local area map and service frequency from the service timetables. The service kilometre was calculated by multiplying the routes length within the study area and the number of services of buses, trams and trains in either directions on the entire week including the weekdays (Monday-Friday) and weekends (Saturday-Sunday).

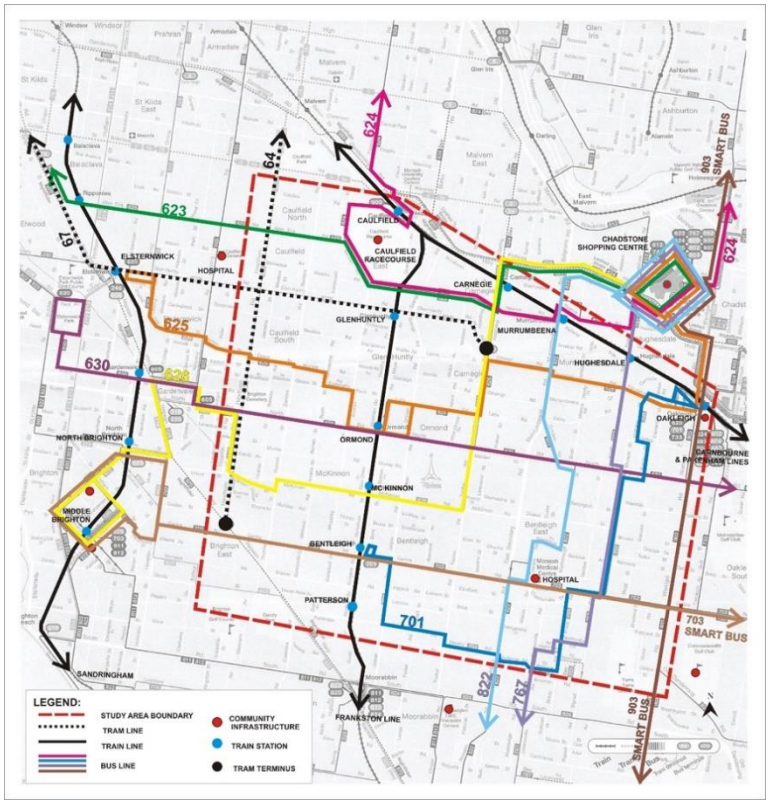


Figure 2. Trip Generators and Existing Public Transport Network.

4. Results

4.1 Description of the Existing Service Supply

The main external trip generator in the study area is the Chadstone Shopping Centre. The majority of bus services in the area is aimed to connect the residential areas with the shopping centre. Another important trip generator outside the study area consists of parks, hospitals, educational institutions and other smaller shopping centres in Middle Brighton and Oakleigh. Inside the study area, train stations and tram terminus points are the major trips generators. Some of these stations have activity centres and retail strips that are also trip generators.

Meandering bus routes and long waiting times are the main issues. There are four meandering bus routes run within the study area, routes 625, 626, 701 and 822. These kinds of tailor-made routes are not effective in terms of operational effectiveness and not attractive for passengers because they do not accommodate directness of travel and high-speed operating time [8]. Moreover, problems of ineffectivity also come from several areas where bus routes are overlapping, as depicted in the map below (Fig. 3).

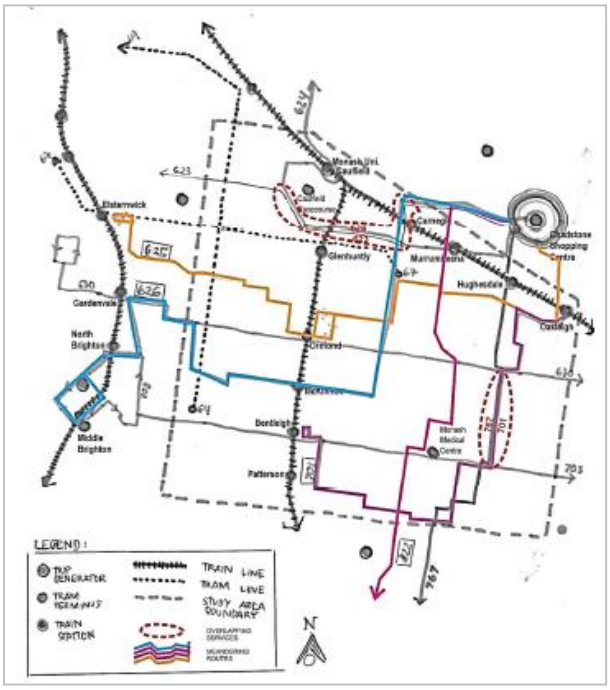


Figure 3. Meandering Bus Routes and Overlapping Services

Furthermore, the long waiting time and transfer time are also a critical problem. Based on the timetable of bus lines running in this study area, the average frequencies are mostly 20 to 30 minutes from Monday to Friday. Only the Smart Bus Route 903 has 10-15-minute frequencies. According to Mees [9], public transport services must have a minimum of 10-minute frequency during weekdays, especially during peak hours. The timetable of existing bus services shows that the frequencies are much reduced on weekends. Buses mostly run every 30 minutes to 1 hour. Meanwhile, even during low demand period, the frequency should be no more than 30 minutes [4, 9].

Lastly, the bus patronage growth data showed an increase in most of the bus routes operating in the study area. Only two routes, 630 and 822, had significant decreases in patronage on both weekdays and weekends. Furthermore, while Route 701 increased significantly by about 20% in terms of annual and average weekday patronage, its patronage in the weekend decreased slightly. Additionally, the patronage of Smart Bus routes, 703 and 903, grew slightly by no more than 10%, and decreased slightly in terms of average weekend use. This data depicts the need of public transport network improvement in fostering the patronage growth as well as addressing the patronage decrease in some bus routes.

Table 1. Bus Patronage Growth 2010 – 2012 (PTV, 2015)

Bus Lines	Patronage Growth (%)			
	Annual	Average Weekday	Average Saturday	Average Sunday
623	22.1	15.0	19.1	4.3
624	15.8	8.6	1.5	15.4
625	N/A	56.3	25.2	32.0
626	N/A	48.7	37.1	50.6
630	-13.1	-19.2	-12.6	-15.9
701	28.0	22.5	-4.6	-8.5
703	6.2	0	-6.9	-9.0
767	18.0	11.6	0.1	2.4
822	-1.6	-6.2	-20.0	-24.3
903	9.6	3.8	-3.0	-4.4

4.2 Quantification of existing public transport service kilometre.

The calculation of the existing service provision is based on the service kilometer in a week (Monday to Friday, Saturday and Sunday). The focus of this calculation is the service kilometer of the bus service. The proposed bus network discussed in the next section should not exceed the existing service kilometer to ensure the minimum cost. The service kilometer of the existing bus service in the study area is roughly 25,663 service kilometers (s km) per week, 4,355 s km per day on weekdays, 2,109 s km on Saturdays and 1,776 s km on Sundays.

4.3 Recommendation.

This study proposes a new public transport network that is integrated and effective in Melbourne's Inner Southeast. This aim can be broken down into two main objectives, i.e. to implement network effect concepts and to create coordinated timetables and services as frequent as needed. These objectives intend to address the main issues mentioned in community consultation.

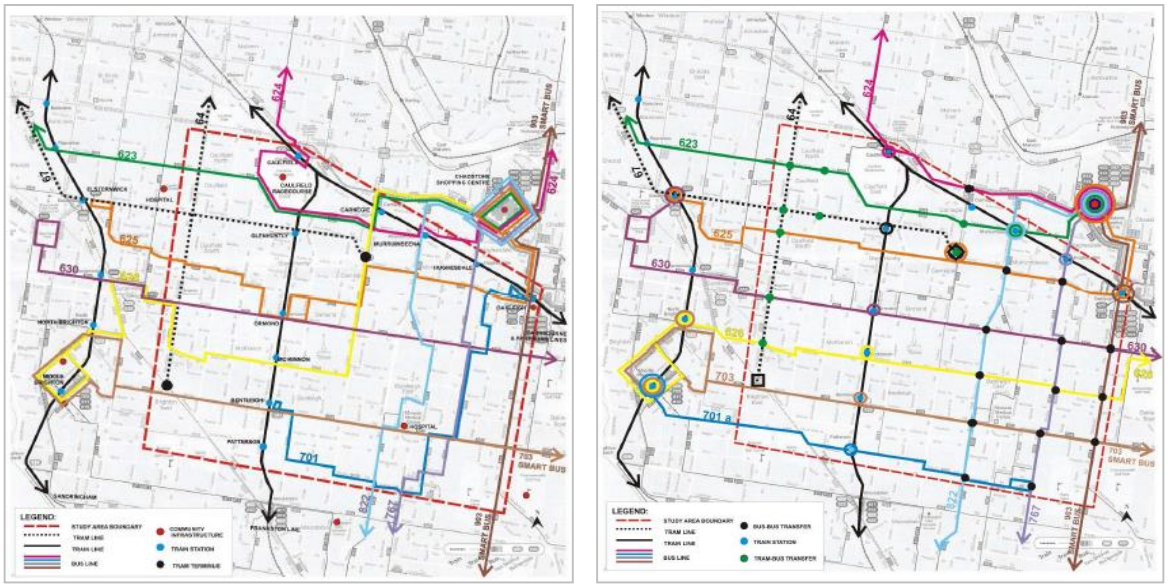


Figure 4. Existing Public Transport Network (left) and Proposed New Bus Lines and Transfer Points (right)

The meandering routes can be replaced by a more effective network so that network effect can be created. The proposed bus network is formed according to the existing arterial road network within the study area (Fig. 4). One siginificant change is to cut Route 701 into 701 A by removing the route duplication with Route 767. This grid network will provide faster journeys and create more transfer points. For example, the length of the new bus route 625 is 1.42 km less than the existing one as it removes the meandering routes around Ormond station. Therefore, passengers from Chadstone Shopping Centre who wish to travel to Elsternwick Station will only spend roughly two minutes (if the bus runs 40 km/hour) in the new bus network. Moreover, people living in the southern part of Glen Huntly Station such as around Oakleigh Road and Mara Road, which originally have no bus services can also benefit from this new 625 route.

As mentioned in the previous section, the existing bus service kilometer is 25,663 service kilometers per week. The proposed new bus network generates roughly similar (25,569) service kilometer as the existing one, with additional frequencies for particular routes. The proposed grid network generates a service kilometer gap and this proposal uses this gap to increase the service

frequency for route 624, 626 and the new route, 701A. This will support the objective of this proposal, which is to reduce the waiting time or transfer time for buses.

In addition, integrating rail-bus and bus-bus transfer time can address the long waiting time issue. The tram and train services in this study area are relatively frequent especially during weekdays and peak hours. However, their connections with bus services, especially from rail to bus, need to be improved. These different modes can be integrated effectively by creating time-transfer to connect [3]. Fig. 5 shows the proposed time-transfer to better connect bus and train services.

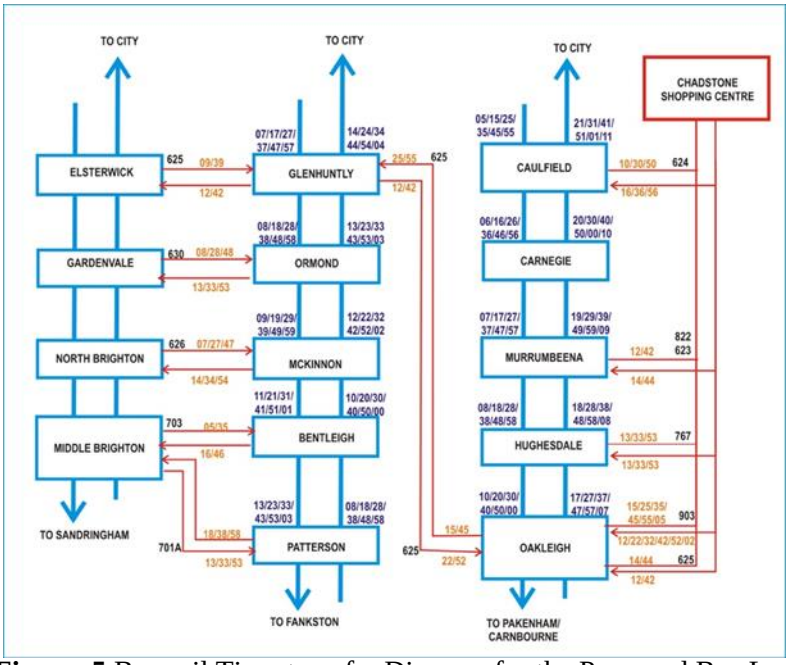


Figure. 5 Bus-rail Time-transfer Diagram for the Proposed Bus Lanes

Instead of increasing the service kilometer of all frequencies that will increase the cost, it will be better to use the existing resources without creating additional cost. As mentioned in the Squareville model, if people are willing to transfer, the grid network will generate a significant increase in bus patronage. In theory, people are willing to transfer if they do not need to wait too long to transfer. Therefore, integrated timetables and time-transfer are important to minimize the transfer time [2]. Good timetabling and integration among different modes of transport contributes in the increase of public transport patronage [2, 3, 6, 9].



Figure. 6 Examples of Convenient Transfer Point within a Transit Stop Highlighting The Minimum Walking Distance and Clock-face Scheduling for Transferring to Other Public Transport Modes [10] [11]

The improvement of transit stop design can also support the transfer between rail-bus and bus-bus services. Coordinated timetables together with a convenient station design that accommodate short walking distance for transfer and provide different kind of amenities will create interesting transit trips environment for the passengers [8]. Public Transport in Zurich has some good examples of a good station design. Fig. 6 shows that the schedules of these different public transport modes are integrated. Cable car, bus, tram and train come at the similar time, and they stop closely to each other. The design of the transfer points in the transit stops is ultimately critical in supporting the proposed integrated and clock-face departure timetables.

Fundamentally, these aspects are included in the operational principles of network planning. It consists of integration of different modes, simple line structure, accommodation of direct and multi-destination routes, and timetabling management [2, 8]. Brown and Thompson [14] suggest that integration between train and bus services improved transit performance in the US. The objectives can be measured according to several indicators such as a rail-bus coordinated timetables and a minimum of 10 minutes time transfer [9]. Grid network is therefore highly recommended for developing a more effective network, as it reduces meandering routes, increases operating speed and achieves maximum operating efficiency [8, p. 186].

4.4 Transjakarta Bus Rapid Transit (BRT) System

The BRT system known as Transjakarta is operated by an agency of the Government of Jakarta with the same name, although the infrastructure and buses are procured by its Transportation Department. Jakarta's 12-corridor, 200 km-long Bus Rapid Transit (BRT) system was initiated by the Governor of Jakarta in 2003, to improve travel for Jakarta's then 8.3 million citizens representing 40% of the metropolitan population. BRT corridor 1, the first in South East Asia, was completed from the commercial hub of Blok M in the southern part of the central city to Kota, the northern area of the city in January 2004. Corridors 2 and 3 opened in January 2006 [13].

4.4.1 Patronage Trends.

Trends in daily patronage from 2004 to 2014 are shown in Fig. 6, along with cumulative BRT length and an index measuring real fares (that have remained at 3,500 rupiahs in nominal terms to date). When the project was finalized in 2012, the BRT system was 180 km in length with the patronage of 370,000 pax/day (2,060 pax/km). As a comparison, in 2006, the patronage was 105,000 pax/day (or 2,500 pax/km) in 2006 [14]. During the project, patronage had increased by 240% although productivity measured in terms of pax/km declined by 18%.

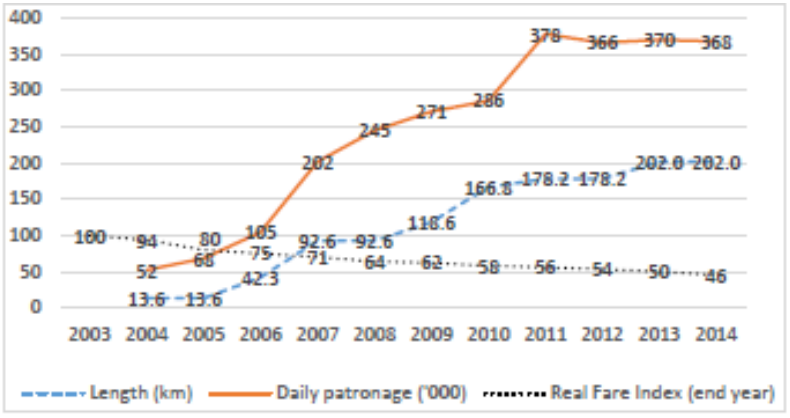


Figure. 7 Trends in patronage, BRT length and real fares 2003-2014 [13]

The actual increase in patronage from 2006 to 2012 was less than half of the planned increase of 600,000 pax/day. By 2012, stagnate declining in patronage growth was revealed to be 3%, then stabilising over 2013 to 2014 due to poor performance, despite the halving of real value of fares from 2004 to 2013 and the addition of a new corridor in 2013.

4.4.2 Passenger Perception

At the close of the project, Transjakarta held a survey to learn passenger perception toward the BRT operational aspects. The survey found that passengers rated the following attributes of BRT as 'generally poor': drivers (poor); officers (very poor); infrastructure (very poor); buses (very poor); operations (good); and ticketing (poor). The UNEP-GEF post-evaluation team's surveys undertaken in January 2014 found that a key attribute that BRT passengers preferred as a whole about the service was its low fare. However, 48% considered waiting times to be 'very long' or 'long' indicating problems with BRT service regularity and reliability. Twenty nine percent of BRT users rated the service as 'fast', 57% rated the service as of 'moderate' speed, and 14% rated it 'slow'. Overall, 43% of users said they were 'satisfied' with the service, 39% said it was 'adequate' and 17% said they were 'dissatisfied' [11, pp. 85-89]. The passenger's overall perception of 'generally poor' to the BRT services they receive underlines the significant challenges facing Transjakarta in its future efforts to improve its performance and increase patronage.

4.4.3 Improvement Recommendation Plan Based on the Melbourne Case.

Given the array of problems currently facing Transjakarta, optimisation of existing corridors, particularly by assessing life-cycle costs and travel time impacts by patronage market segment should be considered. Globally, fares cannot be defined on nodes of future busways because of the free transfer system. Fares should be included on access links of the system and/or transfer links on the actual network, defining a specific mode with a time equivalence of fare that can vary automatically changing attributes in macros. In order to improve the quality of Transjakarta service delivery, it is recommended that further improvement on existing BRT, or other rapid transit projects, focus on collecting travel data on rapid transit users and their households shortly after a project opens; distinguish drivers and passengers when considering shifts from private modes; and identify their household vehicle availability..

5. Conclusions

The meandering routes and uncoordinated timetables are the main public transport issues in Melbourne's Inner Southeastern Suburbs. This study addresses these issues by formulating a set of recommendations, such as implementing coordinated timetables, establishing a good public transport network and improving transit stop design. These recommendations are based on utilizing the existing resources (service kilometer) to gain more benefit with no extra cost. The methodology used in this study can be used for further studies in formulating strategic plans for improving public transport network in other cities including Jakarta, Indonesia.

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