Identifying the Arrangement of Activities of Corridor Spaces in Transit Station

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Abstract

Public transit passengers use corridor spaces in transit stations to access transit services. These transit stations are designed for multi-modal transportation purposes, as space which connects each mode of transit between stations or planned areas plays an important role in the movement of passengers from one mode to another. The characteristics of corridor space vary according to the surrounding activities which shape their diverse functions and the time taken by passengers to connect between transit modes. An exploratory analysis was conducted to determine the basic properties and functions of corridor spaces in Hakata station, Fukuoka Prefecture, Japan with regard to the availability of transit services and activities in station building area. Commercial and facilities activities were selected to identify the characteristics of corridor spaces. A spatial analysis of activities located along the corridor spaces and architectural performance was also conducted using the betweenness analysis in order to identify the interaction between subjected activities and archtecture space in station building. Each type also contained specific functions which defined its spatial performance regarding transit mode connection behavior. Results suggested that the arrangement of activities in corridor spaces influenced passenger route-choice accessibility.

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1. Introduction

Transit-oriented development (TOD) encourages pedestrians to use public transport systems in their daily lives (Singh, Lukman, Flacke, Zuidgeest & Maarseveen, 2017, pp. 96-111). TOD promotes urban development along transit stations (Papa, Pagliara & Bertolini, 2008; Papa & Bertolini, 2015, pp. 70-83) as accessibility is the primary factor that attracts people to use public transit planning systems (Dial & Bunyan, 1968, pp. 345-362). Urban planning principles based on TOD were introduced in the late 1980's (Carlton, 2007) to encourage urban development along transit services. This increased public convenience for using transit systems, with greater accessibility between transit modes and their destinations and reduced energy consumption. Land use planning requires urban activities management and the transportation system plays a big role in TOD development (Morimoto, 2015; Banister & Thurstain-Goodwin, 2011, pp. 212-223).

Japan passed a draft of the Transportation Accessibility Improvement Law in 2000 (Akiyama, Kamata, Wahira & Fujii, 2001, 42-50). This law covered all types of public transportation which comprise the majority of Japanese transit systems (Thomas, 2016). Fukuoka Prefecture was selected as a case study for Japanese TOD development due to its large size, high population, and the availability of transit services (Zhuang & Zhao, 2014, 199-212). Fukuoka Prefecture is the largest city in Kyushu Region with main hubs of public transportation including a port connecting with neighboring countries and an International Airport. Kido (2015) noted that "a railway station conceived as a 'station-city' has many facilities like a city, both above the ground and underground, and other urban functions accommodated in a large station complex with station squares on both sides".

Significant factors that assist station users to access transit modes through the TOD environment can be assessed by observing TOD development in terms of architecture and built environmental design (Ching, 2007; Rodriguez & Joo, 2004, pp. 151-173). One significant issue involves the corridor spaces connecting the modes of public transit (Glick, 2009) which create continuity of accessibility and encourage walkability and other characteristics of the spaces nearby. These particular spaces contain several activities which occupying the transit corridors (Ratner & Goetz, 2013, pp. 31-46). The property and function of the transit corridor have a direct impact on user accessibility (Venter, 2016). Time taken to move between transit station areas as a connecting function of corridor space significantly affects footfall numbers, while corridor space also offers passengers an extensive array of other pursuits during the course of travel such as restaurants, cafés, shopping malls, banking or other business facilities. These activities play a big role in the TOD planning and development concept which encourages a compact city design by digesting space for particular activities into smaller sizes, and then recreates this in the same area or building to reduce travel time from one activity to another.

This study aimed to identify the properties and functions of corridor spaces in the major transit station of Fukuoka Prefecture, and interpret the transit mode connection behavior according to the design space and activities. Transit station planning and design guidelines, especially in terms of the components of activities expressed through the architectural structure were also investigated. Results will contribute a better understanding of the role of corridor space in TOD environments and the relationship with surrounding built environments.

2. Research design

The study conducted in Hakata station building located in Fukuoka city, in southern part of Japan. The Hakata station is the major transportation hub in Kyushu region which connects to other parts of Japan and also connected to Hakata port and Fukuoka airport where connecting to neighbor countries such as China and the republic of Korea.

Hakata station was considered as an urban place due to the various activities that were provided in the station building such as shopping malls (Hankyu Department Store, Amu Plaza mall, Tokyu Hands department store and the Kitte mall), several dining restaurants and café for supporting the passengers.

For non-commercial service facilities, Hakata station has provided the facilities that assist the travel trips such as ticket machine, coin locker, information center, police station, lost and found office as well as the open space for recreation activities.

Figure 1 illustrated Hakata station area where the investigation of this study was selected due to the transit modes available by hosting all scales of railway transport facilities as inter-region, inter-city, and inner city connection. The station building itself connected wide-ranging railway service which is operated by JR Kyushu company and the Fukuoka city subway service which is

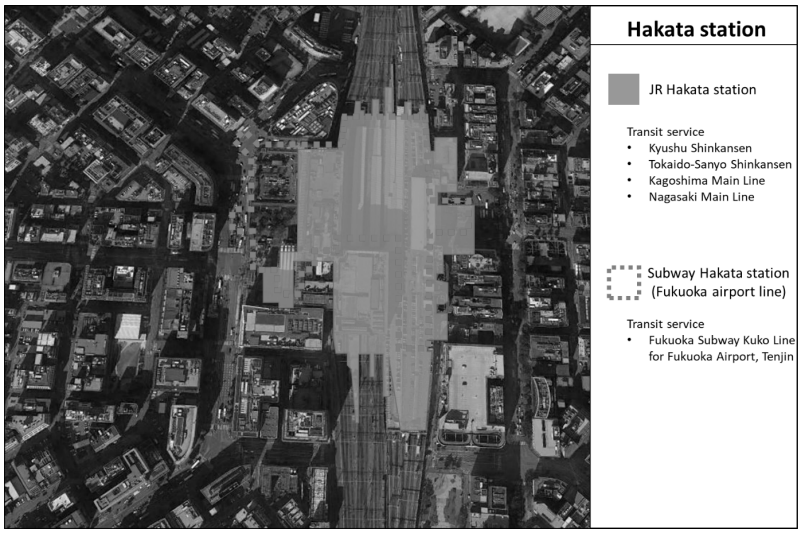

Figure 1. Hakata station area

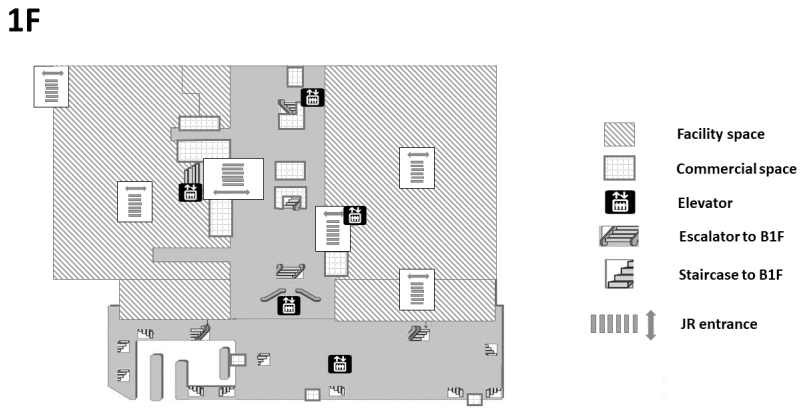

Figure 2. 1F floor plan of Hakata station

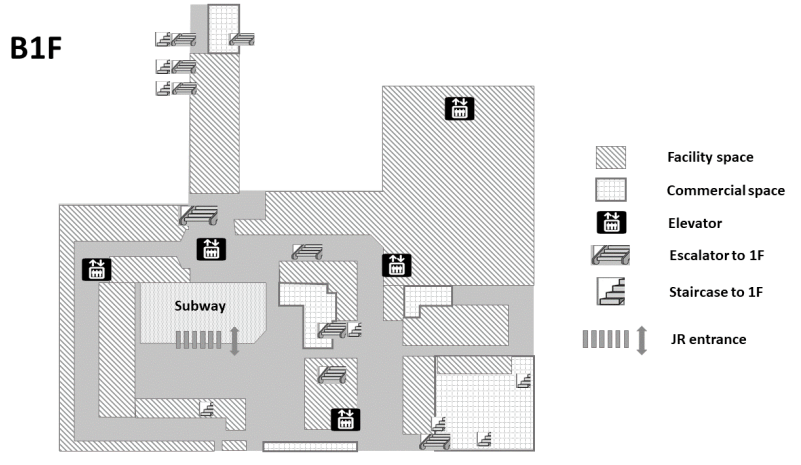

Figure 3. B1F floor plan of Hakata station

operated by Nishitetsu company. These railway services are connected between first floor (1F) of station and underground floor at B1F floor which illustrated in Figure 2 and Figure 3 respectively.

The study focused on the connection of two railway systems which interchanging in the same building as inter-city train line and subway. The accessibility among each railway's platforms are accessible within 200 meters walking radius through commercial corridor and facility corridor. The aim of this study was to identify the performance of architecture structure in TOD environment that interacted with surrounding activities. The methodology was developed to in order to measure the performance of architecture space which focused at corridor space that connects between transit nodes in the same station area.

2.1 Overview of data

Based on data collection, corridor spaces were identified as four types. An 'area connection corridor' is a walkway connecting two or more functions. This interprets the connection between transit modes to other areas in the transit station or between each transit mode. Some stations connect circulation between station buildings and other buildings by bridges as main access routes. A 'commercial corridor' is a space surrounded by commercial activities, managed to support and attract passengers, and also to make the station a focal point of communities. Some stations copy shopping malls by offering interesting and useful retail outlets as convenience stores, cafés, restaurants, souvenir shops and also Bank/ATM facilities. The connection activities can be varied depending on their functions. A 'facility corridor' is the primary function of a transit station as the provider of facilities that transit patrons can access. Station designs should naturally lead passengers past a facilities corridor in a logical order and circulation should be obvious and direct, requiring minimal walking distances.

Facilities functions should also be easy to find. A 'residential corridor' is corridor space where the circulation is between two or more transit modes. For example, some rail stations are connected with bus stops outside the station building as convenient facilities between two transit modes inside the residential area (Table 1).

Transit modes available and the ratio of space usage in station areas are shown in Table 2. Transit services at all stations provided basic transportation system facilities such as buses and railways. Some selected stations were based on similar scales in terms of size and spatial configuration; however, ratios of space usage per activity were different. Commercial activity in Hakata Station offered the highest use of space at 72% followed by transit facilities at 23% and other services occupying only 5%.

2.1.1 Commercial corridor

Commercial corridor is the area along the circulation which primarily composed of commercial activities. Hakata station has the highest percentage of commercial space used among Fukuoka prefecture main rail stations. There several types of commercial activities that being occupy in Hakata station. Table 3. identified the use of commercial activities which found in Hakata station area. The commercial activities classified into five types such as clothes & accessories, souvenir,café & restaurant, Convenience store & Drug store, and Financial activities, e.g. Bank or ATM.

2.1.2 Facility corridor

Facility corridor in provided necessary amenities for a particular purpose which support passengers during their trip. According to the site survey, Hakata station were located in the main circulation areas and provided three activities that support passenger's trip other than commercial activities such as Ticketing facility, Coin storage and Toilets which classify the detail in Table 4.

Table 1. Transit-oriented development corridor space typology

Corridor Type	Type of activity	Space Type		Circulation type	Connection mode
		Inside	Outside		
Area connection Corridor	Closed space	√	X	N	P-P
	Open space	√	√	N	P-P
	Bridge			N	P-P
Commercial Corridor	Café/ Souvenir	√	√	W	P-P
	Restaurant	√	√	W	P-P
	Convenience store/ Drug store	√	√	W	P-P
	Clothes/ Accessories	√	√	W	P-P
	Financial (bank/ATM)	√	X	W	P-P
Facility Corridor	Safety facility	√	√	W	
	Ticketing	√	X	W	P-P
	Storage (coin locker)	√	X	W	P-P
	Toilets	√	√	W	P-P
	Parking	√	√	W	
Residential Corridor	Detached House	X	√	N//A	N//A
	Apartment/ Mansion/ Unit dwelling	X	√	N//A	N//A

N = non-motorize
W = walkway
P-P = pedestrian-pedestrian
N/A = Not found in subjected areas

Table 2. Transit modes available and space usage

Listed Station Area	Transit Modes							Ratio of Space Use in Station (Percentage)		
	Bus Service		Railway Service							
	Bus Center (Inter-city)	Urban Bus	Subway (S) / Monorail (M)	Local Train	Rapid Train	Express Train	Bullet Train	Commercial	Transit facilities	Other Services
Hakata Station	√	√	S	√	√	√	√	72%	23%	5%
Nishitetsu Fukuoka Station (Tenjin)	√	√	S	√	√	X	X	53%	31%	16%
Kokura Station	√	√	M	√	√	√	√	34%	40%	26%

**Spaces count only public space in station area and excluded department stores and hotels*
√ = Available
X = Unavailable

Table 3. Commercial activities in Hakata station

Corridor space	Type of activity	Number of activity	Explanation
	Clothes & Accessories	93	The space in this corridor is located in sub-circulation and does not obstruct movement of the main circulation. Space design is adequate and passengers can spend time in the corridor area while not interfering with the main circulation during rush hour. Activities include shopping for clothes and accessories.
	Souvenir	157	This corridor is designed as a big space and located near the main circulation. It is easy to find and access, and does not interfere with main circulation. The space is acceptable for a commercial area with souvenir shops
	Café & Restaurant	127	Medium-small spaces in sub-circulation are usually designed as restaurant functions with activity time longer than in other areas. Space in the corridor provides seating and cooking areas. Restaurants are always located in the same zone with good ventilation systems.
	Convenience store & Drug store	40	Convenient stores are usually situated near areas of main circulation with easy passenger access. Activities in convenience store areas take little time. Space design of this corridor allows passengers convenient access to the shops. In larger stations, convenience stores may be located in sub-circulation areas so as not to interfere with the main circulation during rush hours.
	Financial (e.g. Bank, ATM)	22	Unoccupied secure spaces are mostly used for the ATM area. This space is not located in the main circulation. Activities in this corridor need more security than others. The ATM corridor is designed to make the passengers feel safe and secure.

Table 4. Facility corridor in Hakata station

Corridor	Type of activity	Number of activity	Explanation
	Ticketing	15	A large space in the station building is usually designed as the ticketing area to accommodate large numbers of passengers. This is a main corridor and circulation designs naturally lead passengers here. It is often located near the station gate.
	Storage	9	Most storage corridors are located in the main circulation area or connection corridors. They should not obstruct the main circulation. Passengers using this activity can access from main walkways.
	Toilet	6	Toilet facilities are often connected to main circulation routes for easy access.

2.2 Spatial analysis methods

For Hakata station, as a case study in this area, architectural spaces and activities along the corridor were examined to identify the relationship between functions and location priority of corridor space in TOD in order to interpret the connection behaviors of the transit modes according to research framework which illustrated in Figure 4.

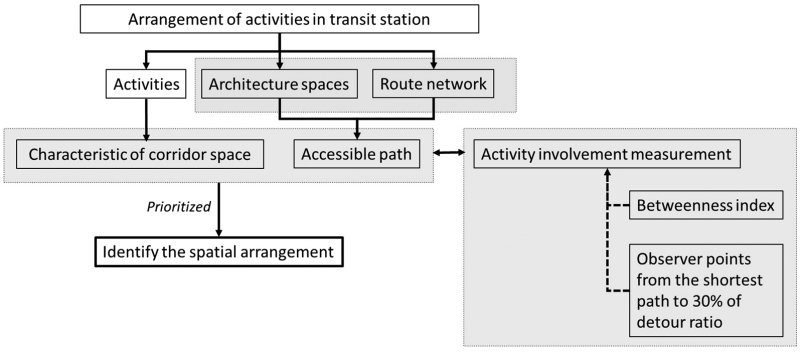

Figure 4. Research framework

In order to measure the corridor space performance in Hakata station, the study operated common path finding by using the Betweenness index in Urban Network Analysis (UNA) toolbox which runs on the Rhinoceros 3D software (Sevtsuk & Kalvo, 2015). Betweenness index is particularly used to simulate the spatial relationship between the street network and surrounding architectures which represents the trajectory that trips might occur according to subjected network.

By calculating the shortest path between origins and destinations within assigned network and distance that needed to calculate. The normalization of betweenness index has defines as an Eq. (1).

$$Betweenness[i]^r = \sum_{j,k \in G-(i), d[j,k] \leq r} \frac{n_{jk}(i)}{n_{jk}} \cdot W_{[j]} \qquad \text{(Eq. 1)}$$

Where;

i = network
j = origin location
k = destination location
r = search radius
n_{jk} = the number of shortest paths between origin (j) and destination (k)
$W_{[j]}$ = the weight of destination j

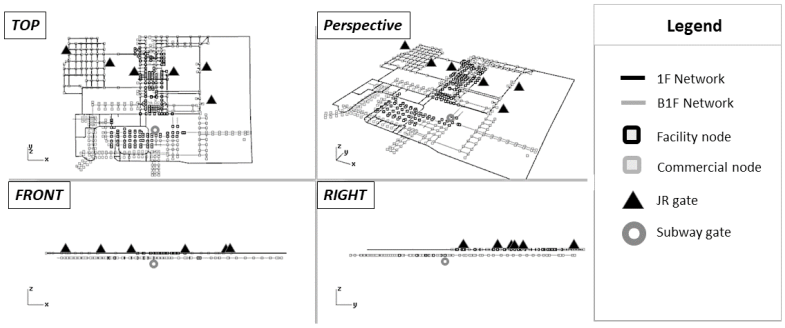

Figure 5. Location of facility and commercial nodes which interpreted as an observer points in first floor (1F) and underground floor (B1F) of Hakata station

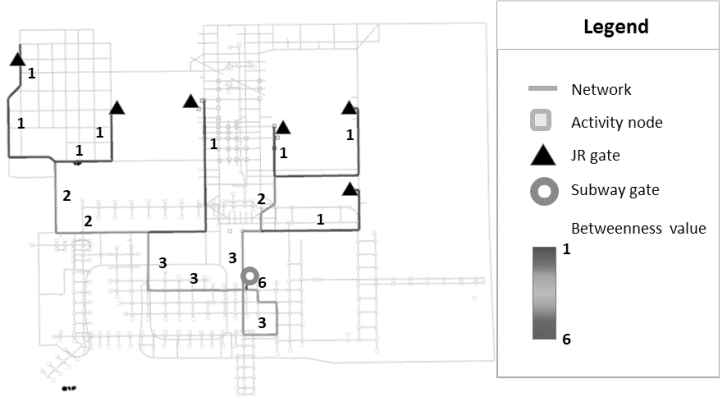

Figure 6. The nearest connection route between every JR gates (1F floor) to subway entrance (B1F floor) of Hakata station

The study has counted the number of activities which located surrounding the nearest connection route between JR gates and subway entrance by represented in observer point function in UNA tool. The observer points are counted the number of trip that pass by the observer point.
Then the study used observer points to represented each activity's location that located in study area which illustrated in Figure 5 in order to interpret that how activities along the corridor area are impact to the potential connection route.

Moreover, the detour ratio variable is subjected to be analyzed in this study due to the interpretation of alternative route analysis on pedestrian accessibility.
The study area that has been investigated covered 30% of detour ratio from the shortest paths of transit modes connection paths, however according to pedestrian behavior that usually take deviate around 10-20% above the shortest route (Sevtsuk & Kalvo, 2015). The investigation did not limit the search radius to rule out the addition time spent on access that might occur from other factors and to concentrate on the distance factor via the nearest route, and percentage of detour ratio which already included the limitation of time of accessibility.

3. Analysis results

Corridor space characteristics are investigated for identifying the relationship between activity arrangements and effective transit modes connecting route in Hakata station building. The circulation of connection route surrounded by two corridor space characteristics as commercial corridor and facility corridor. These characteristics are the major use in Hakata station.

Figure 6 illustrated the spatial circulation that was interpreted by analyzing the most common connection route between all ticket gates of railway service (JR train company) and subway ticket gate (track entrance) by the betweenness index's value shows the number of trip that possibly occur in the shortest distance among nodes.

This study assign detour ratio up to 30% from the nearest route that JR gates could access subway entrance. As a result, facility corridor and commercial corridor were interacted to transit connection path differently which referred to the priority of space and activity arrangement in Hakata station area.

Figure 7. interpreted the percentage that commercial and facility activities are involved along the main connecting route by facility activities involved 12.96% along the nearest connecting route and expanded to 26.97%, 27.11% and 27.5% when assigned detour ratio at 10%, 20%, and 30% respectively.

Although commercial activities have also expanded when assigned a higher detour ratio rate but commercial activities involved the main connection route in lower level as 5.56% and continue to increase when considered with the detour by indicated the involvement as 8.43%, 10.21% and 12.1% when assigned detour ratio at 10%, 20%, and 30% respectively.

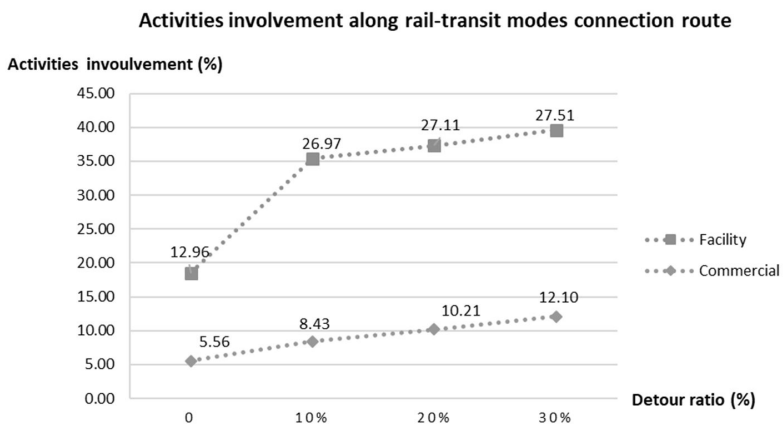

Figure 7. Activities involvement along within 30% detour of the nearest connection route from every JR gates (1F floor) to subway entrance (B1F floor) of Hakata station

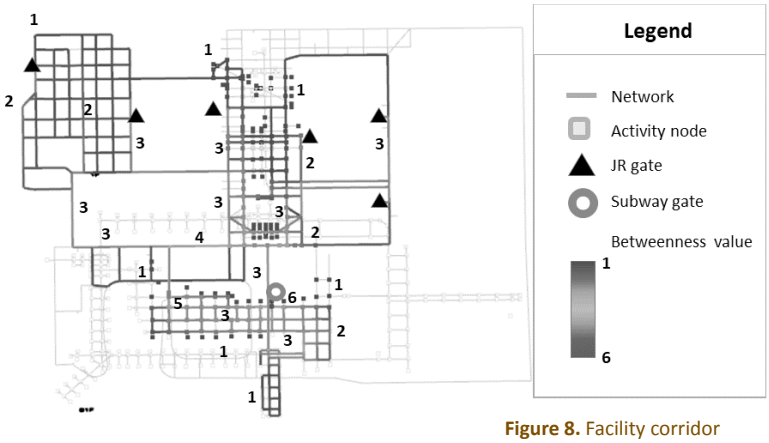

Figure 8. Facility corridor simulation map at 30% detour ratio from the nearest connection route

4.1 Facility corridor

The facility corridor performed the interaction with rail transits major connection paths strongly by illustrating the betweenness index value of facility corridor that indicated the major connection route within 30% of detour between every JR ticket gates to subway gate through the value of trajectory paths that passed by non-commercial facilities in Hakata station area.

Figure 8. illustrated the facility corridor involvement in major connection route which has increased follows the percentage of detour ratios that have been assigned in simulation process.

The facility corridor performed as a main circulation in station building by having 6.25% of such facilities located along the nearest route between JR gates and subway entrance and then continue to rise up to 8.94% at 30% of detour assignment.

4.2 Commercial corridor

The commercial corridor has performed as a sub-circulation in Hakata station by indicated the fewer number of commercial activity involvement to detour ratio from the nearest connection route between JR gate and subway entrance.

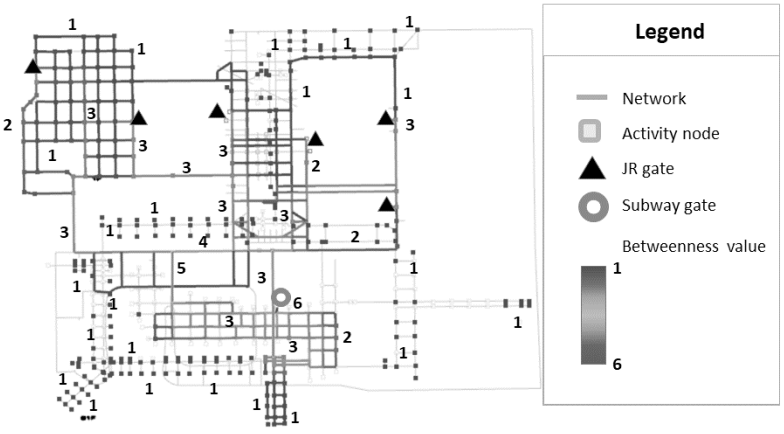

Figure 9. Commercial corridor simulation map at 30% detour ratio from the nearest connection route

Figure 9 illustrated the analyzed map of commercial activity corridor involvement in 30% of detour ratio from the main access route. The main commercial corridor which interpreted by the highest density of commercial activity (counted by the number of activity per area) located in B1F floor of Hakata station had involved in the major connection path in significantly low level.

4. Conclusions

The performance of corridor spaces in Hakata station areas identified the connection characteristics among spaces in transit stations through activities along the corridors. Involvement of corridor spaces can integrate transit mode accessibility development solutions toward better connectivity of space usage in station areas which assist passengers during their trip. Conforming to the achievement of spatial planning of transport facility will encourage potential transit mode connection with high-level accessibility integration. The arrangement of activities in corridor spaces is significantly related to the priority of uninterrupted circulation. Major route connection was considered as high circulation areas for accessing particular modes of transport. As a result, these activities arrangement were prioritized for flowing the passengers based on their purposes of traveling and limitation of time. Results illustrated that transit facilities such as coin storage and toilets also involved main passenger circulation. A clear zoning of activities was clustered into the commercial corridor. Commercial areas such as cafés and restaurants were not designed in main access circulation zones to transit modes. Commercial spaces occupied the largest areas of station space with minor effects on transit station activities. Results suggest the importance of understanding the spatial dynamics between trip purpose and spatial structure to integrate architectural spaces, accessibility routes and the necessary activities to develop optimal connectivity in station building.

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