Night Bus: Route Design Using Big Data

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1. Period of Policy Enforcement

The night bus, or so-called 'Owl Bus', was first enforced in 2013. It provides bus services at night time, as needed by the citizens, at affordable prices by designing routes using big data. Already having an interest in the use of big data, Seoul city analyzed data obtained by the Dasan Call Center, which demonstrated that citizens had considerable interest in the traffic field. Furthermore, communication with citizens via the internet displayed that there was a demand for public transportation that could be safely used at night time when bus services normally end. These led to the initiation of this policy.

Two demonstrative routes were operated from April to July of 2013, and from September 12, 2013, the system was expanded to 9 routes.

2. Background Information

1) Night Bus

Economic activities in Seoul are carried out 24 hours a day, in reality. Countries that display a considerable amount of traffic at night time mostly rely on taxis. However, these are not a sufficient alternative due to a lack of supply compared to excessive demand, poor service (rejection of passengers), safety problems, and high costs during peak night hours. Some of the citizens that participate in night economic activities are service consumers, including restaurants and entertainments, and while others include low income workers, businessmen and company workers, as well as students. Thus, a lack of public transportation at night time signifies the restriction of economic activities at night.

[1] Translation by ESL®

In certain night service corporations, such as ‘clubs’ in large cities of England, leased buses are individually operated to provide transportation to the citizens who reside in adjacent suburbs or small cities. Seoul city is reputed as a ‘city that is not outdone’ by these European cities in terms of its active night economic activities, including entertainment and pleasure services. Thus, although the chauffeur service is broadly used and somewhat established based on a firm demand without depending only on taxis, taxis or chauffeurs are not reasonable means to the young class and those of a low income, and thus, the selection of night transportation means is insufficient.

The citizens expressed this inconvenience through an electronic governmental communication channel, and the city assessed the introduction of night buses.

Meanwhile, since Seoul city was interested in using big data in administration, the intention of the application of big data in the transportation field was a reflection of the citizens’ interest. Upon analyzing 600 thousand cases at the ‘120 Dasan Call Center’, one of the Seoul citizens’ complaint channels, it was displayed that the citizens had the greatest interest (25.5%) in the transportation field. Other than establishing the night bus route, big data was also used in the reduction of traffic accidents.

2) Reducing Traffic Accidents

The number of deaths from traffic accidents in Korea is the highest among OECD countries, which is two to four times the amount of the generally perceived advanced countries. The number of deaths per 100 thousand of the population (2009) was 4.8 in Seoul, 2.4 in London, 1.6 in Tokyo, and 1.4 in Berlin. However, this number of deaths has been decreasing over the past three years due to the initiation of improvement projects in areas with frequent accidents. Consequently, the number of deaths decreased from 501 (2009) to 378 (2013), and the number of injured decreased from 63,584 (2009) to 56,761 (2013). This is the result of the 24.5% reduction of casualties with the improvement project in 266 areas of frequency accidents over the past three years. Various policies have been initiated in attempts to reduce traffic accidents, in relation to the initiation of the customized traffic safety measures for the elderly and children. This is a support project of luminous vests and safety indicators on handcarts for all elderly citizens collecting waste paper (6,354 people) and the expansion of elderly protection zones (more than 20 zones each year), and policies establishing traffic safety experience classes for the elderly. The obligation of traffic safety education upon renewing driver’s licenses has also been initiated. With the expansion of children protection regions (more than 50 regions each year), safe commutes to and from schools is supported by the operation of traffic safety instructors for elementary school students within these regions. Furthermore, policies such as the expansion of pedestrian crossings (105 crossings including 50 diagonal crossings) and intensive control of illegal stopping on sidewalks (138 regions), contribute to reducing traffic accidents involving children.

3. The Importance of the Policy

Implications from Developing Countries:

Seoul is a city that competes for its position among the top in the world in terms of the level of planning and supply of public transportation. However, at the time the demand for night buses was recognized, an additional budget for the service was not prepared. As a result, the means devised from the mission and condition of supplying customized services diligently responding to the demands of the potential users without wasting the budget in the standard plan and supply of the bus routes was the provision of an incremental service expansion of services by assessing the revealed preference and route design using big data. In this sense, there are remarkable implications to the policy makers of cities that are unable to provide public transportation services within situations where such need has been verified, due to financial restrictions and of cities that have poor traffic information required for public transportation service supply plans.

First, poor data infrastructure is a problem that is commonly faced by most developing countries. Regular surveys on passengers are conducted in countries with abundant resources and where the traffic count on roads comprises the basis of constructing traffic data. Since such research costs are very high, it is difficult for traffic data to be properly carried out in poor countries or developing countries.

Second, even if resources are not particularly weak, if mobile phone usage data can be used to provide consumer-customized bus routes, the city government could provide multiplied convenience to the citizens by using the resources to be used in the construction of traffic data on the development of other public goods. The means of using mobile phone data on traffic plans is a field that is interested and developed more in advanced countries than in developing countries.

Even in developing countries that do not have the data required for city planning, including traffic data, the users display a mobile phone possession rate of near 100%, particularly in large cities. These countries have the basis for similarly using big data on city plans, including public transportation planning.

The large cities of developing countries have a relatively low number of cars and, thus, have a greater need for public transportation than rich cities. Regardless of this, bus networks are not properly formed in most cities. The commonality of the cities, such as Jakarta, Hanoi, Phnom Penh, and Kigali, is that there is a significantly high number of motorcycles over public transportation. Motorcycles have much greater flexibility and convenience than cars in certain aspects, and provide reasonable speeds to be depended on as a transportation means in a large city. However, motorcycles do not have the efficiency of public transportation and this could reduce traffic energy and the usage of roads by transporting a large number of passengers at one time. Thus, the excessive use of motorcycles is already becoming the main cause of worsening atmospheric contamination and traffic congestion in mega cities of developing countries where various city problems are surging.

Motorcycles are the method of transportation selected by the citizens as a means that most

proficiently satisfies the needs of transportation with restricted resources and the absence of adequate public transportation. However, if a suitable method of public transportation is not provided at an opportune moment by considering motorcycles as an appropriate long-term measure, the traffic in these mega cities will gradually face a serious problem. That is, various cities will experience growth and development where individual commute patterns become permanent, and as the residents' incomes increase, motorcycles in the city will soon change to cars, which will restrict sustainable development.

Seoul's night buses, which provide optimal services at affordable costs through route plans that use big data, lack official data, but are part of a policy that has a high value of application in developing countries with a very high possession rate of mobile phones. The bus routes are planned using already existing mobile phone history data, and the service is gradually expanded to prepare a basis of public transportation. Thus, there is a need to change the direction of the current unsustainable move.

There has been a case in which the IBM research team devised a bus route in Abidjan, the capital of Ivory Coast, where there were no previous bus route networks, using the mobile phone data provided by the global communication company of Orange in 2013 (BBC 2013).

Planning a Consumer-focused Policy

There is significance in that the demand of the service users was reflected and big data was newly applied in understanding their behavioral patterns during the process of planning the transportation service. The use of big data enabled the service to directly capture the actual properties or behavioral patterns of the 'population' and not a 'sample' data collected according to the purpose of the supplied. User and consumer-based policy can therefore be planned through the attempt of using the collected data, and ultimately, it achieves increased usability, effect, and service quality of the policy.

Most existing policies did not attempt in understanding or considering the main body of society and delivery system using public services due to the planning and execution of the supply under the supervision of the government. The policy also has a special value in preparing an opportunity that can more accurately reflect human social perspectives to a scientific approach by designing a service focused on big data which observes and analyzes the behavior of the main body of society, exceeding the traditional restrictions of planning. It is also noteworthy that private information and public information were combined, unlike existing policies that usually depended only on public data. There is also a significance in that this is Korea's first case of attempting to plan an optimized policy using big data in a city traffic policy, and simultaneously, it proposes various possibilities for the use of big data.

Ahn, Y. J. and Kim, S. I (2014) analyzed the cases of use of big data, including overseas cases, by recomposing Peter Morville's honeycomb model for the verification of user experience, wherein Seoul city's night bus was evaluated as a case that satisfies all aspects of usefulness, usability, credibility, accessibility, and public value as shown in Table 1 below.

Table 1: User Experience Evaluation Table on Using Big Data in the Public Sector of Seoul's Night Bus

Usefulness	The demand of night buses was recognized after analyzing data from Dasan Call Center, and it was determined that this service would be provided
Usability	After demonstratively implementing two routes, the number of routes was expanded to 9 routes
Credibility	The predicted values obtained by analyzing the arrival/departure points from the traffic card and 3 billion cases of telephone calls were almost accurately consistent with the actual population at night time
Accessibility	High accessibility where anyone can access and obtain necessary information
Public Value	Focus on the purpose of public value and not on the purpose of private profit

Source: Ahn, Y. J. & Kim, S. I. 2014 Partial editing of p.447

4. Relevance with Other Policies

Seoul city has great interest in using big data throughout its administration. The prioritized intention of applying big data in the traffic field was a reflection of the citizens' interest. Upon analyzing 600 thousand cases of data from the '120 Dasan Call Center', one of the Seoul citizens' complaint channels, it was displayed that the citizens had the greatest interest (25.5%) in the traffic field. Big data was also used in the reduction of traffic accidents, in addition to establishing the night bus route. Big data and information communication technology are diversely used in the electronic governmental field in an attempt to promote citizen participation and the efficiency of city administration.

5. Goals of the Policy

Night Bus

1) By concentrating services in areas with high demand of night transportation, high bus usage is achieved in order to enhance user satisfaction and support night activities (this service can easily be cancelled if the usage rate is low)

2) Safe return of citizens to their homes during night time (midnight to 5am)

Reduction of Traffic Accidents

Reduction of fatal traffic accidents -> Deaths from traffic accidents is reduced by less than 1/6 (430-> 70)

1) Combined repair of the traffic environment in the residential zone / introduction of the garage verification system in the residential zone

2) Improved safety of public transportation / reinforced security (prevention of crime) in public transportation

3) Reinforced speed restriction of vehicles on the main roads in the city (60-> 50km) / Construction of a system that immediately responds to all fatal traffic accidents

4) Operation of 'Seoul EYE' the dynamic control management system / 24-hour operation of the Seoul safety situation room

(Seoul Traffic Vision 2030)

6. Main Policy Contents

Night Bus

- Decision Making Group: Private Cooperative
- Policy Participating Group: Seoul city, KT (communication company)
- Other Parties of Interest: Taxi corporations, bus corporations, chauffeur corporations, citizens
- Process of Decision Making:
- Began at the request of citizens and developed as a service product through the cooperation of private and public organizations

Due to restricted resources in the beginning of the service and in a situation where there was no public night bus service, a demonstrative operation of restricted routes was necessary. And, in order for the demonstrative operation to perform its role as an accurate test, it was most important to apprehend the demand of night buses to plan optimum bus routes. Although there might be a demand, if the optimal locations are not properly understood to result in a poor usage rate of the test, there will occur the risk of arriving at the conclusion that night buses are

unnecessary.

Here, rather than depending on existing bus operation data or the intuition of professionals, Seoul city decided to apprehend the actual demand of night buses using big data, particularly, taxi smart card data and communication history from mobile phones, which had been discussed locally and internationally for its usability at the time. Through several meetings between Seoul city employees and private professionals, the usability of big data was examined, and a joint initiation strategy was prepared. Specifically, the call location information was processed as 'destination data' and the billing address was processed as 'destination data' to deduce a floating pattern, which resulted in the determination of the night bus routes.

To achieve this, Seoul city concluded an MOU with KT Corporation and prepared a method of obtaining personal location data from mobile phone call history. Although KT Corporation recognized the value of call history, KT could not use the data due to the issue of the violation of privacy. Thus, the opportunity of using this data within the frame of a project for public benefit was welcomed by KT, and they decided to provide the call records to Seoul city, under the condition that the privacy of the consumers would be protected through methods of separating data field related to personal profiles.

After successfully operating the demonstration run of 3 months, 3 billion cases of calls from KT over the month of March 2013 were analyzed. As a result, it was indicated that the greatest floating population at night time was in Hongdae, followed by Dongdaemun, Shillim, Gangnam, Jongno, Garak Market, Shinchon, Nambu Terminal, Kondae, and Apgujeong. Upon analyzing the data of taxi rides during night time, Gangnam displayed the highest demand, followed by Shillim, Hongdae, Kondae, Dongdaemun, Gangbuk Office, Shinchon, Cheonho, Jongno, and Youngdeungpo. The call data and 5 million cases of taxi rides at night time were combined to visualize a pattern of the floating population on a map using the geographic information system (GIS) of Korean ESRI, which was analyzed on the 'Night Bus Route Establishment Support System' developed by the city.

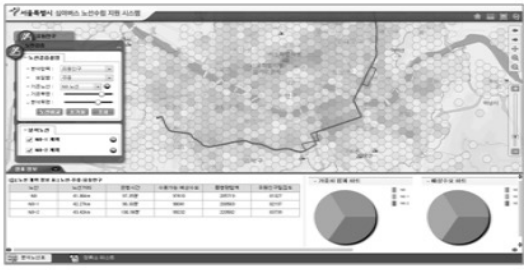
The entire region of Seoul was divided into 1,250 cells of 1km radii, to indicate the floating population and traffic demand, and the existing bus routes, floating population at different times and days, and the pattern of traffic demand were analyzed. In addition, a reanalysis process was conducted, including a calculation of the weight of the floating population near the routes, to deduce the optimum routes and intervals (Seoul City, 2013). As a result, the routes were selected by constructing a radial network connecting 9 suburbs surrounding Gwanghwamun (Fig. 1). The results of the simulation verified that the predicted values obtained from the big data were approximate to the actual values, and thereby, the night bus routes were finalized.

Although N61 had been planned to pass through Nambusunhwan-ro and Dongil-ro at the beginning of the planning phase, the results of the analysis displayed that there was a high floating population in Hyoryeong-ro and Neungdong-ro, near Kondae and Nambu Terminal Station. Therefore, the route was modified, and N13, which was planned to pass through Jangchungdan-ro, was also modified to pass through Dongho-ro. With respect to the route number, N refers to night and the two numbers indicate the locations of departure and arrival. Seoul city was divided into 7 areas, with each area allocated with numbers from 0 to 6.

Visualization of the concentrated area of the floating population	Optimization with simulation of each route	Final route plan

1. Analysis of the concentrated area of the floating population

2. Verification and optimization of the routes based on the floating population



3. Adjustment of the interval of buses based on the floating population

4. Reflection of the night bus routes based on the analysis result

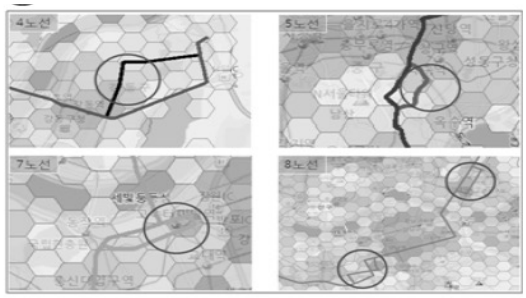


Figure 1: Process of determining routes, intervals, and stations of the night bus

Source: Ma, K. K. 2015; Seoul City, 2013 (Seong, J. E., et al., recited from 2014)

Main Features of the Service

1) Demonstrative operations were conducted on two routes for three months from April 19, 2013, and as a result, it was displayed that the number of accumulated passengers was 218,212,

which was higher than expected. This was calculated to a daily average of 2,098 night bus passengers, with an average of 175 passengers per bus per day. This is 65 higher than the average of 110 passengers per day on standard buses.

After officially initiating 9 routes in September 2013, the official data was published in November 2013. According to this data, a total of 304 thousand passengers used the service for 50 days, which equates to an average of 6,079 passengers per day. Among which, 64.6% users were office workers, 23.5% were chauffeurs, and 11.9% were students (Seoul City, 2014).

With respect to the days of the week, the usage rate was the highest on Saturday morning, with 55.2% of the users concentrated within the 2 hours from 1am to 3am. The usage rate was relatively low during 12am to 1am and 4am to 5am, when subway and local buses were in operation. The usage rate was also affected by the distance of operation, and whether the route passed through subway stations, Jongno, and Gangnam. That is, the five routes where the number of passengers exceeded the average number of passengers had operating distances of over 70km, passed through more than 20 subway stations and passed through Jongno or Gangnam.

All 9 routes are displayed on Fig 2 below.

Figure 2: 9 Night Bus Routes
Source: Seoul City 2014.

The operating time of each route can be checked on the bus information terminal (BIT) installed at each bus station, the traffic information center mobile application (http://m.bus.go.kr), the TOPIS internet website (http://topis.seoul.go.kr) or the smart phone application ('Seoul Traffic Portal'). Meanwhile, the current transferrable regions are restricted to Seoul Station, Dongdaemun, Jongro, and Gangnam Station, where there are many passengers.

Three routes pass through Seoul Station, five routes pass through Dongdaemun, three routes pass through Jongno, and three routes pass through Gangnam Station.

3) The interval between buses is 40 to 45 minutes, which is rather long, but the buses would arrive and depart at the exact times in comparison to night buses. The fare is 2,150 won (Seoul City internal data, 2016) when paid with the traffic card. Buses on the four routes with the longest distances were planned to leave simultaneously from the garages on both ends, in order to minimize the space between intervals in both directions. Buses on the four routes with the shortest distance were planned to drive the full routes by turning at Seoul Station.

4) Through an open contest in June 2013, the brand name 'Owl Bus' was selected, and a character image of an owl driving a bus was designed. For the Owl Bus to be easily distinguished, the character is indicated beside the route number on the LED display on the front and sides of the bus.

Owl Bus N37 Night Bus

Figure 3: Logo selected in an open contest and the night bus electronic display

5) In a survey conducted on 500 passengers after three months of operating two routes, the night bus received a service satisfaction score of 80.15 points (74.3 points for standard buses), and 88.4% of 1,000 respondents indicated that they wanted 'the expansion of the service' in an additional survey. Thus, the service was expanded to 9 routes from September 12 of the same year.

6) The additionally selected 7 routes used the updated big data, as a result of which displayed that the floating population was concentrated in Gangnam, Hongdae, Dongdaemun, Shillim, and Jongno during night time. Thus, the initial plan was modified on six routes. Conclusively, a radial network that passes across the city from Gangnam was composed.

7) As a safety device, the speeding prevention device, which restricts the speed of the buses to 70km, was equipped on all night buses, and a partition wall was installed for the safety of the

driver. Furthermore, an emergency contact network was constructed with nearby police stations in case of emergencies.

8) In order to prevent the drivers from participating in other work during the day time, night time exclusive drivers were employed, with an increase in their wage from 1.75 million won to 2.14 million won, and it is planned to allow the transfer of the night time drivers to day time based on their work evaluation.

9) A method of returning the profit to the operating corporations is being examined.

10) Illegal operation of cars on the bus routes that may conflict with the night buses are to be intensively controlled with the cooperation of the police (pursuant to Articles 81 and 82 of the Passenger Transport Service Act).

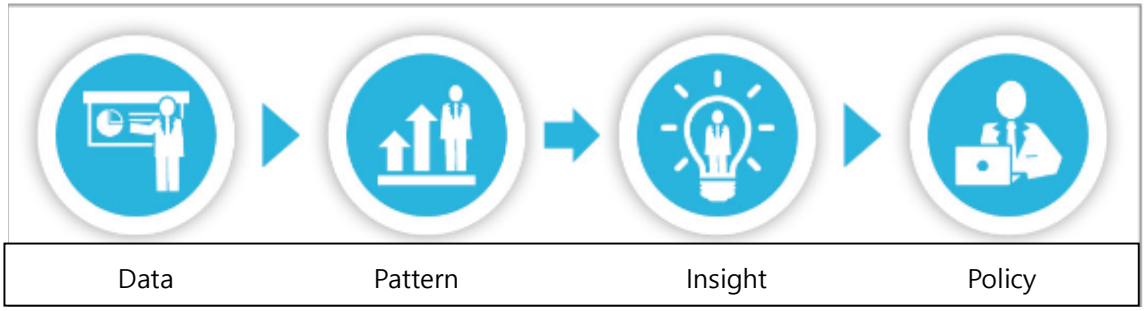
- Reduction of Traffic Accidents

Seoul City has established a traffic accident measure by analyzing various big data of 140 billion cases regarding the traffic accident history, weather, vehicle speeds, digital operation gauge, and floating population obtained by public and private organizations, and will be officially enforcing a traffic accident measure from early this year.

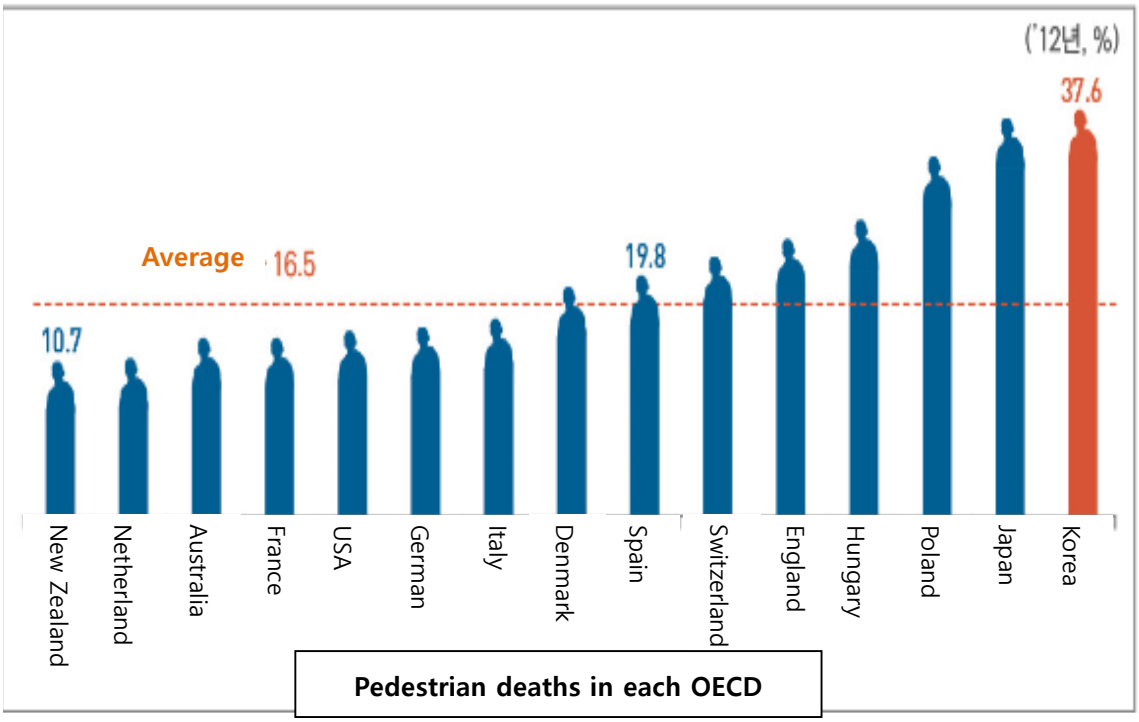
The traffic accident measure was prepared based on the results of intensively analyzing the five categories of traffic accidents of children and elderly pedestrians, traffic accidents on island bus road stations, drunk driving, and dangerous driving behavior. These five categories are specifically examined below.

- Preparation of the Traffic Accident Measure through Big Data Analysis

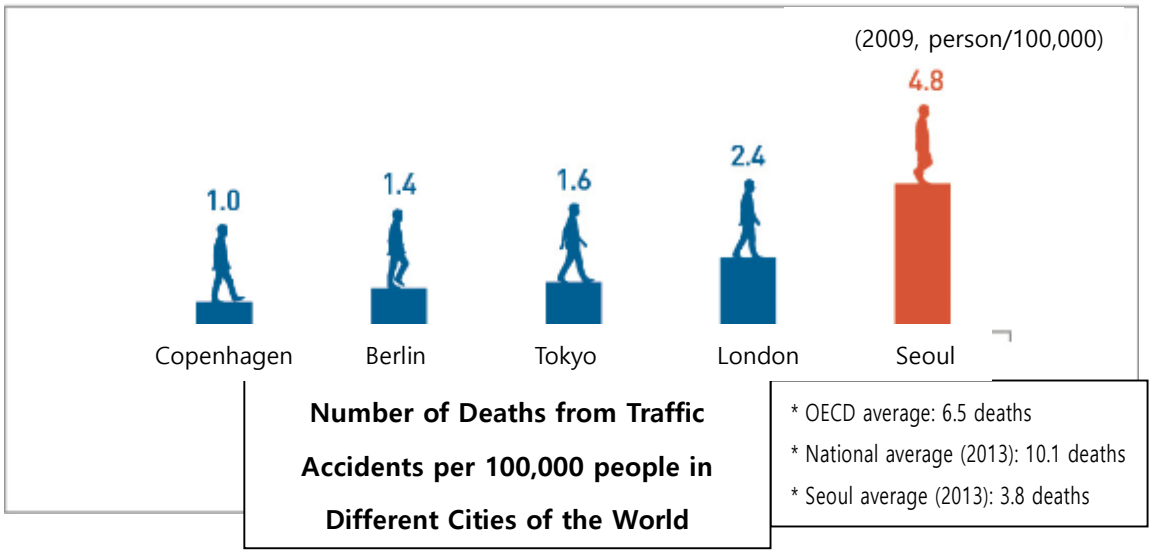
The analysis of big data comprises an integrated analysis of the floating population, weather during relevant time periods, and surrounding traffic safety facilities, after reviewing the location and time of an accident from traffic accident history. To accurately analyze big data, Seoul city has composed the TF team for the collection and analysis of big data for one year. The TF team analyzed the correlation between data that were scattered, to reveal patterns in traffic accidents, and established a traffic safety measure based on the ‘analysis result of the five categories’.



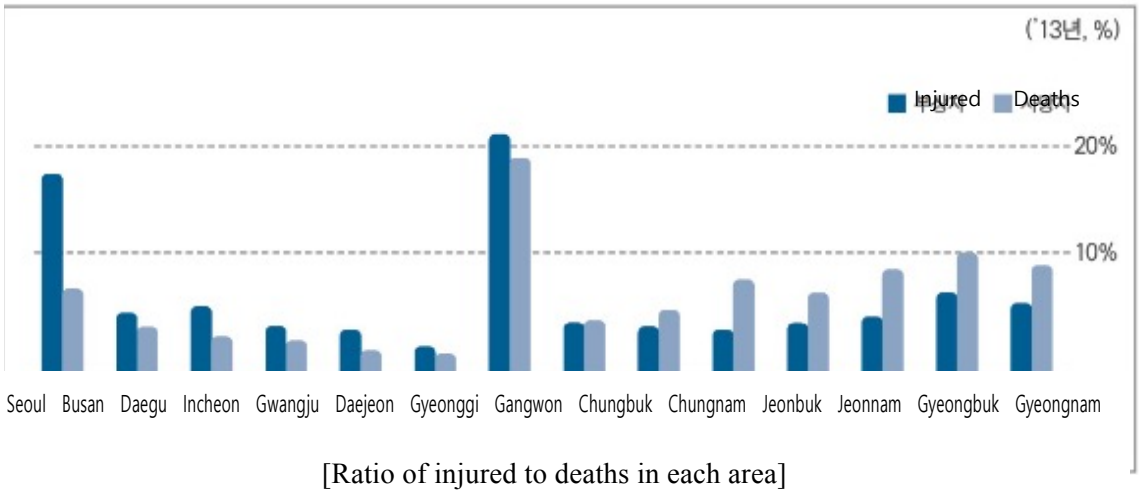
- Highest number of pedestrian deaths among OECD countries



- Two to Four Times the Number of Deaths from Traffic Accidents in Comparison to Main Cities of the World



- Remarkably high ratio of injured compared to deaths among Korean cities

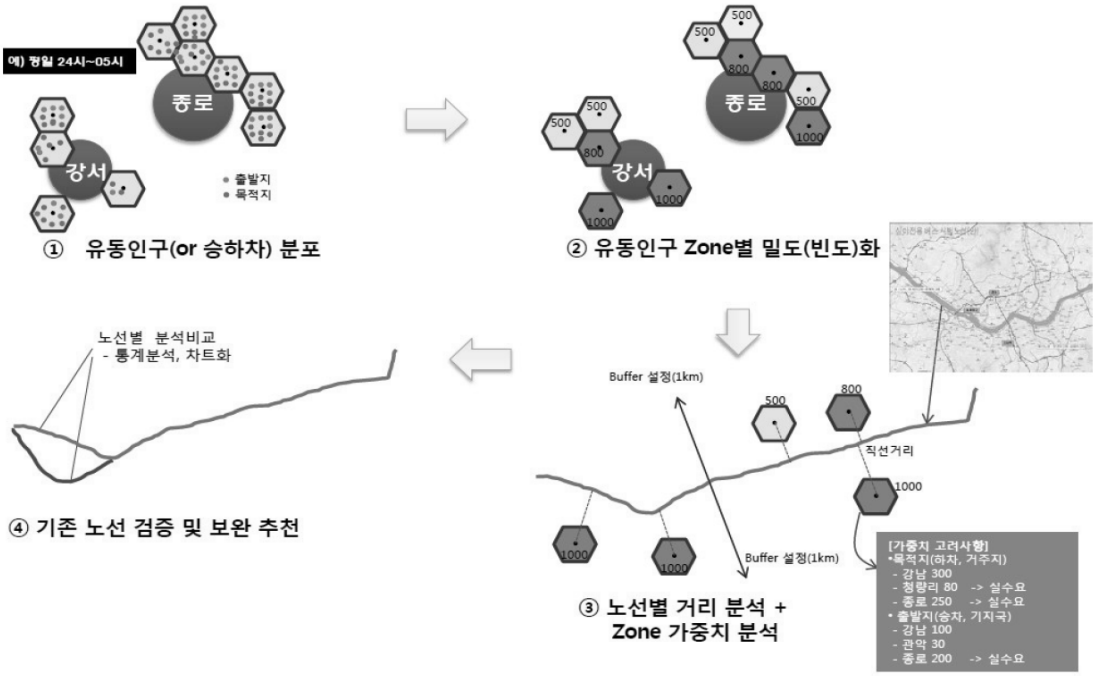


[Ratio of injured to deaths in each area]

7. Technical Details Night Bus

In view of the process of determining specific routes, the route analysis was conducted by creating a density map based on the starting point and destination, and a relevant buffer was set to calculate the actual demand on the hexagon within the buffer. Here, the weight of each distance was calculated, and the difference between existing routes and the routes formed as a result of the statistics were verified. The amount of transportation was indicated by a hexagon at each bus stop, and the buffer was set, followed by the application and calculation of data for each destination and starting point.

Furthermore, the spaces between each bus stop were connected with a line, and any overlapping lines were thickened to visualize the system. Here, the demand for the night bus was calculated by reflecting the floating population. During this process, the modification of bus stops and routes was proposed concerning 8 routes, which was partially accommodated. Through cooperation with bus policy organizations, routes with greater demands and floating populations were created (Seoul City, 2013).



1. Distribution of floating population (or boarding / deboarding)	2. Density of floating population per zone
4. Recommended verification and supplementation of the existing routes	3. Analysis of distance for each route + analysis of weight of each zone

Figure 4: Seoul City Night Bus Intensive Analysis Chart

Source: Seoul City, 2013

- Reduction of Traffic Accidents: http://www.slideshare.net/crashs/ss-45876300

8. Policy Effects

Night Bus

1) The night bus route, which was designed with the use of big data, achieved an amount of transportation that exceeds 5 to 10% of existing routes.

2) The citizens that participated in night activities saved transportation costs, and the usefulness of a safe, convenience, and affordable night transportation means is estimated to have increased the participants' night activities (verified by the research of sales at night spots near the routes). In fact, the female population participating in night activities increased by 11% (Seoul City 2014).

3) There is the effect of preventing night crime (possibility of collecting substantive data).

4) The rejection of passengers by taxis reduced by 8.9% as an additional effect.

5) Within the increasing domestic and international interest in the usability of big data, this became a very practical case that noticeably relieved the inconvenience of the citizens at a small cost. Thus, it displayed a future-oriented aspect of administration that moves with innovation and dynamicity.

6) This policy was selected as the second place in the top 10 policy vote during the first half of 2013, and was reported in various national and international media outlets.

Currently, there are increasing domestic and foreign organizations and public officials that wish to share Seoul city's big data administration and place Seoul city as an informatization benchmarking city model. As an example, the CEO of NESTA, the British National Science, Technology and Arts Foundation visited Seoul city to inspect the night bus route establishment system, and visited other cities and organizations, including Taipei in Taiwan, Jakarta in Indonesia, and the World Bank to disclose a case publication in relation to using big data.

Reduction of traffic accidents

http://www.slideshare.net/crashs/ss-45876300

(Composition of institutional effect/response means for each group in the link below)

- Traffic accidents involving child pedestrians
- Traffic accidents involving elderly pedestrians
- Traffic accidents in island bus road stations
- Accidents from drunk driving
- Analysis of dangerous driving behaviors

9. Challenges and Solutions

Challenges in the administrative procedure to use big data

IT technologies are necessary in the use of big data in policies. However, the administrative procedure for the practical use of big data may be more complicated and difficult. Hardware and software technologies that process big data can be procured through global IT technologies, and thus, it may be a rather simple problem, whereas the administrative procedure is fundamentally much more complex.

During the early phases where experience was insufficient, trials and errors were unavoidable.

However, based on the experience accumulated by conducting various projects related to big data, such as the selection of the night bus routes and the analysis of the elderly welfare facility sites, Seoul city developed an administrative framework that can efficiently manage big data-related administrative procedures. This was completed in five stages, and divided into 14 activities and 41 tasks. Through this framework verified by the execution of actual projects, Seoul city was able to more efficiently find resolutions by systematically operating the relationship of various parties of interest in any succeeding big data-related projects.

For instance, an intimate cooperation between the department obtaining data and the IT department handling big data was important. Through several education programs and workshops, a bond of sympathy and the will to actively cooperate with one another was formed between the departments and these formed the core elements of achieving a successful project. Furthermore, the priority task was deduced by conducting a big data curator nurturing course, and the problems and difficulties were shared with various external organizations, such as private organizations, academic organizations, and research institutes, in order to collect opinions, and thereby constructing a cooperation network (seoulsolution.go.kr).

Burden of Financial Support

According to the quasi-public bus system agreement, which enforced service enhancement through guaranteed stable management of bus companies and enhanced usage of public transportation by Seoul city from 2004, financial support was provided. The amount of financial support provided to supplement the deficit of local buses reached 1 trillion 469.4 billion won from July 2004 to July 2014. The deficit compensation increased from 94.2 trillion won in 2003 before the enforcement of the quasi-public system to 230 trillion won in 2014, which continually increased since the enforcement of the quasi-public system. It is indicated that one of the reasons for the increase in the financial support cost is that there is no longer a need to modify or cancel the routes of buses displaying poor usage, since financial support is guaranteed for deficits of local buses.

Night buses also display a concentrated usage rate during 1am to 3am, and thus, it is possible that a deficit will result during other times on certain routes. In order for the night bus system to become establish as a system that has steady institutional effects and has the advantage of preventing any additional financial consumption, there would be a need to adjust the interval of buses by considering the time periods.

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