Hub locations in urban multimodal networks

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Abstract

The present paper deals with the problem of locating hubs for freight mobility in urban and suburban areas. In particular, we present a heuristic method that combines aspects coming from both classical simple plant location problems and shortest path ones on multimodal graphs. In the first phase of the proposed heuristics, we identify those nodes that could be attractive poles for being logistics platforms. In this phase we select the possible modal change nodes by analysing their communication capabilities with the other nodes of the network, such as depots, transit points, retail points, main accesses to the highways and railways. In the second phase, we first compute shortest mono-modal paths looking for well performing modal change nodes from both the required origin and destination nodes. Then, we evaluate the generalized cost of the corresponding possible multimodal path visiting the previously selected commuting points thus being able to identify the best location for the required hubs in the whole logistic network among the set of candidate nodes.

Computational experiences and results concerning the logistic network of the metropolitan area of the city of Genoa are reported.

*Keywords***:** freight mobility, multimodal transportation network, p-hub median problem, simple plant location problem, shortest path problem

1. Introduction and problem definition

Hub and spoke networks are used to represent those logistic systems in which goods are concentrated in few nodes, that act as connecting points, instead of serving each origin – destination (*o-d*) pair directly; in particular, goods coming from the same origin, even if have different destinations, converge to the hub and are combined with goods that have different origins but the same destination. The hub location problem is then concerned with where locating facilities and how allocating demand nodes to hubs in order to route the flow of goods to origin–destination minimum cost paths.

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The hub location problem has various applications. The research on hub location began with the pioneering work of O'Kelly (1987),that is considered the first mathematical formulation for the hub location problem; in that paper the application concerns airline passenger networks. Starting from that paper, especially in the last decade, there has been a tremendous increase of publications about hub location problems. A very interesting classification and survey of network hub location models is reported in Alamur and Kara (2008), where the authors also provide a synthesis of the related literature.

Almost all of the hub location models defined in the literature have analogous location versions. One of the most recurrent location model is the *p*-hub median problem, where the objective is to minimize the total transportation cost required to satisfy the demand of a given set of nodes, where the flow between origin–destination pairs of nodes is given as well as the number (*p*) of hubs to locate.

A very interesting aspect of the hub location problem is that quite often it relies on the idea of multimodal transportation networks. A noticeable attention has been recently paid to intermodal freight transport research and its development issues (see e.g. Macharis and Bontekoning, 2004; Jarzemskiene, 2007; Crainic et al., 2009). In this direction, only relatively few works have been devoted to the hub location problem in urban areas, and they are mainly focused on mass transit transportation networks, as the work presented by Wang et al. (2006). However, it is well known that many advantages can be derived from using urban logistic platforms (see, e.g. Crainic et al., 2004; Leinbach and Capineri, 2007). For instance, the presence of a logistic platform can drastically reduce the flow of trucks in the city, thus in turn reducing the air and noise pollution. In this perspective, one of the today's open problem is to identify where to locate transhipment depots for freight transport in urban areas, taking into account the urban configuration and the logistic network.

In this work we deal with such problem, focusing our attention on those nodes within a urban intermodal transportation network that could be attractive poles for modal exchanges for freight mobility, being also strategic locations within the overall network. In particular, we identify the possible modal change nodes for the fleet of vehicles by analysing the connection capabilities of the candidate nodes with the other nodes of interest of the network, such as depots, transit points, retail points, main accesses to the highways and railways.

Usually, the hub location problem and its generalization applied to real life sized instances is solved with efficient heuristics, as the ones proposed by Chen (2007) and Silva and Cunha (2009) for the uncapacited case, and in Gavriliouk (2009), where a methodology is presented for reducing the complexity of the problem grouping together *p*-centre of the network.

We present a heuristic algorithm that has been implemented with the aim of defining the best modal change node for each route and the optimal location of hubs in the whole transportation network. The proposed algorithm looks for the best possible modal change nodes and computes minimum cost *o-d* routes in the given urban multimodal transportation network using such nodes for the *o-d* pair under consideration.

The proposed heuristic algorithm is described in details in Section 2. In Section 3 its application to the logistic network of the city of Genoa, Italy, is presented; experimental results, showing some traffic reduction, especially through the most congested nodes, are also given. Finally, some conclusion and outlines for future works are provided.

2. The proposed approach

In this paper we present a heuristic algorithm that combines aspects derived from both classical simple plant location problems and shortest path algorithms on multimodal networks. The goal of the proposed algorithm is first to define for each o-d pair of nodes of interest in the given network the best modal change node for the fleet of vehicles; successively, it aims at defining the location of hubs in the whole transportation network among the previously selected logistic platforms.

The overall aim of the proposed method is to identify those nodes that could be attractive poles for a) being modal changes for freight mobility; b) locating new services; c) reducing the transition costs.

The key and novel issue of the proposed heuristics is that it relies on the role that modal change nodes play in the final locative decision. In fact, in the present method the evaluation of the optimal trade-off between benefits and costs in the choice of o-d routes for freight transportation in urban areas strongly depends on the capability of the selected logistic platforms of serving good demand in a number of different travelling modes. Therefore, we start our selection method by evaluating the candidate hub nodes from a structural point of view, that is by verifying their multimodal connection with the other nodes of the network.

In particular, at the beginning we verify the connection capability of the possible hub nodes to/from either depots or transit and retail points as well as entering points to the network from outside conjunctions. Successively, we look for the best modal change nodes from both the origin and the destination nodes of the considered o-d pair while computing the required mono-modal shortest path; then, the generalized cost of the corresponding possible multi-modal path is evaluated forcing as much as possible routings through those nodes that are suitable for being selected as commuting points. Finally, the set of candidate logistic platform nodes is used for identifying the best hub locations in the whole transportation network as the set of p nodes that minimise the sum of the shortest distance between pair of logistic nodes.

Let us now described in more details the main steps of the proposed heuristics.

2.1. Initialization and basic notation

Let $G = (V, E)$ be a weighted digraph representing the multimodal urban logistic network under consideration. As usual, V is the set of nodes of the network; $V_H \subset V$ represents the subset of nodes that are possible candidates for being logistic platforms. Weight w_i associated to node $i \in V_H$ represents the transition cost at node i. Set E consists of direct connections between pairs of nodes. Let us assume that $E = E_P \cup E_S \cup E_C$, where arcs belonging to E_P represent the so called primary connections in the urban multimodal logistic network, that is arcs that allow to reach the urban area from the suburban zones.

Note that primary arcs usually are the only ones that can be traveled by long vehicles or trucks. Arcs belonging to E_S represent the so-called secondary connections, that is streets or roads that connect peripheral zones to the urban centre; arcs in E_S can be traveled by trucks or wagons. Finally, E_C is the set of arcs representing streets in the most central area of a city. As far as freight mobility, arcs in E_C usually can be traveled only by vans or picks-up. It is worth mentioning that arcs of E_C correspond to private arcs of the urban multimodal transportation network under consideration; therefore, the shortest path between pairs of nodes along E_C is already known and is the same as for passenger mobility.

The referring classification of the considered arcs of E in a urban logistic network is reported in *Figure* 1. In this contest, we are mainly concerned with arcs belonging to E_P and E_S, that is our main interest is the commuting phase between primary and secondary transport modalities, also because, as it has been already said, optimal routes in the central areas are supposed to be known. Let m be the traveling modes that are allowed in G. To each arc $(i,j) \in E$ is associated a m-dimensional vector $\boldsymbol{t}_{ij}(k) = c_{ij}(k)l_{ij}$ representing, for each component k among the m available ones, the travelling cost for moving from i to j using the *k-th* transportation modality. In particular, $\boldsymbol{t}_{ij}(k)$ is expressed by the travelling distance l_{ij} multiplied by a unit cost coefficient $c_{ij}(k)$ taking into account the hourly tariff of the driver and the type k of the vehicle.

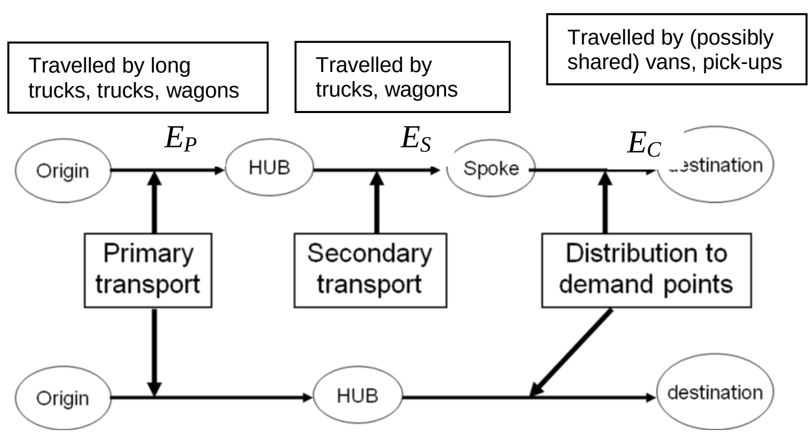

Figure 1. Classification of traveling arcs in a urban logistic multimodal network

Let us now assume that a node $i \in V_H$ can be profitably selected for being the required hub only if it is very efficiently connected to the other nodes of the network, both along the primary and the secondary transport modalities. For this reason, we are first interested in the computation of the connectivity and reachability values of node i, $\forall\ i \in V_H$ from a structural point of view, that is how each node of the multimodal network is connected to the others considering the existing arcs. Therefore, let $\Delta_i = \sum_{j \in V} d_{ij}$ be the sum of the shortest path d_{ij} between node i and all nodes $j \in V$ of the network, $\forall\ i \in V_H$; moreover, let $\delta = \min(\Delta_i)$ be the minimum of such values; relatively to $V_H, \delta(i^*)$ hence is the outgoing median node of G. Analogously, let $\Pi_i = \sum_{j \in V} d_{ji}$ be the sum of the shortest path d_{ji} from all nodes belonging to V and node i, $\forall\ i \in V_H$, and $\chi = \min(\Pi_i)$ the minimum value among the Π_i; therefore, $\chi(i^*)$ is the ingoing median node of G, relatively to V_H.

Note that the identification of the ingoing and outgoing median nodes requires just the solution of the all pair shortest path problem, that is easily obtained from a computational point of view.

Finally, let ε_1 and ε_2 be given defined tolerance values, expressed in percentage, from δ and χ, respectively.

It is worth noting that we are going to restrict the choice of the location of hub nodes among those nodes belonging to V_H that guarantee good communication capabilities with the other nodes of the logistic network. In particular, we restrict the choice of possible logistic platforms to best choice modal change nodes, according to the following definition.

Definition 1. A node $i \in V_H$ is a *best choice modal change node* if $\Delta_i - \delta \leq \delta\varepsilon_1$ and $\Pi_i - \chi \leq \chi\varepsilon_2$.◊

In other words, a best choice modal change node well performs in terms of connection to the other nodes and it is easily reachable from all other nodes. Since modal change nodes strongly impact on the final decision about the sequence of vehicle to choose in the whole urban route of goods, we restrict our choice of possible logistic platforms only to best choice modal change nodes; therefore, we will consider only them in the following computations. In other works, for instance Ambrosino and Sciomachen (2009), the search for the optimal modal change nodes is restricted to a subset of candidate nodes, chosen among the well performing ones.

Therefore, let $V_{H(B)} \subset V_H$, such that $|V_{H(B)}| = n$, be the set of best choice modal change nodes, that is the subset of possible logistic platforms that satisfy our connectivity requirements. Note that the definition of best choice modal change nodes usually allow to reduce the cardinality of the set of possible hub nodes up to 40%.

2.2. Selection of a restricted set of hub locations

Once the restricted set of possible candidate hub nodes is defined, we apply a heuristic algorithm for finding optimal multimodal *o-d* routes in network G. As it has been already said, a key issue of the proposed algorithm is that it strongly relies on the relevant role that is played by the best choice modal change nodes belonging to $V_{H(B)}$.

Since we do not obviously consider hub nodes located downtown, let us assume that possible origin nodes for the required *o-d* shortest paths can be left only travelling either on the primary or secondary transport modalities; this implies that hub locations we are looking for involve only arcs of E_P and E_S. Analogously, let us assume that arcs reaching destination nodes belong either to E_S or E_C. Therefore, let $V_O \subset V$ and $V_D \subset V$ be the subsets of possible origin and destination nodes, respectively.

The proposed algorithm looks for the best location for the hubs among set $V_{H(B)}$ and evaluates the cost of the paths that include such nodes for the restricted pair of *o-d* nodes, $\forall o \in V_O$ and $d \in V_D$. In more details, at the beginning we evaluate the cost of the shortest path starting from any origin node $o \in V_O$ to modal change node i, $\forall i \in V_{H(B)}$. Note that the shortest path P^*_{oi}, in terms of travelled distance, has been already computed in the initialization phase; therefore, we have now only to compute the cost $t(P^*)_{oi}(k) = \sum_{(j,l)\in P^*} c_{jl}(k)\, l_{ij}$ of the shortest path P^*_{oi} from o to node i, $\forall i \in V_{H(B)}$ with respect to the chosen travelling vehicle along arcs belonging to either E_P or E_S.

After that, we sort the considered paths in increasing order according to their cost from node o and select the first $q \leq h$ ones. In this way, we are able to define set $V_{H(B)}(o) \subseteq V_{H(B)}$ of q candidate hub locations reachable from a given origin node $o \in V_O$. Then, the previous steps are repeated for all o in V_O. At the end of these iterations, we determine the subset of best choice modal change nodes that guarantee minimum cost connections from V_O as $\Omega = \bigcap_{o\in V_O} V_{H(B)}(o)$.

Successively, we perform the same steps as before, but now considering as origin node i, $\forall i \in V_{H(B)}$, and as destination any node $d \in V_D$. Analogously as before, we thus define the ordered set $V_{H(B)}(d) \subseteq V_{H(B)}$ of $q \leq h$ candidate hub locations connecting node d. Finally, repeating the same steps for all destination nodes, we determine the subset of best choice modal change nodes that guarantee minimum cost connections to V_D as $\Delta = \bigcap_{d\in V_D} V_{H(B)}(d)$.

In these steps, we have identified a restricted number of possible hub locations that well perform in terms of connection to other nodes of the network, as it has been defined in the initialization phase, and that also belong to shortest paths to / from nodes belonging to $V_{H(B)}$.

Aim of the final phase is to identify those nodes that are able to satisfy minimum cost requirements for the maximum possible number of *o-d* pair of nodes. For this reason, we compute the cost of the shortest path between pairs of selected best choice modal change nodes having origin in Ω and destination in Δ, with all the feasible travelling modalities, with the aim of minimizing the overall cost of the connections with the selected hub nodes. In particular, for each $i \in \Omega$ we look for the minimum cost path from i to any possible hub node in Δ. The idea is to concentrate flow of goods into those nodes that are selected in most *o-d* paths and that can be hence considered our solution of the hub location problem. Finally, for each pair of *o-d* nodes, $\forall o \in V_O$, $\forall d \in V_D$, we compute the minimum cost route as the one resulting from the minimum values among the cost of all possible combined paths from o to d, as it is depicted in *Figure* 2. More precisely, we compare the cost of the following alternative paths and successively select the minimum one: $(o, i\in V_{H(B)}(o), j\in V_{H(B)}(d), d)$ and $(o, i\in V_{H(B)}(o), d)$ and $(o, j\in V_{H(B)}(d), d)$.

Note that in the computation of the cost of the selected paths we count only weight w_i corresponding to the selected modal change node $i \in V_{H(B)}$ between the pair of nodes o and d.

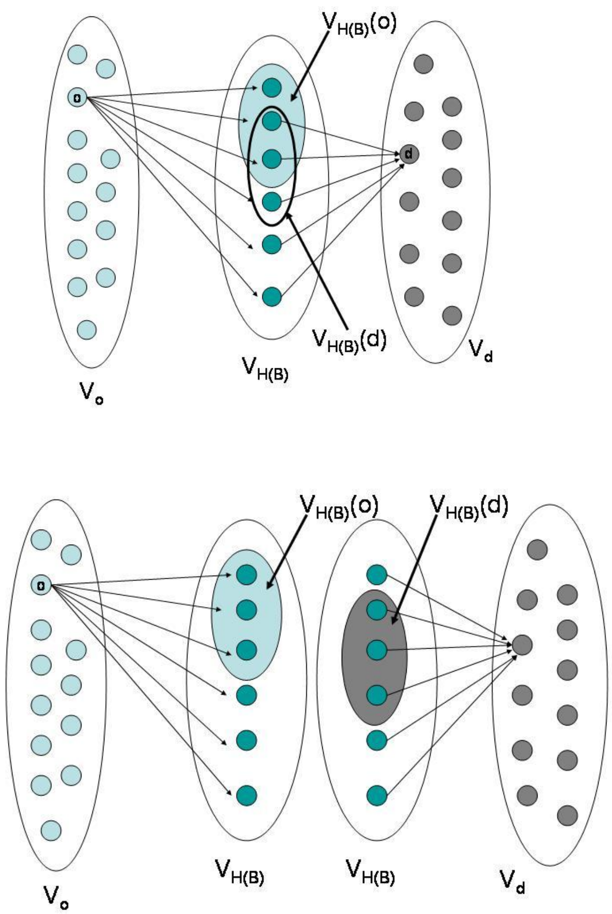

Figure 2. Computation of the final set of selected hub nodes

3. Hub identification in the freight multimodal transportation of the city of Genoa

We have applied the proposed approach to the freight multimodal network of the city of Genoa, Italy. Note that the particular geographical configuration of the city strongly affects the urban mobility. In fact, Genoa has been grown up on the coast in the length of almost 30 km from east to west, apart from two valleys (Bisagno and Polcevera) which cross the north-south direction; therefore, Genoa has just only two main ways to across it, which are the “Sopraelevata” and the “Pedemontana”. Its linear extension is more than 25,3 km on the highway.

The city of Genoa is split into five main zones and nine districts, as it is reported in *Figure* 3:

- the *Center* (that includes those districts: Genoa East and Genoa West);

- the *West side* (that includes those districts: Ponente and Medio Ponente);
- the *East side* (that includes those districts: Levante and Medio Levante);
- the *Bisagno* zone (that includes those districts: Val Bisagno and Bassa Val Bisagno);
- the *Polcevera* zone (Polcevera district).

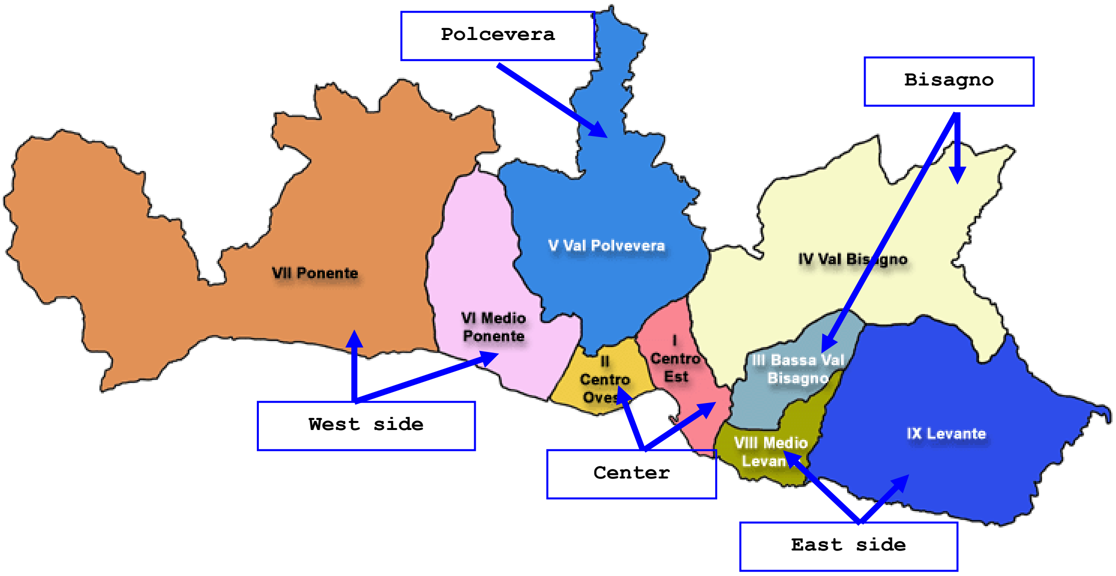

Figure 3. Map of the city of Genoa split into its 9 districts

Each district has a lot of commercial activities that have to be served daily. By using the ULISSE software, that is owned by the Chamber of Commerce and used for the research of national commerce activities data, it has been possible to localize and count the effective number of industrial businesses and companies acting in Genoa, as well as to classify different types of commercial activities according to specific characteristics, such as wholesale, retail and food supply. Consequently, we were able to figure out the demand for goods in Genoa and hypothesize how to organize deliveries in the city. The resulting number and type of commercial activities in each one of the nine districts are reported in *Table* 1. Note that the zone with the highest number of commercial activities is the Center-East with 13466 units, followed by Val Bisagno, that has less than one third of business activities than the first one.

Starting from the data reported in *Table* 1, it has been possible to assume the total daily goods requirements of the districts, counting each kind of activities. In particular, the data provided by the Chamber of Commerce show that in a weekday about 842275 kg of goods are moved over in Genoa; consequently, it has been possible to compute how many logistics platforms the city needs and where to locate them in order to minimize costs and travelled distances. Successively, we derive the minimum number of trucks required for managing and delivering all the stuff. The resulting data are reported in *Table* 2.

District	N°commercial business by wholesale	N°commercial business by detail	N° hotels, restaurants, bar	Total business / district
1 Centre east	3575	8086	1805	13466
2 Centre west	918	2155	497	3570
3 Lower Valbisagno	1045	2537	425	4007
4 Valbisagno	633	712	112	1457
5 Valpolcevera	919	1035	154	2108
6 Middle west side	1062	1739	264	3085
7 West side	647	1383	270	2300
8 Medium east side	442	257	196	895
9 East side	725	1704	374	2803

Table 1. Commercial activities in the districts of Genoa.

Total commercial activities	33691
Total flow of commodities	842275 kg
Daily average per business	25 kg
Delivery vans per day	663
Delivery trucks per day	631
Pallets per day	71901

Table 2. Total daily good requirements in Genoa.

As it has been already said, the flow of goods in Genoa moves mainly along two directions: from east to west side, and vice-versa, and to the highway connections. Since the main aim of the department for transport of Genoa is to limit the road freight access to the city center, the real problem is then where to locate the logistic platforms for serving the whole goods requirements finding intermodal solutions, also avoiding the flow of containers coming from the maritime terminals on road in the city. However, note that the main business activities requiring goods are concentrated just in the middle of the two main directions.

Following what has been described in Section 2, the first step is to represent the freight mobility network within the central and suburban area of the city of Genoa; the resulting multimodal graph model $G = (V,E)$ has 880 nodes, 25 of which belong to V_H, and 1760 arcs. The driving cost that has been considered in the computation of the shortest paths counts for different means, such as cars, motorbikes, delivery vans, delivery trucks and buses. Data related to the flow of goods have been analysed with the software ARCGIS, that is able to elaborate and visualise the data of a multimodal network into a graphic structure representing the real map of the city; note that the resulting graph is thus not only a representation of the multimodal transportation network of the city, but a description of its actual shape, since the terrestrial coordinates of the selected nodes are given as input data. Moreover, ARCGIS allows to represent the network model corresponding to a specific transportation modality. For instance, after the introduction of the trucks prohibitions, it is possible to visualize the enabled paths for trucks in the network, in order to identify where the freight traffic could be driven. In particular, by setting as input [*truck*] = *3*, related to the arcs travelled by trucks, we can visualize, darker than the others, as it is reported in *Figure 4*, the arcs that do not belong to E_P, that is the streets of the city that are not passable by trucks. Note that such visualization helps us in understanding how and where different kinds of goods can transit throughout the city.

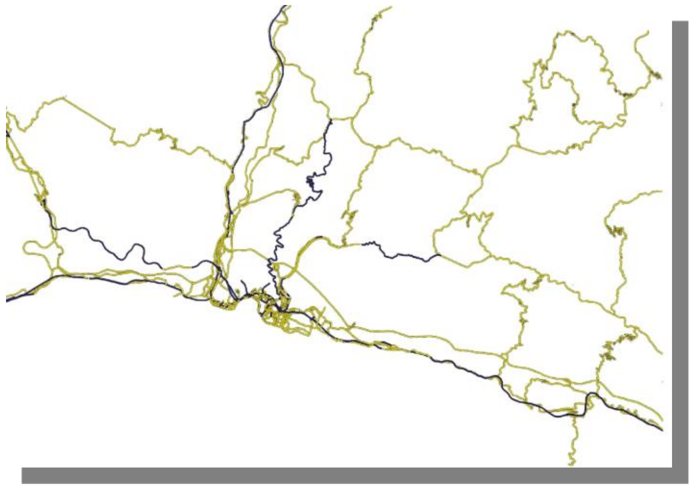

Figure 4. The network model of the city of Genoa developed with ARCGIS with the arcs inhibit to trucks

Flows have been separated on the basis of the type of vehicles travelling on either E_P or E_S. Our analysis concerns the flow of goods from 8 a.m. to 1 p.m. This daily time period has been chosen to capture the peak of heavy traffic in the city of Genoa, since only in this time window it is possible to deliver goods to the major kinds of commercial activities located in the district of the city.

The identification of set $V_{H(B)}$ of the best choice modal change nodes has been performed after the computation of the all pairs shortest path problem. The resulting eight nodes are reported in *Figure* 5, and have been derived setting ε_1 and ε_2 to 40%. Note that the location of the selected candidate hub nodes is optimal from a geographical and infrastructural point of view.

In fact, locating a logistic platform close to the motorway exit at Nervi would reduce the traffic in Albaro, Sturla, Quarto and Quinto zones. In particular, starting form the length of the streets, that is about 2 km and half from the motorway exit to the platform, and the average speed on that arc (30 km/h), the travelling time can be estimated to be between 7 and 8 minutes. Moreover, the route on the opposite way, that is from the platform to downtown, is about 4 km and half and the travelling time is 6 minutes and half; the flow of trucks, can be estimated as well, with a resulting decrease of the average size, from 35 to 18 tons, thus in turn reducing congestion and pollutions. The second logistic platform (Genoa West), that is the median node of the network, is inside the Maritime Station, close to the motorway exit (only 1 km and 230 metres for 6 minutes and half of travelling time), and is able to cover all the business traffic in the central area in few minutes (4 minutes to P.zza De Ferrari). For the third logistic platform (Genoa East) the candidate node is Prato, almost 7 km far from Genoa East motorway exit. It could be used to reach the Bisagno zone in about 12 minutes, and also to serve Castelletto e Oregina. The fourth logistic platform has been selected in Bolzaneto; it could be located at 1 km and 300 metres from the motorway exit (minutes of travelling time) and it could be able to satisfy the demand of Sestri Ponente, Cornigliano, Campi, and Pontedecimo. Another best choice modal change node is located in Via Ovada, that is 2 km far from Voltri motorway exit; such node could be able to cover three districts (Centre-West, Ponente and Medio Ponente), 8955 commercial activities and 22387 kg of freight to bedelivered daily. The other logistic platform placed in Via Romairone, that is 1 km far from Bolzaneto motorway exit, it could be able to cover two districts (Centre-East, Val Polcevera), 15574 commercial activities, and 389350 kg of freights to be delivered daily. Another suitable logistic node is Multedo, that covers the West side district, that could serve the area of the oil port and a lot of industrial sites and the access of the highway A10. Finally, the last selected best choice modal change node is located in Via Struppa, 7 km far from Genoa East motorway exit, and covers four districts (Bassa Val Bisagno, Val Bisagno, Levante, and Medio Levante), 9126 commercial activities, 228150 kg of freights to be delivered daily. Note that the average size designed for all the selected nodes is about 2000 square meters (open and closed) and this space guarantees efficient upload and download operations.

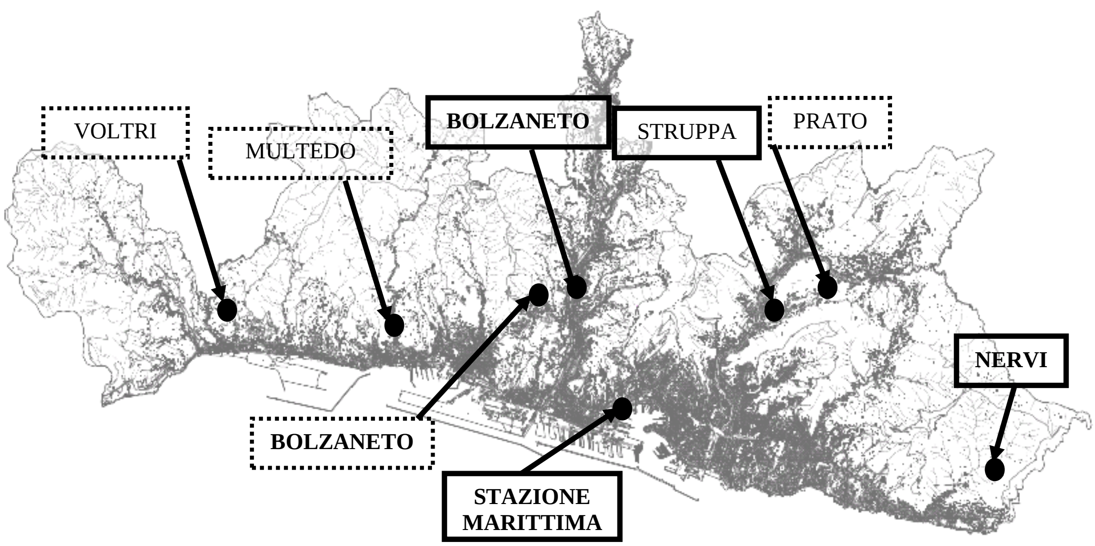

Figure 5. Location of the best choice modal change nodes of $V_{H(B)}$.

The algorithm presented in Section 2 has been implemented in C ++ language and tested at 3200 MHz with 512 Mb of RAM. Before applying it at the freight multimodal network described above, an extensive computational effort devoted at validating the proposed algorithm has been performed. In particular, a number of trials with randomly generated instances have been used as a test bed for verifying both the goodness of the obtained solutions and the corresponding CPU time. More precisely, we ran the algorithm with 500 randomly generated graphs, split into five classes, having, respectively, from 100 to 500 nodes and from 2500 to 23000 arcs. We validated the found solutions with the optimal ones by using an exhaustive algorithm for computing every *o-d* shortest path pair, that is similar to the Warshall-Floyd one. For all instances the solution has been found by our algorithm in less than 1 second of CPU time, while the CPU time of the exhaustive algorithm grows very quickly, from 1,49’’ to 2’ and 16’’. Furthermore, the percentage of optimal solutions found by the proposed algorithm ranged from 62 to 68%, while the maximum optimality gap was 8.40%.

By virtue of the very good performance of the proposed algorithm, we then applied it in order to find the shortest path from east to west side, and vice-versa on the multimodal logistic network described above. After the selection phase of our algorithm, the nodes belonging to Δ and Ω are reduced to four, namely Nervi, Stazione Marittima, Struppa and Bolzaneto; these nodes are highlighted in bold in *Figure* 5. These nodes are then the final selected hubs.

Note that the nodes selected by the proposed algorithm confirm the hypothesized congestion reduction mentioned above. In fact, this solution has been validated by using a discrete event simulation model implemented in Witness 2008. In particular, we analysed the freight flow in the city in different operational scenarios with and without the selected platforms; in the first case, as soon as trucks moved towards the chosen hubs the congestion at the central nodes decreased. It is worth observe that we got up to a 40% traffic reduction in the central eastern area due to the hub located at Nervi.

However, note that the location of the four selected hubs is the optimal solution from a geographical and infrastructural point of view; however, a deeper analysis has shown that other economics factors can influence the final decision about the site to be chosen. In fact, for locating a logistic platform either at Nervi or at the Maritime Station we have to pay too high costs. Moreover, other decisional parameters, such as environmental impact, space availability and citizens’ propensions move in the direction of choosing between the platforms located at either Bolzaneto or Struppa.

4. Conclusions.

In this paper a heuristic method for determining optimal hub locations in urban multimodal freight logistic networks has been presented. The proposed algorithm aims at reducing the number of possible candidate nodes to be selected as optimal solution combining aspects coming from both classical location problems and shortest path ones on multimodal networks. The innovative aspect of the two step algorithm is the key role played by the so-called best choice modal change nodes, that is nodes that well perform in terms of multimodal connection with the other nodes of the network. The application of the presented method to the multimodal logistic network model of the urban area of the city of Genoa has allowed us to initially reduce the number of candidate nodes for being site of logistic platforms from 25 to 8, and finally from 8 to 4. The selected 4 logistics platforms are actually very well located from a logistic point of view and also able to reduce noticeable the flow of goods in the city. This result, further validated by a computational experimentation based on random instance, fully reflect the goal of our research, namely to support decisions in urban freight logistics planning. However, considerations about available space, charge, demand, proximity to specific infrastructures as well as the citizen's propensity are relevant decisional parameters that have to be considered in the final choice of the present location problem. Note that these decisional parameters are fully satisfied by 2 over 4 of the selected best choice modal change nodes. In a forthcoming research project we aim at considering in the final selection process of the optimal solution not only traveling criteria but also some of the above ones and also possible other more subjective criteria, taking into a proper account trade-off between cost and benefits for the urban community.

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References

Alumur S., Kara B.Y. (2008) "Network hub location problems: The state of the art". *European Journal of Operational Research,* 190, pp. 1-21.

Ambrosino D., Sciomachen A. (2009) "Location of logistic platforms within urban transportation networks". Proceedings Mathematical Problems in Engineering, Aerospace and Sciences Cambridge Scientific, pp. 672-680.

Chen J.F. (2007) "A hybrid heuristic for the uncapacitated single allocation hub location problem". *Omega,* 35, 2, pp. 211-220.

Crainic T.G., Ricciardi N,n Storchi G. (2004) "Advanced freight transportation systems for congested urban areas". *Transportation Research C,* 12, pp. 119–137.

Crainic T.G., Gendreau M., Potvin J. (2009) "Intelligent freight-transportation systems: Assessment and the contribution of operations research". *Transportation Research C,* 17, pp. 541–557.

Gavriliouk E.O. (2009) "Aggregation in hub location problems". *Computers & Operations Research,* 36, 12, pp. 3136-3142.

Jarzemskiene I. (2007) "The evolution of multimodal transport research and its development issues". *Transport* 22 4, pp. 296-306.

Leinbach T.R., Capineri C. (2007) "Globalized Freight Transport: Intermodality, E-commerce, Logistics and Sustainability". Edward Elgar, Cheltenham, UK, Northampton, MA, USA.

Macharis C, Bontekoning Y.M. (2004) "Opportunities for o.r. in intermodal freight transport research: a review. *European Journal of Operational Research*, 153, 2, pp. 400 - 416.

O'Kelly, M.E. (1987) "A quadratic integer program for the location of interacting hub facilities". *European Journal of Operational Research* 32, pp. 393–404.

Silva M.R., Cunha C.B. (2009) "New simple and efficient heuristics for the uncapacitated single allocation hub location problem". *Computers & Operations Research,* 36, 12, pp. 3152 – 3165.

Wang J. , Chen S., He Y, Gao L. (2006) "Simulation of Transfer Organization of Urban Public Transportation Hubs". *Journal of Transportation Systems Engineering and Information Technology*, 6, 6, pp. 96–102.