

DETERMINATION NUMBERS OF NODES IN THE POSTAL LOGISTICS NETWORK OF PUBLIC POSTAL OPERATOR

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Abstract: *The issuance of network access points and of services to public postal operator is of great importance to customers and other postal operators. In the analysis of most countries in determining the value of access criteria and the number of nodes of the postal logistics network, we came to the following conclusions: models of approach are different and specific for each country. There is no transparent methodology for the definition of particular criteria values (density of access points, minimum number of post offices, distribution/allocation of post offices on urban and rural network and other). In this paper will be defined the criteria related to the density and distribution of network access points and will be determined minimum numbers of nodes in the postal logistics network of public postal operator. Based on the example of the Republic of Serbia, we will propose a model, and test it.*

Keywords: *Location, Networks, Postal traffic.*

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1. INTRODUCTION

The postal network is defined as “the system of organisation and resources of all kinds used by the universal service provider(s) for the purposes in particular of:

- the clearance of postal items covered by a universal service obligation from access points throughout the territory,
- the routing and handling of those items from the postal network access point to the distribution centre,
- distribution to the addresses shown on items.”

Access points are “physical facilities, including letter boxes provided for the public either on the public highway or at the premises of the postal service provider(s), where postal items may be deposited with the postal network by senders”[5].

The public postal operator's network is the carrier of different logistics costs. Level of logistics costs depends on various factors, that PPO can't always control. Number of units in public network is one factor that has influence on logistics cost level. Postal regulator defines the number of public operator's units, as its location. Determination

number of nodes in postal network is important from the postal clients view.

When defining numbers of nodes in the postal logistics network of public postal operator (Public Postal Network - PPN), the first step that has to be taken is to understand the current and future needs of postal users. Access to universal postal service (UPS) involves the use of access points. Therefore it is necessary to develop criteria that take into account the access to postal services and network, suggesting optimal office hours with users, physical access and other relevant fields. It is necessary, therefore, to define and identify what is important for the community and other factors.

The number and position of facilities in the network where service is provided depends on the type of service (an airport, stations of public transportation, fire brigade, ambulances, police stations, post offices) [1],[16]. In order to define the minimum number and location of nodes in the PPN, we have developed a special methodology and used the original and modified methods to address individual requirements. To measure the distance between the nodes with the requirements for servicing and nodes-candidates for PPN, we used the Euclidean distance formula and the lattice structure. In this paper we have applied the theory of mathematical logic and used the algorithms for

solving requirements problems of location. Algorithm for solving the problem of location requirement has been modified in accordance with the needs of our research.

During the research, we have estimated the importance of certain factors for determining admission criteria. Based on that, we came to a conclusion that it is necessary to make certain measurements and comparisons and systematize the decision making process. In this regard, we suggest that the tests are carried out in several steps:

- Step 1 - Stating the scope of the universal postal service (in some countries in the realm of the universal postal service, in addition to the transfer of letterpost items up to 2kg and parcels up to 20kg, postal and financial services for vulnerable population were included). This step affects significantly the determination of the minimum number of post offices with which Public Postal Operator (PPO) must operate.
- Step 2 – Determining the socio-economic and demographic characteristics of the observed country and establishing the relevant factors for the development of postal services.
- Step 3 – Determining the existing infrastructure of PPO and the structure of the universal postal service’s scope and other services provided by PPO.
- Step 4 – Determining the degree of correlation between environmental factors and the requirements for the universal postal service.
- Step 5 - Determining the criteria related to the density, distribution and minimum number of access points, post offices, etc.
- Step 6 - Mapping and testing of access points on the observed territory and determining the minimum number of nodes/units in public postal network.

Based on the example of the Republic of Serbia, we will propose a model of determination numbers of nodes in the postal logistics network of public postal operator, which will also be tested.

2. UNIVERSAL POSTAL SERVICE AVAILABILITY

Article 11a of the Postal Directive obliges member states of the EU to provide a transparent, non-discriminatory condition of access and availability of the elements of postal infrastructure or services provided under the universal service [4],

[6]. Regardless of the efforts being made in this direction, there is no universal method for defining the criteria values for the access to services [10]. Requirements in terms of PPN and basic goals (density of access points, the minimum number of permanent post offices, coverage area, and others), that PPOs have to attain are given in Table 1.

Table 1. PPN, number and position/location of permanent post offices

| PPO | RADIUS | CRITERIA FOR MUNICIPALITY |
|----------------|---|--|
| Czech Republic | Not more than 10km from any location in the municipality to the post office. In villages with more than 2,500 inhabitants, the radius of 2km. | One post office in each municipality with more than 2500 inhabitants; in municipalities with less than 2500 inhabitants if there are joint municipal building and post offices |
| Deutsche Post | In the districts post office per 80km ² | 1 post office in municipalities with over 2000 inhabitants. office in municipalities with over 4000 inhabitants, the nearest post office at a distance of 2km. |
| Swiss Post | 90% of inhabitants has to walk for 20minutes to the nearest post office, or use public transportation (30 minuta maximum for financial postal services) | |

Source: European Regulators Group for Postal Services (2012).

When it comes to the Republic of Serbia, a minimum number of post offices have been mentioned for the first time in 2010 by the **Rules on the conditions for the commencement of postal activities [12]**. It was determined that the PPO is obliged to provide a minimum number of 1400 post offices in order to perform the universal postal service. Their allocation, density and radius of coverage are not considered in this document. Methods and criteria for determining the number and type of postal units are defined in the work of Kujacic et al, 2012 [8]:

- In every settlement with more than 1000 inhabitants and municipality should be provided with at least one permanent post office.
- In settlements with more than 500 inhabitants, but fewer than 1,000 inhabitants, services are made through a mobile UPN (unit of postal network) or postman stand.

- In settlements with less than 500 inhabitants – provision of service is conducted by a postman in a delivery region.
- In settlements with more than 20,000 inhabitants, there has to be at least one permanent UPN on every 20,000 inhabitants.
- Permanent UPN's cannot be farther than 3,000 m from any building in the settlement and the distance between the two UPN in a particular settlement cannot be more than 6,000 m.

Research has shown:

In order to provide universal service, it is essential that PPO has a minimum of 1052 permanent post offices;

For the purposes of 824 settlements with a population of 500-1000, an alternative form of postal network units whose working hours must not be less than 2 hours a day (for example, mobile post office) has to be provided;

If you take into account indicators of development and the fact that there are only a few municipalities that have the status of an urban metropolitan area, it can be concluded that the PPO must have a total of 1052 post offices, of which 360 should be permanent post offices in the urban city area, while other 692 permanent post offices should be allocated in other parts of Serbia (Table 2).

Table 2. Minimum number of post offices

| | Minimum number of post offices (results of simulation) | Number of post offices in PPO - 2012 |
|-------------------------|--|--------------------------------------|
| Belgrade | 157 | 194 |
| Vojvodina | 341 | 425 |
| Other regions of Serbia | 554 | 863 |
| Total | 1052 | 1482 |

Source: Kujacic et al. 2012

Determination of the minimum number of nodes in settlements with more than 1000 and less than 20000 is relatively easy. The problem arises in determining the number of nodes in settlements with more than 20000, because the next to criteria "on UPN every 20,000 inhabitants," must take into account the urban requirements regarding the distance of UPN [3],[9],[11],[14],[15]. Therefore, we will say a bit more about determining of the minimal number nodes PPN in settlements with more than 20,000 inhabitants.

3. METHODOLOGY FOR DETERMINATION NUMBERS OF NODES

Settlements with a population greater than 20,000 are taken into account.

Depending on the requirements in terms of the gravitational areas and the allowed maximum distance of nodes of service from the nodes of demand, the locations of PPN nodes are determined and the total minimum number of PPN nodes [2], [7].

Settlement areas are divided into squares of N zones whose diagonal is 800m, while the radius of a circumscribed circle around 4 square shaped zone (Figure 1). We use Euclidean distance formula.

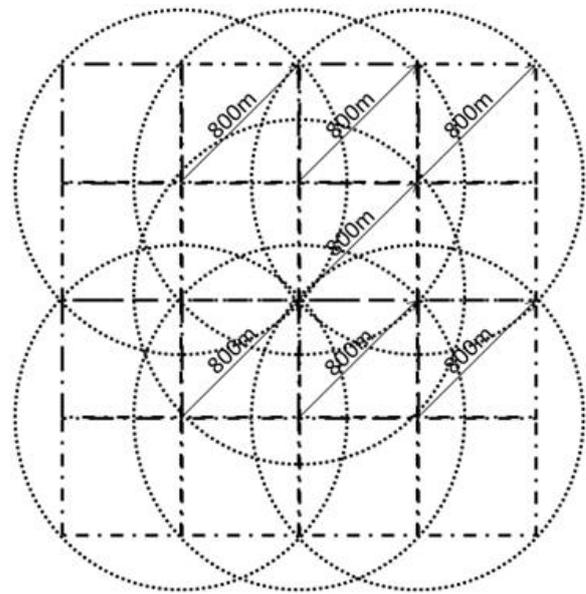


Figure 1. Lattice structure

STEP 1. Lattice structure of the settlement is organized in the following manner - vertical and horizontal line are swiped through the focal point, which generates most gatherings; then, grid is "stretched" left/right and up/down from the focal point, so that it covers the entire settlement area. If the focal point cannot be in the settlement, according to the previously defined the manner, place with the most content is taken as a starting point. This is how a network $G(N, A)$ is obtained, where N represents the number of nodes, A is the number of square zones for which stands $d = 800m$, covering the surface of the settlement.

STEP 2. The values "0" or "1" are assigned to obtained square zones, depending on the urban attributes of observed zones and requirements in terms of coverage radius, i.e. the maximum acceptable distance between the located building in the PPN and the point where demand is generated ("0" for maximum distance up to 800 m and "1" for

maximum distance up to 1600 m). Zones without housing buildings, or, whose percentage of already constructed housing does not exceed 20% of the total area, are not taken into consideration to set up nodes of demand and service. The requirement to determine the radius of the gravitational area is based on the truth of the following statements:

A: The shape of the settlement/zone is an axial shape; B: In the settlement/zone there is a well maintained infrastructure (bicycle and pedestrian path); C: Construction in the settlement/zone is indented; D: The settlement/zone is predominantly single-family residential, E: Settlement/zone has high housing density.

By establishing the logical structure between the evidence, more complex evidence is obtained. Based on this, conclusion is made about the value of the gravitational radius of the zone. The truth value of this complex expression, will indicate the need to define the radius of GP as a value of 1600m, otherwise the value of the radius will be 800m.

STEP 3. Zones are compressed into mega zones, such as type MZ4-11, MZ4-01 (1600 m radius) and MZ2-11, MZ2-01 (radius $800 < r < 1600$).

STEP 4. In each node in network $G'(N',A')$, node is set which generates a service request. There are N' nodes.

When we define the nodes that require service level and nodes that are candidates for allocation of objects in PPN, the task was further resolved as locational problem with the requirements.

4. RESULTS AND DISCUSSION

When considering the implementation of the proposed model for determining the minimum number of PPN nodes, we have considered the example of settlement in Serbia - Backa Palanka. The settlement has a total population of 28,239[13]. Currently the settlement has three permanent post offices – 3 PPN nodes, of which only one post office performs all kinds of services. According to the model of Kujacic et al, in this settlement there should be a minimum of 2 permanent post offices providing all kinds of services.

In order to determine the minimum number of permanent post offices, based on town-planning requirements, the model presented in Chapter 3 will be used.

Settlement is in a compact shape, with well-kept pedestrian and bicycle paths. Settlement has one focal point. Lettice structure was set in relation to the focal point, which divided this settlement into 66 zones. Diagonal of one zone is 800 m. Figure 2 present the values (0 or 1) for each zone that is

considered. Zones that are marked with "x" are not considered, because they do not have market potential, in this particular case. By compressing the zones, mega zones were obtained: 5 - MZ4-11, 1 - MZ4-01, 2 - MZ2-11. Allowed distance for mega zone is 1600m.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| x | x | x | x | x | x | x | x | x | x | x | x |
| x | x | x | x | x | x | x | x | x | x | x | x |
| x | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | x | x | x |
| x | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | x | x | x |
| x | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | x | x | x |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | x | x | x |

Figure 2. Values of zones and mega zone

The application of the proposed methodology determined the position and number of permanent post with complete service level (Figure 3).

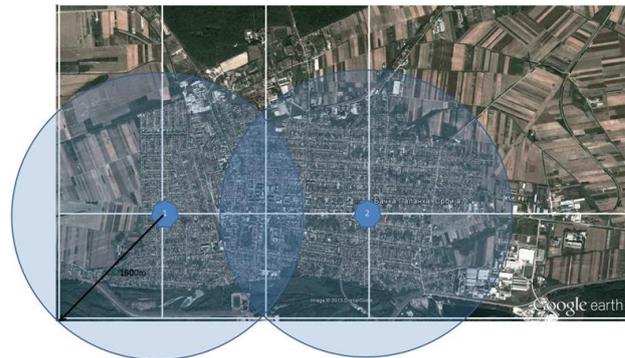


Figure 3. Location of permanent post offices in Backa Palanka

After determining the minimum number of nodes PPN with full service, determined by the availability of services and network for users (Table 3).

In this example, we showed that determining the minimum number of nodes PPN with full service, not decreased the level of service quality. On the contrary, in this example was an increase in the level of quality providing of universal postal services.

In Serbia there are 52 settlements with more than 20,000 inhabitants. By applying the proposed methodology, we have found it necessary to set up 184 post offices (node PPN) for settlements with more than 20,000 inhabitants.

Table 3. Available with services and network

| CURRENT SITUATION | AFTER DEFINING THE MINIMAL NUMBER OF POST OFFICE WITH FULL SERVICE |
|--|---|
| 1 post office with full service 2 post office with partial service | 2 post office with full service |
| 63% of users have access to the post office with full service within a radius of up to 1600m | 100% of users have access to the post office with full service within a radius of up to 1600m |
| 34% of users have access to the post office with full service within a radius of up to 800m | 72% of users have access to the post office with full service within a radius of up to 800m |

5. CONCLUSION

Capacity of the public postal network is a strategic advantage of one country, because it allows access to the universal service in the domestic market, while at the same time, supports the expansion and global integration. Maintenance of public postal network has been entrusted to PPO, while also imposing restrictions on the minimum number and allocation of the permanent post offices on the whole territory of the country.

PPN has to meet the requirements of accessibility to users and to effectively cover the entire territory for which it is organized. That was exactly the reason we had developed a model for determining the minimum number of nodes in PPN. Model has its practical significance, as it is suitable for use by regulators of the postal market, as a tool for determining the minimum number of post offices and establishing the basic conditions for access to the postal network.

From this point of view, a combination of described methods and the model are suitable to apply in the optimization of the PPN.

The results obtained by testing the proposed method indicate the possibility of reducing the number of permanent post those providing universal

postal service, while satisfying the required quality in terms of distance and network availability.

Total savings in logistics network cost was not measured in this case, but we can conclude that savings are not low certainly.

Further research in this area should take into account more parameters in the analysis, such as the characteristics of the observed areas, economic, demographic, social characteristics, etc.

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REFERENCES

- [1] Blagojević, M., Šelmić, M., Macura, D., Šarac, D., 2013. Determining the number of postal units in the network – Fuzzy approach, Serbia case study. *Expert Systems with Applications*, 10, 4090–4095.
- [2] Bohannon, R., 1997. Comfortable and maximum walking speed of adults aged 20-79 years: reference values and determinants. *Age and Ageing* 26, 15-19.
- [3] Filho, C.F.F.C., Rocha D.A.R., Costa M.G.F., Pereira, W.C.A., 2012. *Using Constraint Satisfaction Problem approach to solve human resource allocation problems in cooperative health services*. *Expert Systems with Applications*, 39, 1, 385-394
- [4] European Parliament and the Council of the European Union 1997. Directive 97/67/EC OF, Official Journal of the European Communities.
- [5] European Regulators Group for Postal Services 2012. ERGP REPORT on “access” to the postal network and elements of postal infrastructure; Consultation period: 16th August – 11th September.
- [6] European Parliament and the Council of the European Union 2002. Accompanying document to the Report from the Commission to the European Parliament and the Council on the application of the Postal Directive (Directive 97/67/EC as amended by Directive 2002/39/EC) {COM(2008) 884 final}, 19-20
- [7] Gruen, V., 1964. *The Heart of Our Cities. The Urban Crisis: Diagnosis and Cure*. Simon and Schuster 1964, New York, p. 250: (used in Fairfax County Metro Station Areas Study, 1982).
- [8] Kujačić M., Šarac D., Jovanović B. 2012. Access to the postal network of the public operator, SEETSI & Regional Conference the Role or Strategic Partnership and Re Engineering or the Public Postal Network in the Sustainable Provision or Universal Service Budva, 15-27, ISBN 978-9940-575-11-3, FMSK, Berane.
- [9] Mid-America Regional Council (No Date). *Transit-Supportive Development Guidebook*. Kansas City, Missouri.
- [10] Nera 2007. *Access to Postal Services A Final Report for Postcomm*. London

- [11] Ogilvie, D., Foster, C., Rothnie, H., Cavill, N., Hamilton, V., Fitzsimons, C., Mutrie, N., 2007. Interventions to promote walking: systematic review. *British Medical Journal*, 334 (1204).
- [12] The Republic of Serbia 2010. Regulation on conditions for starting activities of postal services, "Official Gazette of the Republic of Serbia".51/10.
- [13] The Republic of Serbia, Statistical Office of the Republic of Serbia 2011. Census of Population, Households and Dwellings in the Republic of Serbia.
- [14] Transit Cooperative Research Program 2002. Research Results Digest 52: Transit-Oriented Development and Joint Development in the United States: A Literature Review. Washington, DC: Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_52.pdf (accessed September 20, 2012).
- [15] Vučić, V., 1999. Transportation for Livable Cities. New Jersey: Center for Urban Policy Research.
- Zacharias, J., 2001. Pedestrian Behavior and Perception in Urban Walking Environments. *Journal of Planning Literature* 16 (1), 3-18.