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Generalized net model of the Ro-Ro traffic with intuitionistic fuzzy estimation

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Abstract: The present paper describes the process of the Ro-Ro traffic. The evaluations corresponding to the Ro-Ro traffic utilize the theory of intuitionistic fuzzy sets. The model can be used for process optimization.

Keywords: Ro-Ro traffic, Generalized nets, Intuitionistic fuzzy sets

Introduction

In a series of papers [5, 8] we presented Generalized net model of the auto ferry and Ro-Ro traffic. In this paper we present Roll on - Roll off (Ro – Ro) traffic with intuitionistic fuzzy estimation.

Combined transport applies for raise in effective in goods transport. The identity of combined transport is a combination of priority of single kind of transport, participating in haulage and their additional to each other [3, 4]. This way efficiency and optimal use availability infrastructure is reached as well as high quality of offering transport product.

Ro – Ro is a combined technology with a horizontal transfer of transport. In this case the standard combined unit is a vehicle – lorry with a trailer or only trailers. The ships are on two or more decks. Vehicles are shipped or unshipped on one's own drive and for the drivers cabins are available.

The laws of physics give the railway and water transport an environmental advantage. From an environmental perspective, railways and ships are better than road transport because of less air resistance and rolling resistance and because of the possibility of having an even driving pattern with acceleration.

In our country combined transport between road and water (sea and river) transport, have the widest spread as well as containerized traffic on sea as a kind of combined transport.

Main characteristic of the combined transport in the Black sea is a result from the fact than the ships move in large intervals of time (the long time intervals), i.e. the long time of servicing of the standard combined unit in Bulgarian ports.

Practically when the start of servicing of requests for transport is at intervals of longer than 48 hours – the accidental character of flow of requests is changing. In this case the moment of the arrival of the vehicles or containers that will be transported is defined from

the beginning of the loading of the ships. The ships float on schedule and their capacity is known.

To a great importance for Bulgarian Black sea ports are Ro – Ro and container transport.

Now a days between Burgas, Potty and Novorossiysk servicing is realized once a week. The ship is one with capacity of 75 vehicles. Time for realization of circuit trip is six days plus one day for servicing. Consequently, total the time for servicing of requests is seven days. There isn't an alternative route for transport of vehicles – all requests must be service, i.e. no failure. After a certain period of time all vehicles are transported back [6, 7].

In the context of the present model we include some possibilities for the possible ways for evaluation of the auto ferry traffic. To do this we can apply estimations of the Intuitionistic Fuzzy Sets (IFS) [2] on the basis of which some amendments may be undertaken.

The estimations are represented by ordered pairs $<\mu, \nu>$ of real numbers from the set [0,1], where:

$$\mu = \frac{S_1}{S}$$

where:
S – number of all places for vehicles in the ship;
S_1 – number of the requested places in the ship.

$$\eta = \frac{S_2}{S}$$

where S_2 – number of the non requested places in the ship.

The degree of uncertainty $\pi = 1 - \mu - \eta$ reflects the number of vehicles, which have request for places but not use them and vehicles that not have request for place but succeed to get place (in the last minute).

A GN-model

The generalized net model [3, 4] constructed in Figure 1 describes the process of Ro-Ro floats with intuitionistic fuzzy estimation.

The places in the generalized net fall into two categories:

- *T*-places standing for the separate vehicles;
- *L*-places describing the information for the process and intuitionistic fuzzy estimation.

On the other hand the vehicles are interpreted in the Ro-Ro traffic by means of the α-tokens in the *T*-places. The information are described by β-tokens at *L*-places.

Sequentially, α-tokens enter the net through places T_1, T_{10} and T_{19} in some time-moments. These moments will be determined stochastically, when the model is simulated, or they will correspond to real events, when the GN is used for observation of real processes. These tokens have initial characteristic "vehicles *i,* destination", $i = 1, 2, \ldots, n$.

Initially, there might be β_1-tokens located at places L_1 with the characteristics "loading request", $i = 1, 2, \ldots, n$.

Initially, there might be β_2-tokens located at places L_2 with the characteristics "auto ferry *j*", $j = 1, 2, \ldots, m$.

Also initially, when no information has been derived from places L_6, T_7, T_{16} and T_{25}, all estimations take on initial values of <0,0>.

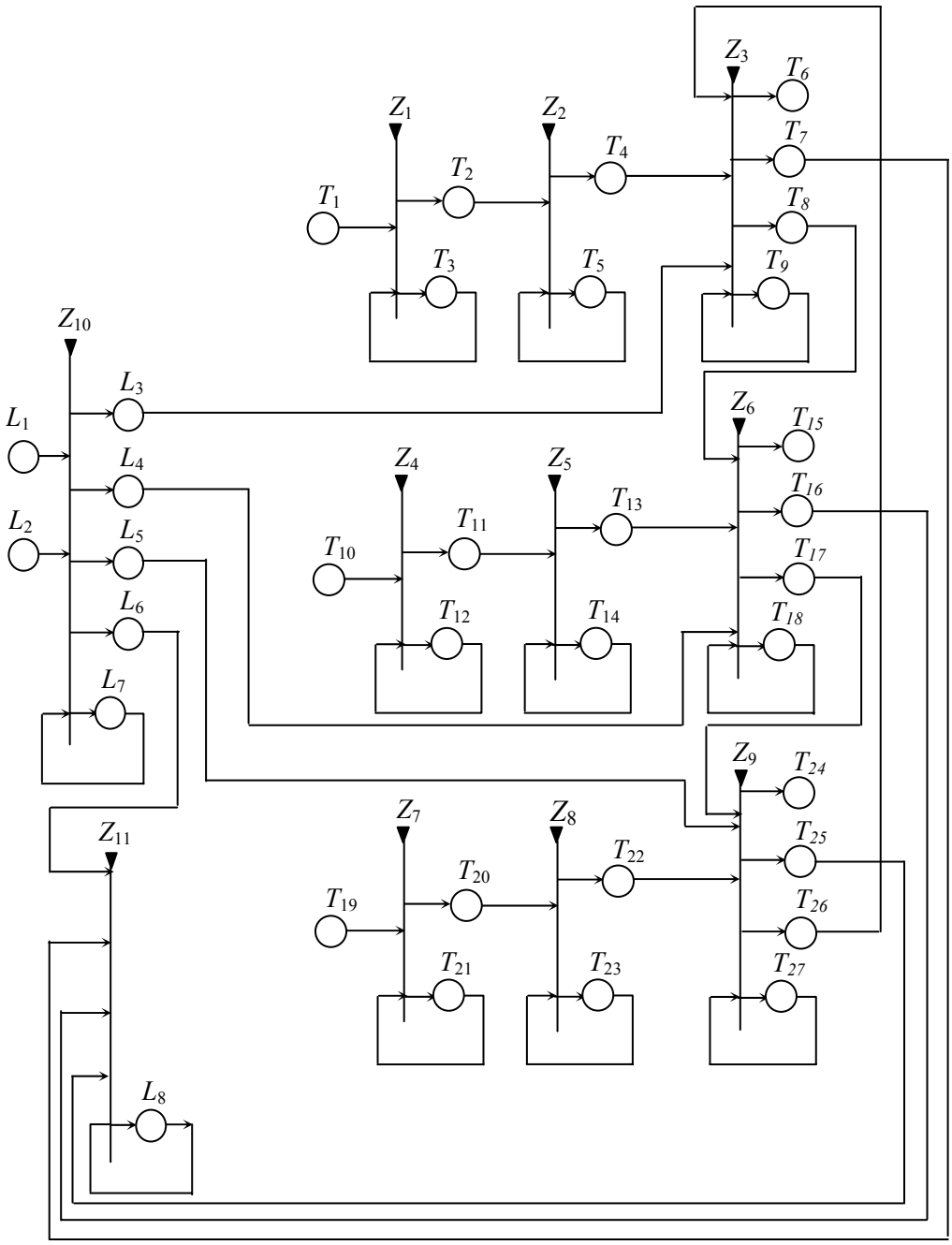

Figure 1: A GN-Model of the Ro-Ro traffic with IFS estimation

The Generalized Net in Action

The Generalized Net [3, 4] contains the following set of transitions:

$$A = \{ Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8, Z_9, Z_{10}, Z_{11}\},$$

where the following transitions represent:

- vehicles on garage and waiting on line for loading of the port Burgas – transitions Z_1 and Z_2;
- the processes of the freighting and unshipping the vehicles on Ro-Ro ship of the port Burgas – transition Z_3 (processes for loading and unloading the Ro-Ro ship);
- vehicles on garage and waiting on line for loading of the port Potty – transitions Z_4 and Z_5;
- the processes of the freighting and unshipping the vehicles on Ro-Ro ship of the port Potty – transition Z_6 (processes for loading and unloading the Ro-Ro ship);
- vehicles on garage and waiting on line for loading of the port Novorossiysk – transitions Z_7 and Z_8;
- the processes of the freighting and unshipping the vehicles on Ro-Ro ship of the port Novorossiysk – transition Z_9 (processes for loading and unloading the Ro-Ro ship);
- transition Z_{10} – process of creation the loading plan for the all ports;
- defining the estimations, on the basis of preliminary set criteria – transitions Z_{11}.

The transitions have the following forms.

$$Z_1 = <\{T_1, T_3\}, \{T_2, T_3\}, R_1, \vee (T_1, T_3)>$$

The index matrix [1] of the transition conditions is:

$$R_1 = \begin{array}{c|cc} & T_2 & T_3 \\ \hline T_1 & false & true \\ T_3 & W^T_{3,2} & true \end{array},$$

where:

$W^T_{3,2}$ = " There is a vacant place in the parking lot",

The α–tokens, entering place T_2 do not obtain new characteristics.

$$Z_2 = <\{T_2, T_5\}, \{T_4, T_5\}, R_2, \vee (T_2, T_5)>$$

The index matrix of the transition conditions is:

$$R_2 = \begin{array}{c|cc} & T_4 & T_5 \\ \hline T_2 & false & true \\ T_5 & W^T_{5,4} & true \end{array},$$

where:

$W^T_{5,4}$ = " There is a vehicle for loading",

The α–token, entering place T_4 obtain new characteristic "vehicle".

$$Z_3 = <\{T_{26}, T_4, L_3, T_9\}, \{T_6, T_7, T_8, T_9\}, R_3, \vee (T_{26}, T_4, L_3, T_9)>$$

The index matrix of the transition conditions is:

$$R_3 = \begin{array}{c|cccc} & T_6 & T_7 & T_8 & T_9 \\ \hline T_{26} & false & false & false & true \\ T_4 & false & false & false & true \\ L_3 & false & false & false & true \\ T_9 & W_{9,6} & W_{9,7} & W_{9,8} & true \end{array},$$

where:

$W_{9,6}$ = " The vehicles are unloads Port Burgas".

$W_{9,7}$ = " There is an information for the ship".

$W_{9,8}$ = " The vehicles are not unloads to Port Burgas".

The α_1–tokens, entering places T_6 and T_8 obtain characteristics respectively:

"Ro-Ro ship j, vehicles i, Port Burgas" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$;

"Ro-Ro ship j, vehicles i, destination" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$.

$$Z_4 = <\{T_{10}, T_{12}\}, \{T_{11}, T_{12}\}, R_4, \vee (T_{10}, T_{12})>$$

The matrix of the transition conditions is:

$$R_4 = \begin{array}{c|cc} & T_{11} & T_{12} \\ \hline T_{10} & false & true \\ T_{12} & W_{12,11} & true \end{array},$$

where:

$W_{12,11}$= " There is a vacant place in the parking lot",

The α'–tokens, entering place T_{11} do not obtain new characteristics.

$$Z_5 = <\{T_{11}, T_{14}\}, \{T_{13}, T_{14}\}, R_5, \vee (T_{11}, T_{14})>$$

The index matrix of the transition conditions is:

$$R_5 = \begin{array}{c|cc} & T_{13} & T_{14} \\ \hline T_{11} & false & true \\ T_{14} & W_{14,13} & true \end{array},$$

where:

$W_{14,13}$= " There is a vehicle for loading",

The α'–token, entering place T_{13} obtain new characteristic "vehicle".

$$Z_6 = <\{T_8, T_{13}, L_4, T_{18}\}, \{T_{15}, T_{16}, T_{17}, T_{18}\}, R_6, \vee (T_8, T_{13}, L_4, T_{18})>$$

The index matrix of the transition conditions is:

$$R_6 = \begin{array}{c|cccc} & T_{15} & T_{16} & T_{17} & T_{18} \\ \hline T_8 & false & false & false & true \\ T_{13} & false & false & false & true \\ L_4 & false & false & false & true \\ T_{18} & W_{18,15} & W_{18,16} & W_{18,17} & true \end{array},$$

where:

$W_{18,15}$= " The vehicles are unloads Port Potty".

$W_{18,16}$= " There is an information for the ship".

$W_{18,17}$= " The vehicles are not unloads to Port Potty".

The α'_1–tokens, entering places T_{15} and T_{17} obtain characteristics respectively:

"Ro-Ro ship j, vehicles i, Port Potty" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$;

"Ro-Ro ship j, vehicles i, destination" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$.

$$Z_7 = <\{T_{19}, T_{21}\}, \{T_{20}, T_{21}\}, R_7, \vee (T_{19}, T_{21})>$$

The matrix of the transition conditions is:

$$R_7 = \begin{array}{c|cc} & T_{20} & T_{21} \\ \hline T_{19} & false & true \\ T_{21} & W_{21,20} & true \end{array},$$

where:

$W_{21,20}$= " There is a vacant place in the parking lot",

The α''–tokens, entering place T_{20} do not obtain new characteristics.

$$Z_8 = <\{T_{20}, T_{23}\}, \{T_{22}, T_{23}\}, R_8, \vee (T_{20}, T_{23})>$$

The index matrix of the transition conditions is:

$$R_8 = \begin{array}{c|cc} & T_{22} & T_{23} \\ \hline T_{20} & false & true \\ T_{23} & W_{23,22} & true \end{array},$$

where:

$W_{23,22}$= " There is a vehicle for loading",

The α''–token, entering place T_{22} obtain new characteristic "vehicle".

$$Z_9 = <\{ T_{17}, L_5, T_{22}, T_{27}\}, \{ T_{24}, T_{25}, T_{26}, T_{27}\}, R_9, \vee (T_{17}, L_5, T_{22}, T_{27})>$$

The index matrix of the transition conditions is:

$$R_9 = \begin{array}{c|cccc} & T_{24} & T_{25} & T_{26} & T_{27} \\ \hline T_{17} & false & false & false & true \\ L_5 & false & false & false & true \\ T_{22} & false & false & false & true \\ T_{27} & W_{27,24} & W_{27,25} & W_{27,26} & true \end{array},$$

where:

$W_{27,24}$= " The vehicles are unloads Port Novorossiysk".

$W_{27,25}$= " There is an information for the ship".

$W_{27,26}$= " The vehicles are not unloads to Port Novorossiysk".

The α''_1–tokens, entering places T_{24} and T_{26} obtain characteristics respectively:

"Ro-Ro ship j, vehicles i, Port Novorossiysk" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$;

"Ro-Ro ship j, vehicles i, destination" $i = 1, 2, \ldots, n, j = 1, 2, \ldots, m$.

$$Z_{10} = <\{L_1, L_2, L_7\}, \{ L_3, L_4, L_5, L_6, L_7\}, R_{10}, \vee (L_1, L_2, L_7)>$$

The index matrix of the transition conditions is:

$$R_5 = \begin{array}{c|ccccc} & L_3 & L_4 & L_5 & L_6 & L_7 \\ \hline L_1 & false & false & false & false & true \\ L_2 & false & false & false & false & true \\ L_7 & W_{7,3} & W_{7,4} & W_{7,5} & W_{7,6} & true \end{array}.$$

$W_{7,3}$= " The cargoplan for port Burgas is created".

$W_{7,4}$= " The cargoplan for port Potty is created".

$W_{7,5}$= " The cargoplan for port Novorossiysk is created".

$W_{7,6}$= " The cargoplan for all ports is created".

The token, entering place L_3 obtain characteristics:

" Cargoplan for port Burgas".

The token, entering place L_4 obtains characteristics:

" Cargoplan for port Potty".

The token, entering place L_5 obtains characteristics:

" Cargoplan for port Novorossiysk".

The token, entering place L_6 obtains characteristics:

" Cargoplan for all ports".

$$Z_{11} = <\{L_6, T_7, T_{16}, T_{25}, L_8\}, \{ L_8\}, R_{11}, \vee (L_6, T_7, T_{16}, T_{25}, L_8)>$$

The index matrix of the transition conditions is:

$$R_5 = \begin{array}{c|c} & L_8 \\ \hline L_6 & true \\ T_7 & true \\ T_{16} & true \\ T_{25} & true \\ L_8 & true \end{array}.$$

The token entering place L_8 obtain characteristic

"estimations $<\mu_k, \nu_k>$".

Initially, when no information has been derived from places L_6, T_7, T_{16} and T_{25}, all estimations take on initial values of <0,0>. When $k \geq 0$, the current $(k+1)$-st estimation is calculated on the basis of the previous estimations according to the recursive formula (as before):

$$<\mu_{k+1}, \nu_{k+1}>= < \frac{\mu_k k + \mu}{k+1}, \frac{\nu_k k + \nu}{k+1} > ,$$

where $<\mu_k, \nu_k>$ is the previous estimation, and $<\mu, \nu>$ is the latest estimation of the ferry traffic , for $\mu, \nu \in [0, 1]$ and $\mu + \nu \leq 1$.

Thus the token in place L_8 forms the final estimation of the Ro-Ro traffic on the basis of the previous and the latest events.

Conclusion

The Generalized Net model described here is a possible model for the process of Ro-Ro traffic. The use of hierarchical operators, which could model the same transition at each place in more detail, would make the model more concrete.

The evaluations corresponding to the Ro-Ro traffic utilize the theory of intuitionistic fuzzy sets

References

[1] Atanassov K., Generalized index matrices. - Compt. Rend. de l'Academie Bulgare des Sciences, Vol.40, 1987, No 11, 15-18.

[2] Atanassov K., Intuitionistic Fuzzy Sets, Springer Physica-Verlag, Berlin, 1999.

[3] Atanassov, K. Generalized nets, World Scientific, Singapore, New Jersey, London 1991.

[4] Atanassov, K. On Generalized Nets Theory, "Prof. M. Drinov"Academic Publishing House, Sofia, 2007.

[5] Bobev V., S. Sotirov, Generalized net model of the auto ferry traffic, using intuitionistic fuzzy estimations, Notes on Intuitionistic Fuzzy Sets, Sofia, 14-15 May 2008

[6] Bobev, V. Investigation and Optimization of the Basic Parameters of Combined Technology between Road and Water Transport. Dissertation, Sofia, 2005. (In Bulgarian)

[7] Bobev, V., I. Penkov. Technological Bases of Research for Ferry-boat Transport. Annual of Burgas Free University. Vol. IX, 2003. (In Bulgarian)

[8] Sotirov S., Bobev V., Generalized net model of the Ro-Ro traffic, Issue on Intuitionistic Fuzzy Sets and Generalized nets, Warszawa, 2008