15th Int. Workshop on Generalized Nets
Burgas, 16 October 2014, 23–28

Generalized net model of the process of wildfire extinguishing by a fire service

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Abstract: A Generalized net model which describes the process of fire extinguishing by a fire service is proposed. The model utilizes up-to-date data about the hot spot being sent to the remote fire station to allow for optimal distribution and control of the available resources.
Keywords: Generalized net, Fire service, Wildfire, Fire extinguishing.
AMS Classification: 68Q85.

1 Introduction

In a series of papers, the authors discuss Generalized Net (GN, see [1,2]) models of anti-fire activities from different points of view (see, e.g., [3–9]). As continuation of our research, here, we construct a GN model which describes the process of fire extinguishing by a fire service.

2 GN model

The GN model presented in Fig.1 consists of six transitions and sixteen places.

- In Z_1 the alarm messages are filtered according to certain criteria.
- In Z_2 all available data for the place where a wildfire is reported is collected. This can be in the form of such measures as coordinates, meteorological data, terrain profile etc.
- In Z_3 all available history for the place is collected.
- Z_4 represents the staff and equipment resources such as fire-fighting machinery.
- In Z_5 a decision is taken whether the available resources are sufficient to cope with the fire.
- Z_6 represents the place of the fire.

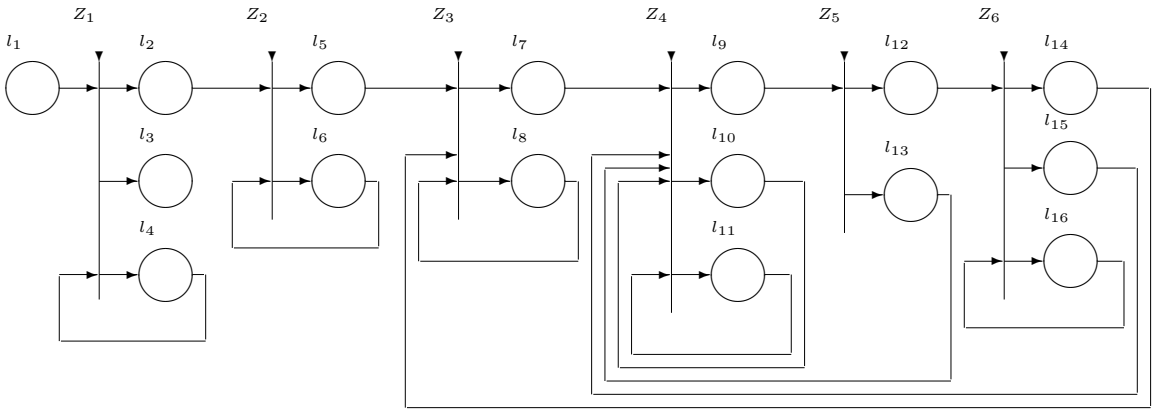

Fig. 1. GN model of the process of fire extinguishing by a fire service.

In the model we have six different types of tokens:

- α represents the alarm message.
- β represents the criteria for the correctness of the alarm messages.
- γ represents the database with data about the place where a fire is reported.
- δ represents the database with historical data about previous fires.
- ϵ represents all machinery available to the fire service.
- ζ represents the fire-fighting stuff of the service.

The α tokens enter the net in place l_1 with initial characteristic:

"alarm message"

Token β stays in place l_4 in the initial time moment with characteristic:

"criteria for correctness of the alarm messages"

Token γ stays in place l_6 in the initial time moment with characteristics:

"database with coordinates, terrain profiles, meteorological conditions etc."

Token δ stays in place l_8 with initial characteristics:

"data about previous fires"

Token ϵ stays in place l_{10} in the initial time moment with characteristic:

"machinery, type, number"

Token ζ stays in place l_{11} in the initial time moment with characteristic:

"stuff, name, decisions taken"

What follows is a formal description of the transitions of the net.

$$Z_1 = \langle \{l_1, l_4\}, \{l_2, l_3, l_4\}, r_1, \square_1 \rangle$$

where

$$r_1 = \begin{array}{c|ccc} & l_2 & l_3 & l_4 \\ \hline l_1 & W_{1,2} & W_{1,3} & false \\ l_4 & false & false & true \end{array}$$

and
$W_{1,2}$ ="the criterion shows that the alarm message is correct"
$W_{1,3} = \neg W_{1,2}$.

$$\square_1 = \wedge(l_1, l_4)$$

If according to the criteria the alarm message is false, the α token enters place l_3 with characteristic

"false alarm"

Otherwise, it enters place l_2 without new characteristic.

$$Z_2 = \langle \{l_2, l_6\}, \{l_5, l_6\}, r_2, \square_2 \rangle$$

where

$$r_2 = \begin{array}{c|cc} & l_5 & l_6 \\ \hline l_2 & true & false \\ l_6 & false & true \end{array}$$

$$\square_2 = \wedge(l_2, l_6)$$

Upon entering place l_5 the α token obtains the characteristic:
"coordinates of the fire, meteorological conditions, terrain profile"

$$Z_3 = \langle \{l_5, l_8, l_{14}\}, \{l_7, l_8\}, r_3, \square_3 \rangle$$

where

$$r_3 = \begin{array}{c|cc} & l_7 & l_8 \\ \hline l_5 & true & false \\ l_8 & false & true \\ l_{14} & false & true \end{array}$$

$$\square_3 = \wedge(l_8, \vee(l_5, l_{14})$$

The token coming from place l_{14} unites with the δ token in place l_8. Upon entering place l_7 the α token obtains the characteristic:

"data about previous fires at the place"

$$Z_4 = \langle \{l_7, l_{10}, l_{11}, l_{13}, l_{15}\}, \{l_9, l_{10}, l_{11}\}, r_4, \square_4 \rangle$$

where

$$r_4 = \begin{array}{c|ccc} & l_9 & l_{10} & l_{11} \\ \hline l_7 & true & false & false \\ l_{10} & W_{10,9} & true & false \\ l_{11} & W_{11,9} & false & true \\ l_{13} & true & false & false \\ l_{15} & true & false & false \end{array}$$

where
$W_{10,9}$ ="A decision to send machinery is taken";
$W_{11,9}$ ="A decision to send more people is taken";

$$\square_4 = \wedge(\wedge(l_{10}, l_{11}), \vee(l_7, l_{13}, l_{15}))$$

When the truth value of the predicates $W_{11,9}$ is "true" token ζ splits into two tokens - the original ζ which remains in place l_{11} and ζ' which enters place l_9 with characteristic:

"names of the fire fighting staff sent to the place of the fire"

When the truth value of the predicate $W_{10,9}$ is "true" token ϵ splits into two tokens - the original ϵ which remains in place l_{10} and ϵ' which enters place l_9 with characteristic:

" type and numbers of the machinery which is sent to the place of the fire"

All tokens entering place l_9 unite and generate a new token $\alpha_{\epsilon,\zeta}$.

$$Z_5 = \langle \{l_9\}, \{l_{12}, l_{13}\}, r_5, \square_5 \rangle$$

where

$$r_5 = \begin{array}{c|cc} & l_{12} & l_{13} \\ \hline l_9 & true & W_{9,13} \end{array}$$

where
$W_{9,13}$ ="the resources being sent are not enough";

$$\square_5 = \vee(l_9)$$

When the truth value of the predicate $W_{9,13}$ becomes "true" the $\alpha_{\epsilon,\zeta}$ token splits into two tokens - the original which enters place l_{12} and a new token $\alpha_{\epsilon,\zeta}$ which enters place l_{13}. In place l_{12} the tokens do not obtain new characteristics. In place l_{13} the tokens obtain the characteristic:

"number of the additional stuff and machinery which is needed; type of machinery"

$$Z_6 = \langle \{l_{12}, l_{16}\}, \{l_{14}, l_{15}, l_{16}\}, r_6, \square_6 \rangle$$

where

$$r_6 = \begin{array}{c|ccc} & l_{14} & l_{15} & l_{16} \\ \hline l_{12} & false & false & true \\ l_{16} & W_{16,14} & W_{16,15} & true \end{array}$$

and
$W_{16,14}$ ="the fire is extinguished"
$W_{16,15}$ ="the resources at the place of the fire are not sufficient"

$$\square_6 = \vee(l_{12}, l_{16})$$

In place l_{16} the tokens receive the characteristic:

"current state of the fire"

Upon entering place l_{14} the $\alpha_{\epsilon,\zeta}$ token obtains the characteristic:

"total burnt area, duration of the wildfire, estimated damages".

3 Conclusion

The proposed GN-model constructed in this paper describes the process of fire extinguishing by a fire service. It can also be used for the simulation of different situations to help in decision-making for them, particularly in training practice for new firies, as well as for the organization in real-time of fire-prevention procedures.

4 Acknowledgments

This research was supported by the Bulgarian National Science Fund, Grant “Simulating the behaviour of forest and field fires”, Ref. No. DFNI-I-01-0006.

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