Information & Security

T. Videv, B. Bozveliev & S. Sotirov
vol. 43, no. 1 (2019): 45-53
https://doi.org/10.11610/isij.4304

Published since 1998

ISSN 0861-5160 (print), ISSN 1314-2119 (online)

Research Article

Modelling of Smart Home Cyber System with Intuitionistic Fuzzy Estimation

Tihomir Videv, Boris Bozveliev, Sotir Sotirov

"Prof. Dr. Assen Zlatarov" University, "Prof. Yakimov" Blvd., Burgas 8010, Bulgaria, https://www.btu.bg/index.php/en/

ABSTRACT:

The turbulent development of the digital technologies in the last few years inevitably led to their usage in all areas of life, including our homes. The technological benefits are demonstrated in the control and management of the so called "Smart House." By extending our opportunities with the remote controller, which provides an enormous freedom of the user, there also comes the threat of breaking in and taking control of the "Smart House." This article reviews the cyber threats to the "Smart House" and provides an analysis by using fuzzy estimations for the possible ways of breaking through the system's defence and interfering with its activities. Various options for preventing cyber threats in such environments are also presented.

ARTICLE INFO:

RECEIVED: 10 JUN 2019
REVISED: 2 SEP 2019
ONLINE: 16 SEP2019

KEYWORDS:

generalized nets, cyber systems, Intuitionistic fuzzy estimation, smart house

Introduction

The current article examines Generalized net (GN) [1, 2] Smart House model which is being controlled remotely by different identifications, channels and automated external systems as well as cloud platform applications. We will view the possibilities of a break-in by a threat in the system, with the idea of taking over the Smart House by rating via intuitionistic fuzzy estimation. Generalized nets and index matrix are tools with which we can describe the processes running through the system to a great detail.[4, 5, 7, 14] Here you can model processes that work in parallel.

✉ Corresponding Author: E-mail: tvidev@abv.bg

With the help of the generalized nets many optimization algorithms were modelled, [3, 9, 10, 14, 13, 11, 21, 17] as well as processes taking place in health and education establishments.[1, 18, 20] A part of the model is connected with intelligent systems as well as neuron nets,[16] genetic and other algorithms.[2, 14, 15, 19, 26, 27] We are examining the system of the Smart House realized by using control modules for remote management via phone, tablet, laptop, PC and more by a cloud platform. Customer applications as well as the automated communication channels are connected in the cloud platform, they are being verified and send requests to their systems. On its own side the cloud structure connects to the controller of the Smart House and via it controls the Smart devices. Possibilities of system penetration are via the customer applications, cloud platform and also through the controller of the Smart House by the different communication channels.[21, 17, 23] When the user enters in a specific app for system control, he verifies himself by entering a password. After the complete verification the app connects to the cloud platform. The software in it connects to the controller that controls the Smart House by a similar verification method. Upon the analysis of the possibilities for invaders in the system, we will add a process achieved via the intuitionistic fuzzy estimation,[24, 25] which will watch over the verification processes and will analyse the successful and unsuccessful attempts and will split the unsuccessful ones to intentional and unintentional. In this article we are observing a common model of the Smart House.[4, 10] The GN model [1, 2] will help us to easily and clearly understand the basic operating mode of the communication systems in the Smart House and the possibilities of penetration in the system so that we can improve the security, to remove malfunctions, and analyse the whole process better.

In this context we will grade the possibilities of a communicational penetration in the system of the Smart House. Here we will use fuzzy sets. The intuitionistic fuzzy sets (IFS) [15, 16, 18, 19] are an expansion of the concept of fuzzy sets. As Zadeh [17] has defined it showing the function $\mu_A(X)$ which determines the membership of an element x to the plurality of A rated in the range of [0; 1]. The difference between the fuzzy sets and the intuitionistic fuzzy sets (IFS) is in the presence of a second function $\mu_A(x)$, which determines if it is not a member of the element x in the plurality of A, where $\mu_A(x) \in [0; 1]$ $\nu_A(x) \in [0; 1]$ if $\mu_A(x) + \nu_A(x) \in [0; 1]$. The IFS itself is formally denoted by:

$$A = \{\langle x, \mu A(x), \nu A(x)\rangle\, x \mid \in E\}$$

We need (IFS), in order to evaluate the possible intrusion of the communication. The estimations are presented by ordered pairs $\langle \mu, \nu \rangle$ of real numbers from set [0, 1], where:

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

where:

S- All verification attempts.

S_1 -All successful verification attempts when the token in place L_6, L_7, L_9, L_{10}, L_{14}, L_{18}.

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

where:

S - All verification attempts.

S_2 – All unsuccessful intentional attempts for a break-in.

$$\pi = \frac{S_3}{S}$$

where:

S_3 - Unsuccessful unintentional verification attempts are started and unfinished for different reasons as well as problems with the internet connection.

GN Model

The systems of Smart house facilitate the users.

Initially the following tokens enter in the generalized net:

For facilitation we separate the following types of tokens:

α – Intruder $i \in [1 \div n]$

β – Database

Υ – Person $j \in [1 \div n]$

μ - Verification

Ω - IFE

ω - Channel of the protocols and the management

The GN model of atomized lightening system (Figure 1) is introduced by the set of transitions:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6\},$$

where the transitions describe the following process:

- Z_1 = “Actions of the intruder”
- Z_2 = “Actions of the users”
- Z_3 = “Management of protocols”
- Z_4 = “Cloud platform management”
- Z_5 = “Systems management”
- Z_6 = “IFE Evaluation”

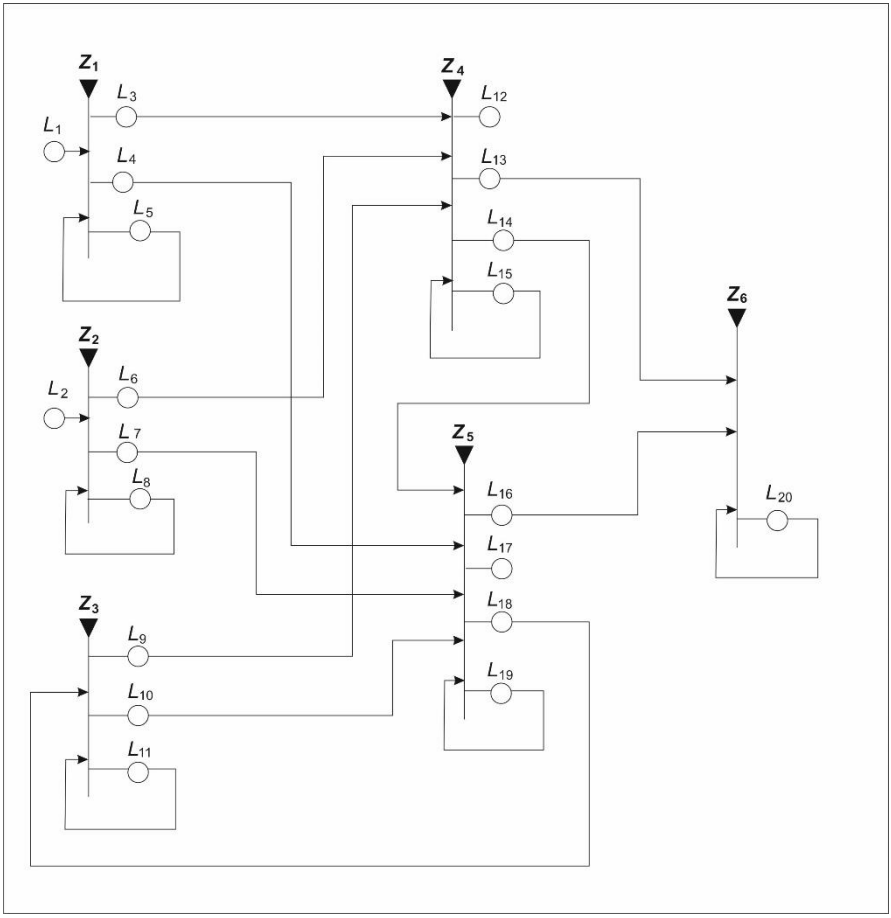

Figure 1: GN model of the Smart house system.

$$Z_1 = <\{ L_1, L_5\},\{ L_3, L_4, L_5 \}, R_1, \wedge (L_1, L_5) >$$

$$R_1 = \begin{array}{c|ccc} & L_3 & L_4 & L_5 \\ \hline L_1 & False & False & True \\ L_5 & W_{5,3} & W_{5,4} & False \end{array}$$

where:

$W_{5,3}$ = "Intruder manages to break in the verification of cloud platform"

$W_{5,4}$ = "Intruder manages to break in the verification of systems management"

The α token that enters place L_1 obtains the characteristic "Intruder."

The μ_1 token that enters place L_3 obtains the characteristic "The Intruder is breaks verification of the cloud platform."

The μ_2 token that enters place L_4 obtains the characteristic "The Intruder is breaks verification of the Systems management."

The β_1 token that enters place L_5 obtains the characteristic "Data base of the Intruder."

$$Z_2=<\{ L_2, L_8 \},\{ L_6, L_7, L_8, \},R_2, \vee (L_2, L_8)>$$

$$R_2 = \begin{array}{c|ccc} & L_6 & L_7 & L_8 \\ \hline L_2 & False & False & True \\ L_8 & W_{8,6} & W_{8,7} & False \end{array}$$

where:

$W_{8,6}$ = "Verification is OK"

$W_{8,7}$ = "Intruder has broken access database verification"

The γ token that enters place L_2 obtains the characteristic "Person."

The μ_3 token that enters place L_6 obtains the characteristic "Verification to enter in the cloud platform."

The μ_4 token that enters place L_7 obtains the characteristic "Verification in smart house controller."

The β_2 token that enters place L_8 obtains the characteristic "The person's data base."

$$Z_3 = <\{ L_{11}, L_{18}\}, \{ L_9, L_{10}, L_{11}\}, R_3, \vee (L_{11}, L_{18})>$$

$$R_3 = \begin{array}{c|ccc} & L_9 & L_{10} & L_{11} \\ \hline L_{11} & W_{11,9} & W_{11,10} & False \\ L_{18} & False & False & True \end{array}$$

where:

$W_{11,9}$ = "Verification is OK."

$W_{11,10}$ = $W_{11,9}$

The ω_1 token that enters place L_9 obtains the characteristic "Control Smart device."

The ω_2 token that enters place L_{10} obtains the characteristic "Connection with home controller."

The β_3 token that enters place L_{11} obtains the characteristic "Data base of the protocols."

$$Z_4 = < \{ L_3, L_6, L_9, L_{15}\},\{ L_{12}, L_{13}, L_{14}, L_{15}\}, R_4, \vee (L_3, L_6, L_9, L_{15}) >$$

$$R_4 = \begin{array}{c|cccc} & L_{12} & L_{13} & L_{14} & L_{15} \\ \hline L_3 & False & False & False & True \\ L_6 & False & False & False & True \\ L_9 & False & False & False & True \\ L_{15} & W_{15,12} & True & W_{15,14} & False \end{array}$$

where:

$W_{15,14}$ = "Verification is OK".

$W_{15,12} = \neg\ W_{15,14}$

The γ_2 token that enters place L_{12} obtains the characteristic "Exit."

The Ω_1 token that enters place L_{13} obtains the characteristic "IFE identification."

The ω_3 token that enters place L_{14} obtains the characteristic "Management of the controller."

The β_4 token that enters place L_{14} obtains the characteristic "Data base of the cloud platform."

$$Z_5 = <\{ L_4, L_7, L_{10}, L_{14}, L_{19}\},\{ L_{16}, L_{17}, L_{18}, L_{19}\}, R_5, \vee (L_4, L_7, L_{10}, L_{14}, L_{19}) >$$

$$R_5 = \begin{array}{c|cccc} & L_{16} & L_{17} & L_{18} & L_{19} \\ \hline L_4 & False & False & False & True \\ L_7 & False & False & False & True \\ L_{10} & False & False & False & True \\ L_{14} & False & False & False & True \\ L_{19} & W_{19,16} & W_{19,17} & W_{19,18} & False \end{array}$$

where:

$W_{19,16}$ = "Verification is OK"

$W_{19,17} = \neg\ W_{19,16}$

$W_{19,18} = W_{19,16}$

The Ω_2 token that enters place L_{16} obtains the characteristic "IFE identification."

The γ_3 token that enters place L_{17} obtains the characteristic "Exit."

The ω_4 token that enters place L_{18} obtains the characteristic "The protocols canal."

The ω_5 token that enters place L_{19} obtains the characteristic "Canals of the real system."

$$Z_6 = < \{ L_{13}, L_{16}, L_{20}\},\{ L_{20} \}, R_6, \vee (L_{13}, L_{16}, L_{20}) >$$

$$R_6 = \begin{array}{c|c} & L_{20} \\ \hline L_{13} & True \\ L_{16} & True \\ L_{20} & True \end{array}$$

The Ω_3 token that enters place L_{20} obtains the characteristic "IFE identification."

Conclusions

The "smart house" system is used for facilitation of the user. The model is presented whit its generalized net and shows the processes which are running through the system, as well as the possible mistakes which could be caused. The possibility of a break-in in the system by a user with bad intentions is also being observed by using the fuzzy evaluation via IFE. The GN model helps us analyse the possible problems or simulate other problems so that we can optimize the systems behaviour.

Acknowledgements

This work was supported by the Bulgarian Ministry of Education and Science under the National Research Programme "Information and Communication Technologies for a Digital Single Market in Science, Education and Security" approved by DCM # 577/ 17.08.2018.

References

1 Nikolay Andreev, Peter Vassilev, Vassia Atanassova, Olympia Roeva, and Krassimir Atanassov, "Generalized net model of the cooperation between the Departments of transfusion Haematology and the National Centre of transfusion Haematology," *Advances in Neural Networks and Applications 2018 (ANNA'18)*, St. Konstantin and Elena Resort, Bulgaria, September 15-17, 2018, pp. 1-4.

2. Maria Angelova, Olympia Roeva, and Tania Pencheva, "Artificial Bee Colony Algorithm for Parameter Identification of Fermentation Process Model," *3rd International Conference on: Applied Physics, System Science and Computers*, Dubrovnik, Croatia, Lecture Notes in Electrical Engineering, September 26-28, 2018.
3. Krassimir Atanassov, Evdokia Sotirova, and Velin Andonov, "Generalized Net Model of Multicriteria Decision Making Procedure Using InterCriteria Analysis," Fuzzy Logic and Technology 2017, *Intelligent Systems and Computing* 641 (2018): 99-111.
4. Krassimir Atanassov, "Index Matrices with Elements Index Matrices," *Proceedings of the Jangjeon Mathematical Society* 21, no. 2 (2018): 221-228.
5. Krassimir Atanassov, "Intuitionistic Fuzzy Sets and Interval Valued Intuitionistic Fuzzy sets.," *Advanced Studies in Contemporary Mathematics* 28, no. 2 (2018): 167-176.
6. Krassimir Atanassov, "n-Dimensional Extended Index Matrices," *Advanced Studies in Contemporary Mathematics* 21, no. 2 (2018): 245-259.
7. Krassimir Atanassov, "On Two-Way Generalized Nets, Annual Meeting of the Bulgarian Section of SIAM," BGSIAM 2017: *Advanced Computing in Industrial Mathematics, Studies in Computational Intelligence* 793 (2017): 51-62.

8. Krassimir Atanassov, Evdokia Sotirova, and Veselina Bureva, "On Index Matrices Part 4: New Operations over Index Matrices," *Advanced Studies in Contemporary Mathematics* (Kyungshang) 23, no. 3 (2013): 547-552.
9. Veselina Bureva, Evdokia Sotirova, and Hristo Bozov, "Generalized Net Model of Biometric Identification Process," *Proceedings of the 20th International Symposium on Electrical Apparatus and Technologies* (Siela, 2018): 1-4.
10. Veselina Bureva, Evdokia Sotirova, Stanislav Popov, Deyan Mavrov, and Velichka Traneva, "Generalized Net of Cluster Analysis Process Using STING: A Statistical Information Grid Approach to Spatial Data Mining," *International Conference on Flexible Query Answering Systems*, Lecture Notes in Computer Science, Vol. 10333 (2017): 239-248.
11. Veselina Bureva, Evdokia Sotirova, and Panagiotis Chountas, "Generalized Net of the Process of Sequential Pattern Mining by Generalized Sequential Pattern Algorithm (GSP)," *Advances in Intelligent Systems and Computing* 323 (2015): 831-838.
12. Veselina Bureva, Plamena Yovcheva, and Sotir Sotirov, "Generalized Net Model of Fingerprint Recognition with Intuitionistic Fuzzy Evaluations," Fuzzy Logic and Technology 2017, *Intelligent Systems and Computing* 641 (2018): 286-294.
13. Veselina Bureva, Stanislav Popov, Evdokia Sotirova, and B. Miteva, "Generalized Net of the Process of Hierarchical Cluster Analysis," Annual of Assen Zlatarov University, Burgas, Bulgaria, vol. XLVI, no. 1 (2017): 107-111.
14. Stefka Fidanova and Olympia Roeva, "Influence of Ant Colony Optimization Parameters on the Algorithm Performance," Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 10665 (2018): 358-365.
15. Stefka Fidanova and Olympia Roeva, "InterCriteria Analysis of Different Variants of ACO algorithm for Wireless Sensor Network Positioning," Lecture Notes in Computer Science, vol. 11189 (Cham: Springer, 2019).
16. Todor Petkov, Plamena Jovcheva, Zhivko Tomov, Stanislav Simeonov, and Sotir Sotirov, "A Generalized Net Model of the Neocognitron Neural Network," International Conference on Flexible Query Answering Systems, *Lecture Notes in Computer Science*, vol. 10333 (2017): 249-259.
17. Desislava Peneva, Violeta Tasseva, Vassilis Kodogiannis, Evdokia Sotirova, and Krassimir Atanassov, "Generalized Nets as an Instrument for Description of the Process of Expert System Construction," *2006 3rd International IEEE Conference Intelligent Systems*, London, UK (2006).
18. Simeon Ribagin, Panagiotis Chountas, and Tania Pencheva, "Generalized Net Model of Muscle Pain Diagnosing," *Lecture Notes in Artificial Intelligence*, vol. 10333 (2017): 269-275.
19. Olympia Roeva, "Application of Artificial Bee Colony Algorithm for Model Parameter Identification," in I*nnovative Computing, Optimization and Its Applications*, edited by I. Zelinka et al., Chapter 17 (Springer, Cham, 2018), 285-303, https://doi.org/10.1007/978-3-319-66984-7_17.
20. Anthony Shannon, Sotirova, Mariya Hristova, and Dae San Kim, "Generalized Net Model of a Student's Course Evaluation with Intuitionistic Fuzzy Estimations in a Digital University," *Proceedings of the Jangjeon Mathematical Society* 13, no.1 (2010): 31-38.
21. Evdokia Sotirova, D.D. Dimitrov, and Krassimir Atanassov, "On Some Applications of Game Method for Modelling Part 1: Forest Dynamics," *Proceedings of the Jangjeon Mathematical Society* 15 no. 2 (2012): 115-123.

22. Velichka Traneva, Evdokia Sotirova, Veselina Bureva, and Krassimir Atanassov, "Aggregation Operations over 3-dimensional Extended Index Matrices," *Advanced Studies in Contemporary Mathematics* (Kyungshang) 25, no. 3 (2015): 407-416.
23. Ivelina Vardeva and Dimitar Valchev, "Generalized Net Model for Building a Standard Ad-hoc Ondemand Distance Vector Routing in a Wireless Network," Development in Fuzzy Sets, Intuitionistic Fuzzy Sets," *Generalized Nets and related topics, Applications* Vol. II (Warsaw: System Research Institute, Polish Academy of Science, 2010), 303-310.
24. Ivelina Vardeva and Liliya Staneva, "Intuitionistic Fuzzy Estimations of Establishing Connections with File Transfer Protocol for Virtual Hosts," *1st Int. Workshop on IFSs*, Mersin, 14 Nov. 2014, *Notes on Intuitionistic Fuzzy Sets* 20, no. 5 (2014): 69–74.
25. Ivelina Vardeva and Valery Gochev, "Calculation of Estimations of Messages by Generalized Nets and Intuitionistic Fuzzy Truth Values," *2012 6th IEEE International Conference Intelligent Systems*, Sofia, Bulgaria, September 6-8, 2012, pp. 242-245.
26. Dafina Zoteva, Olympia Roeva, and Vassia Atanassova, "Generalized Net Model of Artificial Bee Colony Optimization Algorithm with Intuitionistic Fuzzy Parameter Adaptation," *Notes on Intuitionistic Fuzzy Set* 24, no. 3 (2018): 92-104.
27. Dafina Zoteva, Vassia Atanassova, Olympia Roeva, and Eulalia Szmidt, "Generalized Net Model of Artificial Bee Colony Optimization Algorithm," *Neural Networks and Applications 2018 (ANNA'18)*, St. St. Konstantin and Elena Resort, Bulgaria, September 15-17, 2018, pp. 1-4.

About the Authors

See p. 44 of this volume.