

CSE 543: Information Assurance and Security

Using Machine Learning to detect classifying Malware in IoT Systems

Group 14 Weekly Report - 10

Person prepared this report: All the members of the group

Person approved this report: Amogh Manoj Joshi

Person submitted this report: Priyadarshini Venkatesan

List of members

- 1. Amogh Manoj Joshi (Group Leader)
- 2. Priyadarshini Venkatesan (Deputy Leader)
- 3. Vignan Varma Chekuri
- 4. Venkata Karthik Reddy Peddireddy
- 5. Siva Priya Bollineni
- 6. Anusha Akuthota
- 7. Sarika Naidu Chirki
- 8. Ramya Thota

Meeting Notes

03/24/2023: [12:30 pm - 1:00 pm] [Mode: In Person] [Loc: Hayden Library, common area]

- A last in-person meeting was held to finalize the to-do tasks for the remaining days till the report submission.
- The group members had summarized their detailed results based on the research papers they had read.
- The list of contents, organization of topics and flow of report was discussed in the meeting. Similarly, the remaining to-do tasks were discussed and distributed among the group members.
- Attendance: All the members were present.

Tasks Summary

Task Number	Task Name	Description of Task	Member	Task Status
1	Summarizing individual learnings	Team members summarized their learning for the project.	All Members	Done
2	Discussing and finalizing topics	Agreed on what to include on the final report	All Members	Done
3	Distributing to-do tasks	The task for the report was split among the team-mates.	All Members	Done
4	Working on the remaining to-do tasks	Members are working simultaneously on the tasks allocated to them. All Members		On-Going
5	Preparing the final report	Members are collaborating for the final draft of the report	All Members	On-Going

Task Progress

Task Name	Member	Date and time of Review	Reviewer(s)	Mode of Review	Review Conclusion	Recommended Action
1)Summarizin g individual learnings	All members	03/23/2023	All the members of the group	Group meeting	Satisfactory	Completed
2)Discussing and finalizing topics	All members	03/24/2023	All the members of the group	Group meeting	Satisfactory	Completed
3)Distributing to-do tasks	All members	03/24/2023	All the members of the group	Group meeting	Satisfactory	Completed
4)Working on the remaining to-do tasks	All members	03/28/2023	All the members of the group	Group meeting	Needs work	Ongoing
5)Preparing the final report	All members	03/28/2023	All the members of the group	Group meeting	Needs work	Ongoing

Problems:

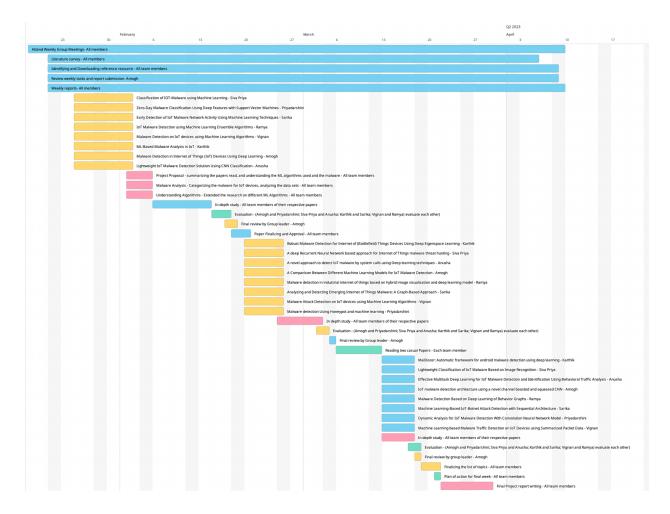
Faced by: All Team Members

Status: Solved

Problem: Assembling data and organizing the content into a single report.

Gantt Chart:

Link to Gantt Chart



References:

Indepth:

- 1. F. Hussain, R. Hussain, S. A. Hassan and E. Hossain, "Machine Learning in IoT Security: Current Solutions and Future Challenges," in IEEE Communications Surveys & Tutorials, vol. 22, no. 3, pp. 1686-1721, thirdquarter 2020, doi: 10.1109/COMST.2020.2986444.
- 2. S. Madan and M. Singh, "Classification of IOT-Malware using Machine Learning," 2021 International Conference on Technological Advancements and Innovations (ICTAI), Tashkent, Uzbekistan, 2021, pp. 599-605, doi: 10.1109/ICTAI53825.2021.9673185.
- 3. R. El-Sayed, A. El-Ghamry, T. Gaber and A. E. Hassanien, "Zero-Day Malware Classification Using Deep Features with Support Vector Machines," 2021 Tenth International Conference on Intelligent Computing and Information Systems (ICICIS), Cairo, Egypt, 2021, pp. 311-317, doi: 10.1109/ICICIS52592.2021.9694256.
- 4. A. Kumar and T. J. Lim, "EDIMA: Early Detection of IoT Malware Network Activity Using Machine Learning Techniques," 2019 IEEE 5th World Forum on Internet of Things (WF-IoT), Limerick, Ireland, 2019, pp. 289-294, doi: 10.1109/WF-IoT.2019.8767194.
- 5. Santhadevi D, Janet B, "IoT Malware Detection using Machine Learning Ensemble Algorithms", International Journal of Advanced Science and Technology (IJAST), vol. 29, no. 10s, pp. 8006-8016, Jun. 2020.
- 6. Achary, Rathnakar, and Chetan J. Shelke. "Malware Attack Detection on IoT Devices Using Machine Learning." In Smart Data Intelligence: Proceedings of ICSMDI 2022, pp. 11-22. Singapore: Springer Nature Singapore, 2022.
- 7. S. Riaz et al., "Malware Detection in Internet of Things (IoT) Devices Using Deep Learning," Sensors, vol. 22, no. 23, p. 9305, Nov. 2022, doi: 10.3390/s22239305.
- 8. A. M. N. Zaza, S. K. Kharroub and K. Abualsaud, "Lightweight IoT Malware Detection Solution Using CNN Classification," 2020 IEEE 3rd 5G World Forum (5GWF), Bangalore, India, 2020, pp. 212-217, doi: 10.1109/5GWF49715.2020.9221100.
- 9. A. Azmoodeh, A. Dehghantanha and K. -K. R. Choo, "Robust Malware Detection for Internet of (Battlefield) Things Devices Using Deep Eigenspace Learning," in IEEE Transactions on Sustainable Computing, vol. 4, no. 1, pp. 88-95, 1 Jan.-March 2019, doi: 10.1109/TSUSC.2018.2809665.
- 10. Hamed HaddadPajouh, Ali Dehghantanha, Raouf Khayami, Kim-Kwang Raymond Choo, A deep Recurrent Neural Network based approach for Internet of Things malware threat hunting, Future

- Generation Computer Systems, Volume 85,2018, Pages 88-96, ISSN 0167-739X, https://doi.org/10.1016/j.future.2018.03.007.
- 11. M. Shobana and S. Poonkuzhali, "A novel approach to detect IoT malware by system calls using Deep learning techniques," 2020 International Conference on Innovative Trends in Information Technology (ICITIIT), Kottayam, India, 2020, pp. 1-5, doi: 10.1109/ICITIIT49094.2020.9071531.
- 12.Kumar, Rajesh & Zhang, Xiaosong & Wang, Wen & Khan, Riaz & Kumar, Jay & Sharif, Abubakar. (2019). A Multimodal Malware Detection Technique for Android IoT Devices Using Various Features. IEEE Access. PP. 1-1. 10.1109/ACCESS.2019.2916886.
- 13. Hamad Naeem, Farhan Ullah, Muhammad Rashid Naeem, Shehzad Khalid, Danish Vasan, Sohail Jabbar, Saqib Saeed, Malware detection in industrial internet of things based on hybrid image visualization and deep learning model, Ad Hoc Networks, Volume 105, 2020, 102154, ISSN 1570-8705, https://doi.org/10.1016/j.adhoc.2020.102154.
- 14. S. Sharma and S. Bharti, "Malware Analysis using Ensemble Techniques: A Machine Learning Approach," 2021 International Conference on Artificial Intelligence and Machine Vision (AIMV), Gandhinagar, India, 2021, pp. 1-5, doi: 10.1109/AIMV53313.2021.9670949.
- 15. J. Su, D. V. Vasconcellos, S. Prasad, D. Sgandurra, Y. Feng and K. Sakurai, "Lightweight Classification of IoT Malware Based on Image Recognition," 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), Tokyo, Japan, 2018, pp. 664-669, doi: 10.1109/COMPSAC.2018.10315.
- 16.ElMoataz Billah Karbab, Mourad Debbabi, Abdelouahid Derhab, Djedjiga Mouheb, MalDozer: Automatic framework for android malware detection using deep learning, Digital Investigation, Volume 24, Supplement, 2018, Pages S48-S59, ISSN 1742-2876, doi: https://doi.org/10.1016/j.diin.2018.01.007.
- 17. S. Ali, O. Abusabha, F. Ali, M. Imran and T. ABUHMED, "Effective Multitask Deep Learning for IoT Malware Detection and Identification Using Behavioral Traffic Analysis," in IEEE Transactions on Network and Service Management, 2022, doi: 10.1109/TNSM.2022.3200741.
- 18. J. Jeon, J. H. Park and Y. -S. Jeong, "Dynamic Analysis for IoT Malware Detection With Convolution Neural Network Model," in IEEE Access, vol. 8, pp. 96899-96911, 2020, doi: 10.1109/ACCESS.2020.2995887.
- 19. Nakahara, Masataka & Okui, Norihiro & Kobayashi, Yasuaki & Miyake, Yutaka. (2020). Machine Learning based Malware Traffic Detection on IoT Devices using Summarized Packet Data. 78-87. 10.5220/0009345300780087.
- 20. Asam M, Khan SH, Akbar A, Bibi S, Jamal T, Khan A, Ghafoor U, Bhutta MR. IoT malware detection architecture using a novel channel boosted and squeezed CNN. Sci Rep. 2022 Sep 15;12(1):15498. doi: 10.1038/s41598-022-18936-9. PMID: 36109570; PMCID: PMC9477830.

- 21. Fei Xiao, Zhaowen Lin, Yi Sun, Yan Ma, "Malware Detection Based on Deep Learning of Behavior Graphs", *Mathematical Problems in Engineering*, vol. 2019, Article ID 8195395, 10 pages, 2019. https://doi.org/10.1155/2019/8195395
- 22. Dartel, B.V. (no date) MALWARE DETECTION IN IOT DEVICES USING MACHINE LEARNING.
- 23. Taheri, R., Javidan, R., & Pooranian, Z. (2021). Adversarial android malware detection for mobile multimedia applications in IoT environments. Multimedia Tools and Applications, 80(24), 16713-16729.
- 24. Wan, T.-L., Ban, T., Cheng, S.-M., Lee, Y.-T., Sun, B., Isawa, R., Takahashi, T., & Inoue, D. (2020). Efficient detection and classification of internet-of-things malware based on byte sequences from executable files. IEEE Access, 8, 103068-103078.

Casual:

- 25. Abusnaina, Ahmed & Anwar, Afsah & Alshamrani, Sultan & Alabduljabbar, Abdulrahman & Jang, RhongHo & Nyang, Daehun & Mohaisen, David. (2021). ML-based IoT Malware Detection Under Adversarial Settings: A Systematic Evaluation.
- 26. Nakhodchi, S., Upadhyay, A., Dehghantanha, A. (2020). A Comparison Between Different Machine Learning Models for IoT Malware Detection. In: Karimipour, H., Srikantha, P., Farag, H., Wei-Kocsis, J. (eds) Security of Cyber-Physical Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-45541-5_10
- 27. Al-Sarem M, Saeed F, Alkhammash EH, Alghamdi NS. An Aggregated Mutual Information Based Feature Selection with Machine Learning Methods for Enhancing IoT Botnet Attack Detection. Sensors (Basel). 2021 Dec 28;22(1):185. doi: 10.3390/s22010185. PMID: 35009725; PMCID: PMC8749651.
- 28. J. M. M. Matin and B. Rahardjo, "Malware Detection Using Honeypot and Machine Learning," 2019 7th International Conference on Cyber and IT Service Management (CITSM), Jakarta, Indonesia, 2019, pp. 1-4, doi: 10.1109/CITSM47753.2019.8965419.
- 29. Amin, M., Shehwar, D., Ullah, A. et al. A deep learning system for healthcare IoT and smartphone malware detection. Neural Comput & Applic 34, 11283–11294 (2022). https://doi.org/10.1007/s00521-020-05429-x
- 30. M. Dib, S. Torabi, E. Bou-Harb and C. Assi, "A Multi-Dimensional Deep Learning Framework for IoT Malware Classification and Family Attribution," in IEEE Transactions on Network and Service Management, vol. 18, no. 2, pp. 1165-1177, June 2021, doi: 10.1109/TNSM.2021.3075315.
- 31. K. D. T. Nguyen, T. M. Tuan, S. H. Le, A. P. Viet, M. Ogawa and N. L. Minh, "Comparison of Three Deep Learning-based Approaches for IoT Malware Detection," 2018 10th International Conference on Knowledge and Systems Engineering (KSE), Ho Chi Minh City, Vietnam, 2018, pp. 382-388, doi: 10.1109/KSE.2018.8573374.

- 32. Peters, W., Dehghantanha, A., Parizi, R.M., Srivastava, G. (2020). A Comparison of State-of-the-Art Machine Learning Models for OpCode-Based IoT Malware Detection. In: Choo, KK., Dehghantanha, A. (eds) Handbook of Big Data Privacy. Springer, Cham. https://doi.org/10.1007/978-3-030-38557-6 6
- 33. M. Fahim and A. Sillitti, "Anomaly Detection, Analysis and Prediction Techniques in IoT Environment: A Systematic Literature Review," in IEEE Access, vol. 7, pp. 81664-81681, 2019, doi: 10.1109/ACCESS.2019.2921912.
- 34. R. Vishwakarma and A. K. Jain, "A Honeypot with Machine Learning based Detection Framework for defending IoT based Botnet DDoS Attacks," 2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2019, pp. 1019-1024, doi: 10.1109/ICOEI.2019.8862720.
- 35. R. Kumar and G. Geethakumari, "Temporal Dynamics and Spatial Content in IoT Malware detection," TENCON 2019 2019 IEEE Region 10 Conference (TENCON), Kochi, India, 2019, pp. 1590-1595, doi: 10.1109/TENCON.2019.8929496.
- 36. Larsen, E., MacVittie, K., & Lilly, J. (2021). A Survey of Machine Learning Algorithms for Detecting Malware in IoT Firmware. ArXiv, abs/2111.02388.
- 37. Zhongru Ren, Haomin Wu, Qian Ning, Iftikhar Hussain, Bingcai Chen, End-to-end malware detection for android IoT devices using deep learning, Ad Hoc Networks, Volume 101, 2020, 102098, ISSN 1570-8705, https://doi.org/10.1016/j.adhoc.2020.102098.
- 38. A. Abusnaina et al., "DL-FHMC: Deep Learning-Based Fine-Grained Hierarchical Learning Approach for Robust Malware Classification," in IEEE Transactions on Dependable and Secure Computing, vol. 19, no. 5, pp. 3432-3447, 1 Sept.-Oct. 2022, doi: 10.1109/TDSC.2021.3097296.
- 39. L. Xiao, X. Wan, X. Lu, Y. Zhang and D. Wu, "IoT Security Techniques Based on Machine Learning: How Do IoT Devices Use AI to Enhance Security?," in *IEEE Signal Processing Magazine*, vol. 35, no. 5, pp. 41-49, Sept. 2018, doi: 10.1109/MSP.2018.2825478.
- 40. R. Raman, "Detection of Malware Attacks in an IoT based Networks," 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Dharan, Nepal, 2022, pp. 430-433, doi: 10.1109/I-SMAC55078.2022.9987253.