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У збірнику представлені матеріали, присвячені питанням створення і впровадження інформаційних технологій, актуальним проблемам забезпечення інформаційної та кібербезпеки, протидії інформаційним операціям і кібертероризму, інтелектуальним технологіям підтримки прийняття рішень, проведенню аналітичних досліджень на основі сучасних методів інтелектуального аналізу даних.

Для фахівців в області інформаційних технологій, інформаційної і кібернетичної безпеки, а також для аспірантів і студентів старших курсів вищої школи відповідних спеціальностей.

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ZETTELKASTEN AS A SEMANTIC FRAMEWORK FOR DECISION-SUPPORT TECHNOLOGIES IN CYBERSECURITY

Yaroslaw Dorogyy[1 [0000-0003-3848-9852]], Nataliya Maslova[2 [0000-0002-9078-0973]], Illia Harbaruk[3 [0009-0004-4264-8689]]

[1] Donetsk National Technical University, str. Sambirska , 76, Drohobych, Ukraine

[2] Lviv State University of Life Safety, 35, Kleparivska St., Lviv, Donetsk National Technical University, str. Sambirska , 76, Drohobych, Ukraine,

[3] Donetsk National Technical University, str. Sambirska , 76, Drohobych, Ukraine

[1] yaroslav.dorohyi@donntu.edu.ua,

[2] masgpp2@gmail.com

[3] illia.harbaruk.kita@donntu.edu.ua

Based on the Zettelkasten methodology and graph modeling, an approach to intelligent decision support in cybersecurity is proposed. The aim of the study is to develop a semantic knowledge base that provides access to relevant information and enables the identification of logical relationships between concepts. The method includes the creation of atomic notes, the construction of bidirectional semantic links, and the analysis of the graph structure using metrics such as density, centrality, and modularity. The obtained results demonstrate improved structural coherence of knowledge, the emergence of new analytical connections, and faster generation of analytical insights.

***Keywords*:** decision support; cybersecurity; semantic knowledge base; Zettelkasten.

Introduction

Cybersecurity is a complex and dynamic domain in which the decision-making process directly depends on high-quality information analysis. Traditional databases, hierarchical catalogs, and static repositories are insufficient for supporting operational analytical activities. Intelligent technologies capable of revealing conceptual relationships and enabling decision-making based on a graph representation of an integrated knowledge network are becoming essential.

Leading publications and recent studies [1–5] confirm that Zettelkasten and graph-based knowledge systems can serve not merely as information storage tools but as technologies for supporting thinking and decision-making, while their integration with artificial intelligence opens prospects for partial automation of analytical processes.

However, comprehensive studies dedicated specifically to the application of the Zettelkasten methodology for decision support in cybersecurity are lacking. This highlights the scientific novelty and relevance of the topic and justifies the need for further research on the development of intelligent knowledge bases for cybersecurity.

The aim of this work is to substantiate and develop an approach to using the Zettelkasten methodology and graph-based knowledge systems as an intelligent decision-support technology in the field of cybersecurity.

Methodology

The conceptual model is based on a networked semantic structure of knowledge in which informational elements are linked through associative relationships. The research model includes three stages: (1) creating atomic notes according to the Zettelkasten methodology; (2) organizing these notes into a semantic knowledge base with bidirectional links; and (3) graph-based representation for structural evaluation and analytical support.

The research methodology includes building a knowledge base in the Obsidian.md environment; using metadata, tags, and bidirectional links to form semantic relationships; applying the DataView and Graph Analysis plugins for dynamic querying and measuring structural indicators; and analyzing the resulting knowledge graph using density, centrality, and modularity metrics.

The practical implementation was carried out in Obsidian using metadata, tags, bidirectional links, and the DataView and Graph Analysis plugins. The structural quality of the graph was assessed through link density, node centrality, and modularity metrics. The impact on analytical activity was evaluated through the speed of retrieving relevant information and the consistency of analytical conclusions.

Findings

The constructed Zettelkasten-based knowledge system formed a network structure with the characteristics presented in Table 1.

Table 1. Results of the Semantic Graph Structure

Evaluation metric	Value
Link density	5,05
Node centrality	7,1%
specialized / general concepts	26,45%
Isolated notes	7%
Total notes	1278

The results presented in the table confirm the high link density of the graph (5.05), the low proportion of isolated nodes (7%), and the presence of conceptual hubs with elevated centrality values (7.1%). This indicates the structural integrity of the semantic knowledge base. In addition, the experiment recorded a reduction in the time required to retrieve relevant information (up to 23%).

The graph-based representation of knowledge facilitated the identification of new interdependencies between attack techniques, defense mechanisms, regulatory requirements, and OSINT data, forming analytical hypotheses that did not emerge at the level of individual notes (Figure 1).

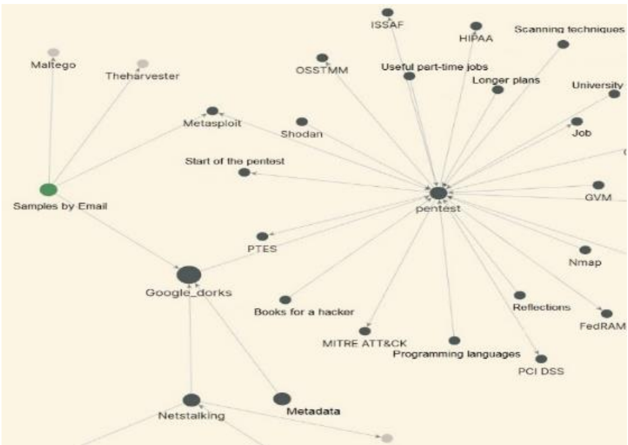

Figure 1. Fragment of the semantic graph

Reducing knowledge duplication and enabling the detection of weakly connected fragments improved the logical coherence and updateability of the information model.

The results confirmed that a Zettelkasten-based semantic graph knowledge system enhances both the validity and the speed of analytical decision-making in cybersecurity.

Conclusions

Zettelkasten combined with graph modeling demonstrates effectiveness as an intelligent decision-support technology in cybersecurity. The high connectivity of the structure, the presence of conceptual hubs, and thematic clusters contribute to faster analytical conclusions and reduce the risk of overlooking important dependencies. The limitations of the study relate to the dependence of result quality on the systematic creation of notes and the absence of large-scale experimental testing. Future development involves integrating AI mechanisms (NER, Graph LLM) for automated knowledge-graph expansion and evaluating the model on larger datasets.

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