

2HCDL: Holistic Human-Centered Development Lifecycle

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Abstract—The recent events affecting global society continuously highlight the need to change the development lifecycle of complex systems by promoting human-centered solutions that increase awareness and ensure critical properties such as security, safety, trust, transparency, and privacy. This fast abstract introduces the Holistic Human-Centered Development Lifecycle (2HCDL) methodology focused on: (i) the enforcement of human values and properties and (ii) the mitigation and prevention of critical issues for more secure, safe, trustworthy, transparent, and private development processes.

Index Terms—Agile, By-Design Approach, Cybersecurity, DevOps, Holistic, Human-centered, Lifecycle, Privacy

I. INTRODUCTION

Ensuring trustworthiness and safe operation in complex systems with vulnerable hardware and software components is of paramount importance. Recent events, such as cyberattacks on critical infrastructure and global service disruptions, underscore the urgent need for innovative engineering approaches. This paper introduces the Holistic Human-Centered Development Lifecycle (2HCDL) methodology, which integrates target properties (e.g., security, safety, trust, transparency, and privacy), aligns with industrial needs, and focuses on stakeholders' requirements. The paper presents the Envisioned Objectives (EOs) of the 2HCDL methodology, its proposed solution, a prototype architecture, and future research directions.

II. ENVISIONED OBJECTIVES

To address the challenges in complex system development, the 2HCDL methodology targets the following Envisioned Objectives (EOs):

- 1) Holistic approach (EO1): Managing software, hardware, automation, electronics, and stakeholders' expertise through comprehensive solutions [1], [2].
- 2) Human-centered approach (EO2): Aligning development with social and ethical values, sustainability, and trustworthiness, and involving diverse stakeholders [1], [3].
- 3) Modeling the behavior (EO3): Considering behavioral profiles of stakeholders in system modeling, implementation, validation, and prediction, utilizing AI, Digital Twins, crowdsourcing, and collaborative platforms [4].
- 4) Integrated by-design approach (EO4): Incorporating target properties as specific principles from the early stages of development to prevent flaws, vulnerabilities, and cybersecurity issues [1].

- 5) Self-adaptation and prediction (EO5): Employing self-adaptive methodologies for efficient component validation, reducing development costs, and predicting issues [5], [6].
- 6) Multidisciplinary approach (EO6): Utilizing various sources of knowledge, such as law, standards, technical specifications, and best practices, for requirements elicitation [7], [8].
- 7) Quantitative and Qualitative proposal and solutions (EO7): Employing quantitative and qualitative analysis for risk management, testing, monitoring, and analyzing cybersecurity risks and violations, and integrating standards, metrics, and guidelines [8], [9].
- 8) Combining different Xs (EO8): Integrating and analyzing different target properties (Xs), such as security (Sec), privacy (Pri), transparency (Tra), lawfulness (Law), accountability (Acc), auditability (Aud), and certification (Cer), for achieving the required quality level [2], [10].

III. THE 2HC DEV-X-OPS METHODOLOGY

The 2HCDL methodology consists of two phases (see Figure 1): Holistic Human-Centered Development (2HC Dev) and Holistic Human-Centered Operation (2HC Ops). In the 2HC Dev phase, the methodology emphasizes modeling, X-by-Design development, and validation. It incorporates user research, user interface design, interaction design, accessibility, and usability testing. The 2HC Ops phase involves deployment, monitoring and logging, and reports & recommendations, enabling self-assessment and prediction. The methodology supports continuous and incremental delivery, by-design principles, self-adaptation, and timely prediction.

IV. ARCHITECTURE AND PRELIMINARY IMPLEMENTATION

The 2HCDL methodology is supported by a prototype architecture that accommodates the 2HC Dev (see Figure 2) and 2HC Ops (see Figure 3) phases. The architecture includes components such as knowledge management, user/domain customization, modeling & coding, testing & validation, usage profile definition, operational environment setting, monitor & logging, and data analytics. This architecture provides a reference for implementing 2HCDL and supports the development and operation of complex systems.

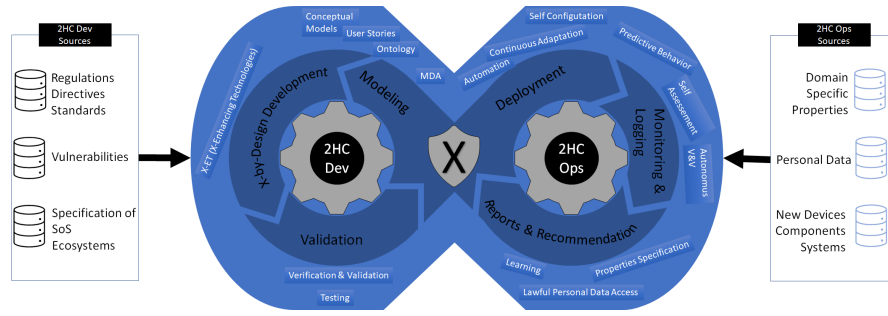


Fig. 1. Holistic Human-Centered Dev-X-Ops (2HC Dev-X-Ops).

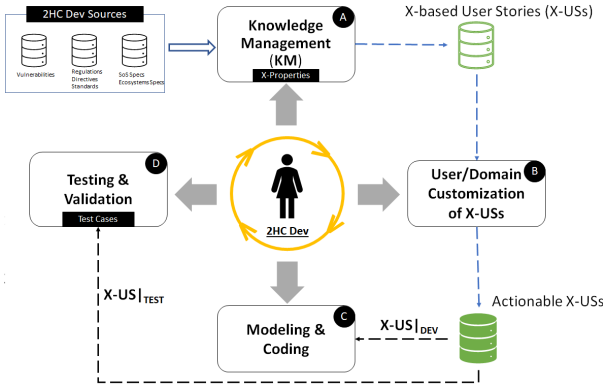


Fig. 2. 2HC Dev-X-Ops: Architecture Supporting Dev Phase.

The 2HC DL methodology builds upon existing partial implementations such as DOXAT [11] and FISS [12]. DOXAT focuses on testing the Policy Decision Point (PDP) in access control systems, ensuring security and privacy. FISS analyzes a target system’s architectural and behavioral specifications to identify safety and security interactions. These implementations contribute to realising the 2HC DL methodology by integrating and extending them to cover other Xs properties.

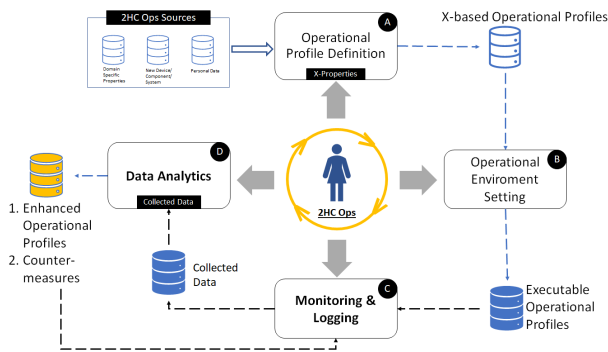


Fig. 3. 2HC Dev-X-Ops: Architecture Supporting Ops Phase.

V. CONCLUSION

The 2HC DL methodology offers a holistic, human-centered approach to system development, integrating critical properties and meeting stakeholders’ requirements. By combining target

properties, employing a multidisciplinary approach, and supporting self-adaptation and timely prediction, 2HC DL enables the development of trustworthy and safe systems. The prototype architecture serves as a foundation for implementation and further exploration.

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REFERENCES

- [1] B. Nicoletti, *Industrial Revolutions and Supply Network 5.0*. Cham: Springer International Publishing, 2023, pp. 43–101.
- [2] J.-S. Shin and J. Kim, “Smartx multi-sec: A visibility-centric multi-tiered security framework for multi-site cloud-native edge clusters,” *IEEE Access*, vol. 9, pp. 134 208–134 222, 2021.
- [3] B. Kehrbusch and G. Engels, *Digital Transformation—Towards Flexible Human-Centric Enterprises*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2023, pp. 497–526.
- [4] J. Dobaj, A. Riel, T. Krug, M. Seidl, G. Macher, and M. Egretzberger, “Towards digital twin-enabled DevOps for CPS providing architecture-based service adaptation & verification at runtime,” in *Proc. of the 17th Symposium on SEAMS*. ACM, 2022, pp. 132–143.
- [5] M. Casimiro, P. Romano, D. Garlan, G. A. Moreno, E. Kang, and M. Klein, “Self-adaptation for machine learning based systems,” in *ECSA (Companion)*, 2021.
- [6] D. Weyns, I. Gerostathopoulos, N. Abbas, J. Andersson, S. Biffli, P. Brada, T. Bures, A. Di Salle, M. Galster, P. Lago, G. Lewis, M. Litoiu, A. Musil, J. Musil, P. Patros, and P. Pelliccione, “Self-adaptation in industry: A survey,” *ACM Trans. Auton. Adapt. Syst.*, vol. 18, no. 2, May 2023.
- [7] S. Baltes and S. Diehl, “Towards a theory of software development expertise,” in *Proc. of the 2018 26th ACM ESEC/FSE*, 2018, p. 187–200.
- [8] R. Hernández, B. Moros, and J. Nicolás, “Requirements management in DevOps environments: a multivocal mapping study,” *Requirements Engineering*, pp. 1–30, 2023.
- [9] A. Van Looy, “A quantitative and qualitative study of the link between business process management and digital innovation,” *Information & Management*, vol. 58, no. 2, p. 103413, 2021.
- [10] J. Giraldo, E. Sarkar, A. A. Cardenas, M. Maniatakos, and M. Kantarcioglu, “Security and privacy in cyber-physical systems: A survey of surveys,” *IEEE Design & Test*, vol. 34, no. 4, pp. 7–17, 2017.
- [11] S. Daoudagh, F. Lonetti, and E. Marchetti, “An automated framework for continuous development and testing of access control systems,” *Journal of Software: Evolution and Process*, vol. 35, no. 3, 2023.
- [12] Priyadarshini, S. Greiner, M. Massierer, and O. Aktouf, “Feature-based software architecture analysis to identify safety and security interactions,” in *20th IEEE International Conference on Software Architecture, ICSEA 2023, L’Aquila, Italy, March 13-17, 2023*. IEEE, 2023, pp. 12–22.