Enterprise Modelling Methodology for Socio-Cyber-Physical Systems Design: Case from Cybersecurity Education and Climate-Smart Agriculture

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INTRODUCTION

The incorporation of various aspects and requirements in socio-cyber-physical (STP) system simulation modelling drives challenges for the application of appropriate methodology and visualisation. The research problem lies in the multi-dimensionality and complexity of these systems. According to information science, the definition of STP implies an understanding of how digital information interacts with and transforms the physical world (which compromises both natural and manmade materials) (Rijswijk et al., 2021). The multi-dimensionality of these system authors is expressed in: 1) time (historical and actual data, future predictions, and continuous updating based on simulation modelling results) (Frazzon et al., 2020); 2) the physical world and its digital representation (Rijswijk et al., 2021); 3) the change in social practices by the influence of the cyber world (Skarga-Bandurova et al., n.d.). All the above-mentioned factors have to be reflected within the comprehensive simulation model.

The author's proposed hypothesis is: the application of multi-scalability and multi-dimensionality within the enterprise modelling approach provides the opportunity to develop a comprehensive model for socio-cyber-physical systems.

The enterprise modelling method provides an excellent background for case studies and the application of the modern Living Lab approach for socio-cyber-physical systems design. But a research gap exists in contextual modelling for the particular solution. It means that for various cases there is specific contextual information that has to be described and taken into account in order to reach the main goal. The author proposes an extension of 4EM methodology for application in two various cases: 1) development of methodology for cybersecurity education; and 2) requirements for the definition of a climate-smart agriculture solution for farmers.

MATERIALS AND METHODS

Method: application of enterprise modelling methodology for 2 various cases: 1. climate-smart agriculture; 2. methodology development for advancing cyber security competencies.

EM consists of 6 inter-related models (Stirna & Persson, 2018):

Goal model, which in general defines the objectives of a company and its problems

in reaching such goals and implementing business processes;

Business law model, which describes the laws that have to be complied with in reaching the goals set and/or implementing business processes or rules in a particular context;

Concept model, which explains concepts used in other models;

Business process model, which generally describes processes to be implemented for reaching the goals and functionality tool;

Actor and resource model, which in general includes the required human resources and material-technical resources for implementing business processes or a particular user;

The model of technical components and requirements, which in general describes the provision of software and hardware for business process implementation, as well as how to reach the goals set and functions of a new remote communication tool.

The model development process was conducted according to methodology requirements in the following steps: 1) expert interview before the modelling session; 2) modelling session; 3) model justification within the expert group.

RESULTS

Results shows that 4EM methodology is an effective methodology for case analysis in uncertain situations and where the solution is not obvious. It brings new insight for the proposed situation and explicitly describes the innovative solution.

The outcome of the modelling sessions conducted was the development of models with incorporated stakeholder needs and requirements. The advantage of the application of 4EM methodology is simplicity and comprehensiveness at the same time. Methodology provides flexibility in a situational analysis and definition of sub-models, which supports the proposed case need and stakeholders' view and ideas. The iterative model design process provides an effective Living Lab approach for stakeholder community building and a snowball effect in engagement.

DISCUSSION

A discussion point regarding 4EM methodology is its completeness and how detailed the description of models and developed sub-models have to be. The application of 4EM in two various cases proves the hypothesis that methodology can be applied as an effective tool for community building within Living Lab.

Future work is related to the incorporation of technological solution and pattern design for the more effective elicitation of requirements.

CONCLUSIONS

The 4EM model has been developed, summarising the requirements and different aspects in using emerging technologies in various situations. It also includes aspects such as social, technological and security factors. Actors and goals have been defended, and important components recognised. Security capabilities and context elements have been determined according to the goal model. Several threats and problems have been identified. The advantage of this model is that the authors formulate technical requirements according to the set context. This approach is a new addition to the existing 4EM process.

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KEYWORDS: Enterprise modelling, Socio-cyber-physical systems, 4EM methodology, Climate smart agriculture, Cyber-security education

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