A Tool and an Approach for the Automatic Generation of Digital Networks

Francesco Pilotti, Giorgio Campea, Daniela D'Alessandro, Daniele Di Valerio and Gaetanino Paolone
Gruppo SI S.c.a.r.l., 64100 Teramo, Italy

Keywords: Automatic Code Generation, Digital Network, Model Driven Engineering, Small- and Medium-sized Enterprises (SMEs), Technological Platform.

Abstract: Today, Web and Mobile applications play an important role in any Information System (IS). Small- and Medium-sized Enterprises (SMEs) need these applications to digitalise themselves and be competitive in a globalised world. However, developing Web applications is a challenging goal. Model Driven Engineering (MDE) is a well-known process for the development of software systems. To sidestep the pitfalls concerning the adoption of MDE in the industry, and to provide SMEs with easy-to-use tools to enter the global market, the paper presents DNetGenerator, a tool which performs the automatic code generation of Web portals in C# code. The Web portals are part of a previous study, aimed at developing Technological platforms for SMEs, in order for them to create and manage a digital network. DNetGenerator allows the deployment of the Web portals on the cloud. The paper presents the process for using the tool as well. With DNetGenerator, SMEs will be able to design, generate and deploy their Web portals, according to their requirements and without any programming skills.

1 INTRODUCTION

Today, Web and Mobile applications play an important role in any Information System (IS). These applications perform many business functions (e.g., order processing, customer relationship management, e-commerce of goods and/or services, etc.). This is true both for large enterprises and Small- and Medium-sized Enterprises (SMEs) willing to implement the digital transformation of their businesses. Since Web and Mobile applications are a relevant component of an IS, nowadays ISs have strong digital features and can be defined *digital* ISs. The main goal of these systems is to improve productivity and efficiency performing the aforementioned business functions. In this context, a Web portal is a portal which performs (some of) these functions. Any organization, SMEs above all, needs these tools to digitalise itself and be competitive in a globalised world.

The backbone of the economy of most countries is composed of SMEs. As pointed out very clearly in the literature, digitalisation has a positive effect on market performance of enterprises and helps the growth of their businesses. It also sets the conditions for SMEs competitiveness in the global market. In light of the literature review conducted in (Pilotti et al., 2021), in order to survive in the global market SMEs must ally themselves with other SMEs operating in the same market segment, and offer an amazing shopping experience to their customers. The pillar of the proposal in (Pilotti et al., 2021) is the notion of digital network, i.e., "*a network of collaborating SMEs physically distributed over a territory, which share the objective of selling goods and/or services to potential consumers through a digital platform*". Web and Mobile applications are relevant components of a digital network.

Developing Web applications is a challenging goal (Agustin and del Barco, 2013). For an IT project to be successful, it must reproduce, as much as possible, the business context, in such a way all the stakeholders can recognize in the software their daily modus operandi: each "actor" plays a set of "use cases" within an organization, regardless of automation. Similarly, for an e-commerce Web application to be efficient, it must reproduce the same purchasing process of the SME commissioning it.

Pilotti, F., Campea, G., D'Alessandro, D., Di Valerio, D. and Paolone, G.
A Tool and an Approach for the Automatic Generation of Digital Networks.
DOI: 10.5220/0011138700003266
In *Proceedings of the 17th International Conference on Software Technologies (ICSOFT 2022)*, pages 121-128
ISBN: 978-989-758-588-3; ISSN: 2184-2833

The Use Case (UC) construct (Booch et al., 1999) is particularly relevant since it exists in the business context independently from the automation process. (Paolone et al., 2008) proposed a methodology that helps reproducing UCs and objects of the business domain into enterprise Web applications. In that work, the UCs were treated as the main pillar for the Web application development, since they are the central concept of the business model: every SME owner and/or manager knows the UCs of their SME, as well as the interactions among them. (Paolone et al., 2010) and (Paolone et al., 2011) reshaped the point of view in (Paolone et al., 2008) in a novel use-case-driven methodology, within the general frame of reference of the Model-Driven Architecture (MDA). MDA enables model-driven software development which treats models as primary development artefacts. Model-Driven Development (MDD), Model-Driven Engineering (MDE), Model-Driven Software Development (MDSD), and MD* are terms used for referring to the existing approaches to model-driven development (Jörges, 2013). (Paolone et al., 2020) mentioned the pitfalls concerning the adoption of MDE in the industry. To sidestep these pitfalls, and to provide SMEs with easy-to-use tools to enter the global market, we developed DNetGenerator, a tool which performs the automatic code generation of the SMEs and Customers portals (the *Web portals*). The Web portals are part of the Technological platform proposed in (Pilotti et al., 2021). The tool also allows the deployment of the Web portals on the cloud. Using DNetGenerator, any SME will be able to design, generate and deploy their Web Portals according to their requirements and without any programming skills.

The present paper is part of an ongoing industrial research project. The frame of reference is MDA, but the pillars of the proposal are, besides the UCs, stereotypes and portal style. Stereotypes allow the implementation of structurally equal portal models; portal style defines the look and feel of each Portal. Both Portals automatically generated by DNetGenerator are essential part of the digital IS of each SME adhering to a digital network. We are aware that the topics addressed in the paper are many, and it is out of the scope of this paper to detail them all. The core concepts and notions briefly recalled in Section 2 aim to give a sketch of the general background that motivates and permeates the project.

The remaining part of the paper is structured as follows. Section 2 summarizes the Background of the paper. Section 3 contains an overview of DNetGenerator and the Technological platform development approach (i.e., the steps required to design, generate and deploy Web portals); it also illustrates the current development state of the tool. Section 4 is about the related work, while Section 5 concludes the paper with a look to the future work.

2 BACKGROUND

This Section collects notions and concepts relevant for our project.

2.1 Technological and Methodological Foundations

Regarding the technological and methodological foundations of the project, we make explicit reference to the Background in (Paolone et al. 2020). The software development process used for the creation of DNetGenerator is, in fact, an instantiation of the proposal described in (Paolone et al. 2020), the only difference being that the generated source code is C# instead of Java. The foundations of the project are: Unified Modeling Language (UML) as modeling language (OMG, 2017); Rational Unified Process (RUP) and MDA as methodological paradigms; the model-driven transformation; cloud computing as baseline technology; finally, automatic code generation.

UML stereotypes are relevant elements for the project. They are language extensions for creating new kinds of building blocks derived from the existing ones, to be used in a specific business domain (Booch et al. 1999). Stereotypes are effective model elements to implement model-driven transformation. They provide details expressive enough for representing a business domain into an application.

RUP is the best-known refinement of the Unified Process (UP). It is an iterative and incremental process for the development of general purpose software (Kruchten, 2003). The disciplines of RUP are: 1. Business Modeling, 2. Requirements, 3. Analysis and Design, 4. Implementation, 5. Test, 6. Deployment, 7. Configuration and Change Management, 8. Project Management, and 9. Environment.

2.2 Portal Style

Regarding the Web portal style, relevant notions for the paper are related to Web design and usability (ISO, 2018). The look and feel of a Web portal concerns both visual aspects (layout, colors, shapes, etc.) and the user's modality of interaction. It can provide many benefits in terms of user experience. An

effective Web portal enables a highly customizable and engaging experience, meeting user's needs and expectations. User Experience Design (Norman, 1999) and User Interface Design (Galitz, 2007) are the most common and effective approaches to embed usability principles into a Web application.

2.3 Alliances and Digital Networks

The current competitive scenario is globalised. SMEs' competitiveness is limited in such a setting, due to two primary factors: (a) limited access to resources and (b) local presence of multinational enterprises (Masroor and Asim, 2019). A systematic review about the current technological challenges and SMEs performance in the global market is (Prasanna et al., 2019). In (Ensari and Karabay, 2014), SMEs' flexibility and capacity to efficiently react to business changes is underlined, while their dimension emerges as a major limitation. The lack of adequate management and technical skills within SMEs is one of the main challenges and barriers to their digital transformation (Rupeika-Apoga et al., 2022).

SMEs alliances and networks are a recurring and articulate topic in research concerning relationships among firms. An incomplete list of contributions is the following: (Varadarajan and Cunningham, 1995; Gulati, 1998; Naeem et al., 2016; Yu et al., 2019; Agostini and Nosella, 2019; Hilmersson and Hilmersson, 2021). The concept of alliance is firmly embedded into that of digital network; in particular, the classification in (Varadarajan and Cunningham, 1995), concerning horizontal and vertical alliances, was adopted in (Pilotti et al., 2021) in defining the digital network and its Technological platform.

3 THE DNETGENERATOR TOOL

An IS is the "technological image" of a business system. SMEs willing to join together in order to build a digital network create a new business system, which is composed of the business system of each adhering SME, and new information from the digital network. DNetGenerator aims to build an IS for creating a technological image of the digital network business system. DNetGenerator automatically generates the Web portals of the Technological platform conceptual model in (Pilotti et al., 2021).

This Section provides an overview of DNetGenerator, and the Technological platform development approach. A Subsection is devoted to showing the details of the tool. The software development approach adopted for the development of DNetGenerator is the same used in (Paolone et al., 2020).

It is important to keep in mind that the development of Web portals is actually part of the development of ISs. Therefore, automatic Web portal generation can be supported by code generators designed for ISs development. However, the IS of a digital network is a new system, not just an extension of each adhering SME IS: this is the peculiarity of our proposal. DNetGenerator can be considered a tool for developing ISs, with a distinctive feature: the generated Technological platform perfectly adheres to the digital network business system.

3.1 Overview of DNetGenerator

DNetGenerator is developed in C# and deployed on a cloud environment (it is an aPaaS). The cloud is also the deployment environment of the generated Web Portals. Using the cloud as generation and deployment environment potentially ensures the alignment between business and IT for the SMEs adhering to the digital network. Business-IT alignment is one of the main focuses in research concerning firms organizational and technological issues (Njanka et al., 2021; Canhoto et al., 2021).

The availability of a tool such as DNetGenerator constitutes a tangible help for the SMEs because, by implementing the automatic code generation, it reduces the level of IT skills that SMEs must have to equip themselves for global competition and establish alliances through a digital platform. The tool quickly and easily generates and deploys the Web portals of the digital network: in so doing it helps sidestepping the obstacles concerning skills, resources and commitment that SMEs usually face in implementing digital platforms (Cenamor et al., 2019).

We assume an arbitrary number of SMEs willing to found a digital network. The following definitions (DN stands for digital network) are used within our overall research project:

- *DN Founder*: the SME founding the digital network;
- *Adhering SME*: a SME joining the digital network;
- *DN Manager*: the actor of the DN Founder;
- *SME Manager*: the actor of an Adhering SME;
- *DN Customer*: any Web user interested in products and/or services of a digital network.

The users of DNetGenerator are the actors of the system. From the user's perspective, the process for using DNetGenerator is the following: a) the DN Founder requests to the DNetGenerator Admin to

create a digital network within the tool; b) the Admin registers the digital network and enables a DN Manager to create new projects; c) the DN Manager uploads the business information of the DN Founder; d) the DN Manager can choose whether to add a new project or a new company (Adhering SME); e) the DN Manager can choose: one among many possible stereotypes to design the structure of the Web portals, the portal style elements of choice, and the Internet domains; f) the SME Manager uploads the business information of the Adhering SME; g) the DN Manager generates the Technological platform (Web portals and DB); h) the DN Customer uses the Web portals.

At a high level of abstraction, DNetGenerator is a black box that receives as input a digital network conceptual model and returns the C# code of the Web portals.

3.2 Technological Platform Development Approach

The Section illustrates the process for creating the Technological platform of a digital network using DNetGenerator.

With the economy in a critical phase, organizations are resetting their goals. To realize these goals, projects are striving for lower costs and higher productivity. On the one hand these goals might be reached by outsourcing, on the other hand standardization, industrialization and reuse could also contribute. A long-term promise in the field of increasing productivity and reuse is to handcraft less code, and generate it from the project's design or model. Reaching this goal has been the one of the main motivations that guided us (and still does) in developing DNetGenerator. The availability of this tool is particularly relevant for SMEs and their need for affordable and easy-to-use software solutions.

DNetGenerator enables a model driven approach to develop projects. The preliminary phase concerns the definition of the digital network business model (computation-independent). This model contains the actors, the Business Use Case Realizations (BUCRs) and the business objects. The phase is in charge of the DN Manager. Afterwards, the approach for building a Technological platform can be expressed in a small number of steps:

1. Derive the digital network conceptual model from the digital network business model. The DN Manager must define structural and behavioral features of the Web portals.
2. Link the digital network conceptual model to the DNetGenerator stereotypes. A growing collection of 5 standard types to generate the digital networks is available, making life easier when it comes to requirements analysis, project creation, testing, and code generation.
3. Decorate the digital network conceptual model. To be able to generate code, the BUCRs are combined with the elements from the domain model and the fitting stereotypes. The BUCRs are associated with the Use Case Realization (UCR) stereotypes.
4. Select the logical model in DNetGenerator. A stereotype in DNetGenerator can be applied to any digital network in order to generate a Technological platform. The UCRs of DNetGenerator are to be used by the DN Manager to configurate names, Internet domains, images, etc., of the Web Portals.
5. Generate code. The generation is based on a cloud reference architecture. The logical model is transformed in a physical model (C# and DB).

DNetGenerator links the digital network conceptual model to the coding of the structural and behavioral aspects. The process described above can be used by a domain expert with no technological background. This was a major requirement of the tool, that has oriented and guided its development. In order to meet this requirement, we adopted a RUP-compliant software development approach, which is also in accordance with (Paolone et al., 2008; Paolone et al., 2010). According to the RUP disciplines, the DNetGenerator development process is summarized below. After defining the DNetGenerator idea, a transition happened from the business idea to the project idea. *Requirements* was about defining the requirements of the tool in order to fulfill the needs of the DN Manager: he/she has only business knowledge. Such an activity produced the BUCRs mentioned in Section 3.3. *Analysis & Design* performed the trace operation of the BUCRs into UCRs, producing the latter. Some of the UCRs are shown in Section 3.3. *Implementation* was carried out to create all the scenarios of all the designed UCRs. The *Test* of the tool is currently in progress. DNetGenerator has been deployed in a testing environment. The same environment is used to deploy and test the generated projects.

3.3 DNetGenerator at Present

The Section describes the current development state of DNetGenerator.

The BUCRs are the following:

- Company Archive: the BUCR allows the request and registration of the digital networks in order for them to use DNetGenerator.
- Project Archive: the BUCR allows the creation of projects related to a company (SME).
- DN Generator: the BUCR allows the automatic generation of the Web portals defined within a company project.
- DN Deployment: the BUCR allows the deployment of the generated Web portals on the cloud.

Some of the UCRs related to the above mentioned BUCRs are presented below, with screenshots taken from DNetGenerator. To achieve a high usability of DNetGenerator, the UIs are visually simple and easy-to-use: the user has only to select options, press buttons, and insert the information in the required fields. The Home Page is shown in Figure 1.

Figure 1: DNetGenerator Home Page.

The UCR Company traces the BUCR Company Archive and is shown in Figure 2.

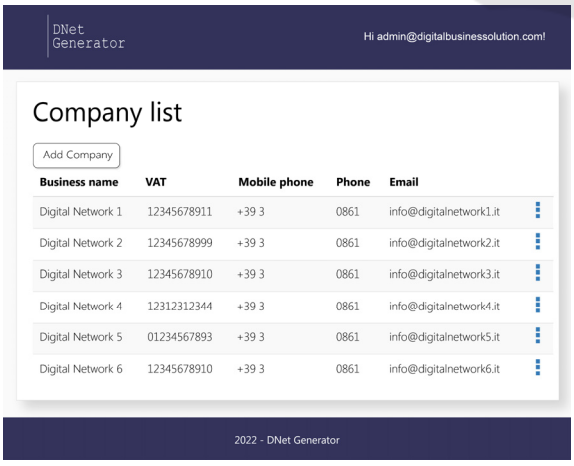

Figure 2: The UCR Company.

The UCR Project traces the BUCR Project Archive and is shown in Figure 3.

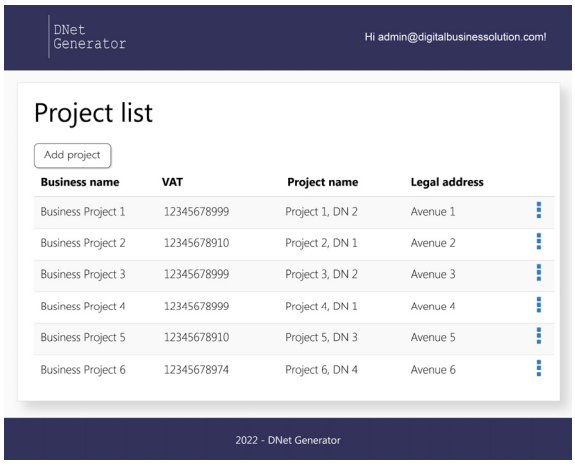

Figure 3: The UCR Project.

Generate is the last UCR described in this paper. It starts by clicking on the “Generate” button as shown in Figure 4.

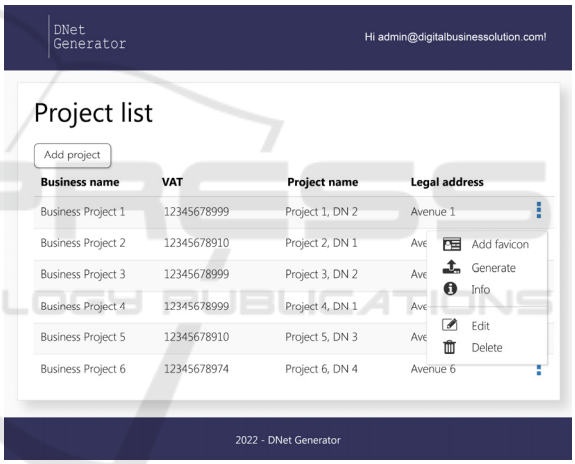

Figure 4: The UCR Generate.

The first scenario of the UCR is shown in Figure 5.

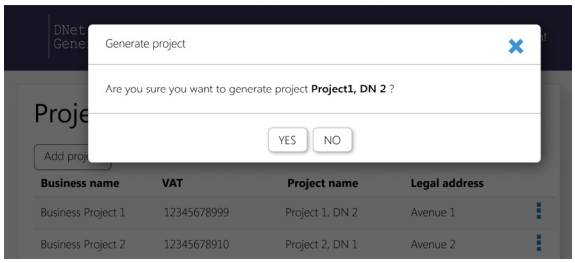

Figure 5: The UCR Generate first scenario.

The generation process is starting at this point (Figure 6): the Web portals and the DB are being generated.

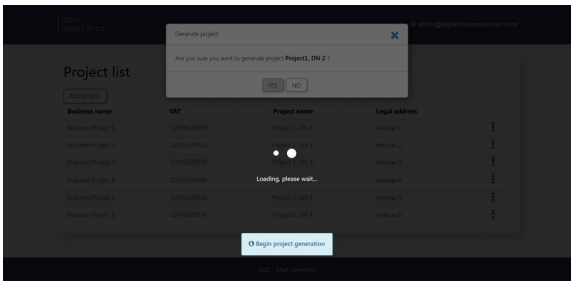

Figure 6: The starting of the generation process.

4 RELATED WORK

To our knowledge, there aren't tools aimed at automatically generating Technological platforms for digital networked SMEs. Hence, the related work of the paper concerns both proposals of code generators in the IS domain, and proposals based on different technologies and paradigms which equip SMEs with digital platforms or methods in order to implement digital networking.

This Section starts with an overview about methods and tools for code generation in MDE and MDA domains, with particular reference to Web portal development proposals. Then it turns to a set of heterogeneous proposals concerning methods, models, and tools technologically and conceptually different from DNetGenerator, but aiming at the same purpose of our tool, i.e., building and supporting digital networks in order for SMEs to be competitive in the global scenario.

4.1 Model-Driven Code Generation

Currently, there are many software development tools enabling model-driven code generation. The contribution in (Kahani et al., 2019) provides an up-to-date state of the art about model transformation tool and techniques. As of today, generating 100% source code is not possible yet. Nonetheless, many empirical studies show that adopting MDE allows for partial code generation.

For example, (Parada et al., 2011) propose an MDE approach to automate code generation that takes into account UML 2.x class and sequence diagrams for embedded systems. This approach generates code (through a tool called GenCode, whose input is the XMI of the UML model) up to the level of method invocations, while variable assignments or math operations cannot be generated.

Regarding UI design based on stereotypes, (da Costa et al., 2014a) proposed a UI stereotype to build Web portals. This stereotype enables the automatic generation of Web Portal UI components. The authors adopted a model driven development approach, namely the Model-Based UI (MBUI) approach proposed by the same authors in (da Costa et al., 2014b). An MDA compliant reference framework establishes the foundation of MBUI. It decomposes UI development in four steps, corresponding to the MDA levels. In (da Costa et al. 2014a), three metamodels are used to specify essential characteristics for the interaction design through a high-level UI description. The proposed generation approach complies with the Interaction Flow Modeling Language (IFML), an OMG standard. Both (da Costa et al., 2014a) and our proposal rely on model driven development aiming at automatic code generation, but the first approach is limited to UI generation, whereas DNetGenerator automatically generates the full executable code of Web portals.

4.2 Tools and Methods for Implementing Digital Platforms

There are many contributions in the literature concerning methods and tools to enable or enhance the digital transformation of SMEs within networks and alliances, and to further their competitiveness in a global scenario. These contributions are heterogeneous and multidisciplinary. A few of them are listed below.

(Hönigsberg and Dinter, 2019) present a specific method which provides a guidance for digital transformation of SME networks, regarding value co-creation (VCC) in particular. The evaluation of the method was carried out with both an artificial evaluation and a case study - a network composed of 4 SMEs in the textile industry. The proposal is built upon 6 requirements drawn from seminal literature and a meeting with the 4 SMEs. From these requirements, the authors derive a process model for implementing the digital transformation in SME networks, then embed it in a larger context taking into account procedure, general conditions, and forms of the method. Finally, 3 viewpoints (a. strategy process, b. digital transformation, c. value co-creation in networks) are considered. The method is composed of 6 process steps, within the formulation and implementation phases. Differently from DNetGenerator, this proposal does not define a specific technological framework, as authors, according to the first elicited requirement, state that "*The method has to be goal-oriented and strategy focused*".

(Aulkemeier et al., 2019) propose an architecture for an inter-organizational platform to facilitate collaboration among partners, in particular by enabling them to build quick connect and disconnect relationship. The authors present a state of the art of collaboration architectures, to assess the predominant inter-organizational IT architectures. In order to improve the quick connect capability of organizations within a business network, they defined the requirements and the platform architecture, following two different design science research methodologies. Then, they created a prototype - for the online retail sector - of the collaboration platform and evaluated it by implementing services. The conclusion of the authors is that the platform approach increases flexibility in business-to-business collaboration. The proposal in (Aulkemeier et al., 2019) shares our very goal to enable platform-based collaboration for organizations, and it is focused on allowing flexible relationships among them; however, it is not aimed at enabling the same kind of digital network that our proposal does. In fact, DNetGenerator generates and deploys, in its final version, a Technological platform specifically designed for implementing vertical and horizontal alliances among SMEs.

(Penha-Lopes et al., 2020) identified the current problems affecting the traditional software development, and presented GENerate Input Output (Genio), a platform which adopts an MDE approach for code generation, supported by patterns (i.e., repeating code lines). Each Genio pattern includes the corresponding generation process: through inference, it translates the model into source code. There are four models to be created in Genio. Genio also manages, maintains, and controls manual components of the code (i.e., not corresponding to a pattern). The modeling doesn't require technological skills, only a good business knowledge: this is a common feature with our proposal.

5 CONCLUSIONS AND FUTURE WORK

This paper describes DNetGenerator, a tool that automatically generates the Web portals of the Technological platform of a digital network, as described in (Pilotti et al., 2021). It is an instantiation of the software development process described in (Paolone et al., 2020).

DNetGenerator is able to generate 100% of the source code of the Web portals, and deploy them on the cloud ready to be used. This is an important achievement of the ongoing industrial research project. The Web portals are the first components of the Technological platform which can be generated by the tool. Implementing the automatic generation of the add-ons of the Technological platform conceptual model (customer satisfaction component, Mobile apps) will be part of the future work.

As of today, DNetGenerator is a working prototype; it is an early example built to test the concept and the process related to digital networks. Further refinements are needed to improve its capability, as well as case studies to validate it.

Other future research directions concern the refinement of the stereotypes and the elements of portal style to be implemented in DNetGenerator. Moreover, the definition of new stereotypes and elements will be useful in order to provide a wider range of choices to SMEs, for example, for digital networks operating in specific domains.

REFERENCES

Agostini, L., and Nosella, A. (2019). Inter-organizational relationships involving SMEs: A bibliographic investigation into the state of the art. *Long Range Planning*, volume 52, pages 1-31.

Agustin, J.L.H., and del Barco, P.C. (2013). A model-driven approach to develop high performance web applications. *Journal of Systems and Software*, volume 86, pages 3013-3023.

Aulkemeier, F., Iacob, M.-E., and van Hillegersberg, J. (2019). Platform-based collaboration in digital ecosystems. *Electronic Markets*, volume 29, pages 597-608.

Booch, G., Rumbaugh J., Jacobson I. (1999). *The Unified Modeling Language User Guide*, Addison-Wesley. New York, NY.

Canhoto, A.I., Quinton, S., Pera, R., Molinillo, S., and Simkin, L. (2021). Digital strategy aligning in SMEs: A dynamic capabilities perspective. *The Journal of Strategic Information Systems*, volume 30(3):101682.

Cenamor, J., Parida, V., Wincent, J. (2019). How entrepreneurial SMEs compete through digital platforms: The roles of digital platform capability, network capability and ambidexterity. *Journal of Business Research*, volume 100, pages 196-206.

da Costa, S.L., Neto, V.V.G., and de Oliveira, J.L. (2014a). A User Interface Stereotype to build Web Portals. In *LA-WEB 2014, 9th Latin American Web Congress*, pages 10-18. IEEE.

da Costa, S.L., Neto, V.V.G., de Oliveira, J.L., and dos Reis Calcado, B. (2014b). User Interface Stereotypes: A Model-Based Approach for Information Systems User Interfaces. *Anais do X Simpósio Brasileiro de Sistemas de Informação (SBSI)*, pages 113-124.

Ensari, M.S., and Karabay, M.E. (2014). What Helps to Make SMEs Successful in Global Markets? *Procedia Social and Behavioral Sciences*, volume 150, pages 192-201.

Galitz, W.O. (2007). *The Essential Guide to User Interface Design – An Introduction to GUI Design Principles and Techniques*, Wiley Publishing. Indianapolis, IN, 3rd edition.

Gulati, R. (1998). Alliances and Networks. *Strategic Management Journal*, volume 19(4), pages 293-317.

Hilmersson, F.P., and Hilmersson, M. (2021). Networking to accelerate the pace of SME innovations. *Journal of Innovation & Knowledge*, volume 6, pages 43-49.

Hönigsberg, S., and Dinter B. (2019). Toward a Method to Foster the Digital Transformation in SME Networks. *ICIS 2019, 40th International Conference on Information Systems*. AIS.

International Organization for Standardization (ISO) (2018). *Ergonomics of Human-system Interaction—Part. 11: Usability: Definitions and Concepts*. ISO/DIS Standard no. 9241.11. International Organization for Standardization. Geneva, Switzerland.

Jörges S. (2013). *Construction and Evolution of Code Generators: A Model-Driven and Service-Oriented Approach*, Springer. Berlin/Heidelberg, Germany.

Kahani, N., Bagherzadeh M., Cordy J.R., Dingel J., and Varró D. (2019). Survey and classification of model transformation tools. *Software & Systems Modeling*, volume 18, pages 2361-2397.

Kruchten, P. (2003). *The Rational Unified Process: An Introduction*, Addison-Wesley. New York, NY, 3rd edition.

Masroor, N., and Asim, M. (2019). SMEs in the Contemporary Era of Global Competition. *Procedia Computer Science*, volume 158, pages 632-641.

Naeem, M., Moalla, N., Ouzrout, Y., and Bouras, A. (2016). A Business Collaborative Decision Making System for Network of SMEs. In *PLM 2016, 13th IFIP International Conference on Product Lifecycle Management*. Springer.

Njanka, S.Q., Sandula, G., and Colomo-Palacios, R. (2021). IT-Business Alignment: A Systematic Literature Review. *Procedia Computer Science*, volume 181, pages 333-340.

Norman, D.A. (1999). Affordance, conventions, and design. *Interactions*, volume 6, pages 38-42.

Object Management Group (OMG) (2017). OMG Unified Modeling Language (OMG UML), Version 2.5.1, OMG Document Number: Formal/2017-12-05, December 2017. Available online: https://www.omg.org/spec/UML/2.5.1/About-UML/ (accessed on 15 February 2022).

Paolone, G., Clementini, E., and Liguori, G. (2008). A methodology for building enterprise Web 2.0 Applications. In *MITIP 2008, International Conference on Modern Information Technology in the Innovation Processes of the Industrial Enterprises*, pages 228-233. University of West Bohemia.

Paolone, G., Di Felice, P., Liguori, G., Cestra, G., and Clementini, E. (2010). A Business Use Case Driven Methodology - A Step Forward. In *ENASE 2010, 5th International Conference on Evaluation of Novel Approaches to Software Engineering*, pages 221-226. SCITEPRESS.

Paolone, G., Di Felice, P., Liguori, G., Cestra, G., and Clementini, E. (2011). Use Case Double Tracing Linking Business Modeling to Software Development. In *Information Technology and Innovation Trends in Organizations*, Physica-Verlag HD. Berlin/Heidelberg, Germany, pages 187-195.

Paolone, G., Marinelli, M., Paesani, R., and Di Felice, P. (2020). Automatic Code Generation of MVC Web Applications. *Computers*, volume 9:56.

Parada, A.G., Siegert, E., de Brisolara, L.B. (2011). Generating Java code from UML Class and Sequence Diagrams. In *SBESC 2011, Brazilian Symposium on Computing System Engineering*, pages 99-101. IEEE.

Penha-Lopes, J., Au-Yong-Oliveira, M., and Gonçalves, R. (2020). Model Driven Automatic Code Generation: An Evolutionary Approach to Disruptive Innovation Benefits. In *CIMPS 2019, 8th International Conference on Software Process Improvement*. AISC vol. 1071, Springer Nature Switzerland AG, pages 234-249. Cham, Switzerland.

Pilotti, F., Paolone, G., Di Valerio, D., Marinelli, M., Cocca, R., and Di Felice, P. (2021). An IT Infrastructure for Small- and Medium-sized Enterprises Willing to Compete in the Global Market. In *ICEIS 2021, 23rd International Conference on Enterprise Information Systems*, volume 2, pages 768-775. SCITEPRESS.

Prasanna, R.P.I.R., Jayasundara, J.M.S.B., Naradda Gamage, S.K., Ekanayake, E.M.S., Rajapakshe, P.S.K., and Abeyrathne, G.A.K.N.J. (2019). Sustainability of SMEs in the Competition: A Systemic Review on Technological Challenges and SME Performance. *Journal of Open Innovation: Technology, Marketing, and Complexity*, volume 5(4):100.

Rupeika-Apoga R., Bule L., and Petrovska K. (2022). Digital Transformation of Small and Medium Enterprises: Aspects of Public Support. *Journal of Risk and Financial Management*, volume 15:45.

Varadarajan, P., and Cunningham, M. (1995). Strategic alliances: A synthesis of conceptual foundations. *Journal of the Academy of Marketing Science*, volume 23(4), pages 282-296.

Yu, B., Xu, H., and Dong, F. (2019). Vertical vs. Horizontal: How Strategic Alliance Type Influence Firm Performance? *Sustainability*, volume 11:6594.