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BEDe: A Modelling Tool for Business Ecosystems Design with ADOxx

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Abstract. In this contribution we explore a design technique for business ecosystem applying conceptual modelling techniques as a means to conceptualize such environments and provide capabilities to explore and analyze its outcomes in a comprehensive manner. The motivation for this work is attributed to the need of methods in the field that support design, collaborations during evaluation/evolution phases of business ecosystems. The requirements are derived from a review of literature and case studies, used as input for a conceptual analysis performed. As an outcome we propose a modelling method and prototype that provides a formal representation of the concepts identified, interaction and sharing capabilities of models and enables domain-specific extension capabilities realized through metamodeling.

Keywords: Business Ecosystems, Business Strategy, Conceptual Modelling, Metamodelling, Modelling Method Engineering.

1 Introduction and Problem Statement

Today's consumers no longer need standardized products or services, nor goods in harmonized quantities. Instead, they demand integrated and complex solutions that satisfy their specific needs. Consequently, the value-adding processes of a company are not limited to its structural boundaries and require an integrated organizational structure that utilizes resources allocated flexibly and in a cooperative manner.

Considering these trends, interactive and dynamic structures between organizations are required. However, a single organization can no longer meet the above challenges [1, p. 24] in isolation. The alternative for vertically integrated companies is a market with many participants that respond independently to quantity and price. In such markets there is a low level of coordination and no common evolution of specific capabilities. When a common benefit is advantageous and complex knowledge is required, such markets fail; they lack in skills as they are specialized in standardized goods [1, p. 24].

1.1 Business Ecosystems as a Concept

"Business ecosystems" offer a solution to these problems: they are characterized as networks of organizations and individuals who jointly develop skills and coordinate their investments. Assuming the rapidly changing environment, this form of organization offers advantages in the appropriate context to traditionally integrated enterprises. Flexible configuration of the ecosystem enables intelligent offerings based on coordinated activities, and capabilities to respond to unexpected events.

The concept of “business ecosystems is not new and has been under investigation in recent years (e.g. [2], [3], [4, pp. 50–51]), lately experiencing a boom in strategy development [5, p. 2256]. In “The Palgrave Encyclopedia of Strategic Management” [6] Teece assumes that “the concept of ecosystem might now substitute for the industry as a useful domain for performing economic analysis.” [6, p. 2]. Reviewing these results published, it can be observed that due to extended definition space, a common understanding of the terminology cannot be derived; conceptual design instruments are required to retrospectively understand and learn from past developments with respect to ecosystems but also provide tools for planning and assessing future designs and their evolution. As such, this contribution aims to clarify and derive systematically a conceptual view of the terminology established, develop a modelling method formalizing the terminology including processing techniques for design interaction and assessments.

1.2 Observations and Identified Challenge

Tsujimoto explores in [4] that the focus of research is set to a limited degree on ecosystem dynamics and patterns as well as organizational behavior [4, p. 52]. It is increasingly important to investigate design approaches for business ecosystems and understand how one needs to construct value-creating systems [7, pp. 255–256]. Following Philips and Srai in [8] there has been limited focus on the creation and design of business ecosystems [8, p. 3], further extended by Senyo et al. in [9] arguing that this research trend should be supported by modelling artefacts as a basis for validation [9, p. 58]. Consequently, the research objective underlying the work presented aims to introduce a metamodel for business ecosystem, having its baseline on a conceptual analysis of the terminology used in literature and elevating the formal knowledge representation towards functionality to support the design and evaluation phases systematically, using the representation capabilities of digital model artefacts.

The remainder of the paper is structured as follows: chapter 2 provides an introduction to related work as input for the concept development performed in chapter 3.1. Chapter 3.2 presents the BEDe modelling method applying the framework of Karagiannis discussed in [10] and using the design technique discussed in [11]. The paper concludes with a presentation of the resulting prototype in chapter 4 as an evaluation and concluding remarks/further research directions in chapter 5.

1.3 Related Work

This chapter introduces related work within the domain and establishes the foundation for the conceptualization performed.

Business Ecosystem. Business ecosystems according to Moore [3] are *“an economic community supported by a foundation of interacting organisations and individuals (...).”* [3, p. 9]. Jacobides et al. see their distinctiveness in complementarity: *“(...) they provide a structure within which complementarities (of all types) in production and/or consumption can be contained and coordinated without the need for vertical integration.”* [5, p. 2263]. Adner suggests they are a *“(...) multilateral set of partners that need to interact in order for a focal value proposition to materialise”* [12, p. 42].

We can recognize that “structure” for coordination between nodes is required. This implies that nodes are typed and represent partner relations, which, based on their classification describe the coordination structure. Thus, a distinction can be made based on the classification of a business ecosystem as suggested by Adner in [12, p. 40] into ecosystems-as-structure, focusing on the value proposition and ecosystems-as-affiliation, focusing on communities, sharing a common network and platform. This observation is defined within the proposed metamodel as “views” on the ecosystems, characterized as a network structure, utilizing the concepts for describing them and resulting in a meaningful, human-interpretable visualization. Four types of concepts are recognized from literature:

- Actors: as typed members within the ecosystem,
- Activities: as a classification of interaction,
- Positions: as a classification of actors in the network, and
- Links: defined generically as relationships.

These concepts are considered in the conceptualization specifically focusing on Actors and Relationships as the combination of both aspects result in Activities (tasks performed between actors), Position as the relative position within a concrete ecosystem and Links as the foundation for any relationship established. The related work shows that the semantics of ecosystems is derived from the relationship of actors which define the behavior aspects and domain purpose in the design.

Actors. The work of Iansiti and Levien in [2, p. 4] and Moore in [3] identify three types of actors. They are understood as constraints imposed on the generic type of an actor and relate to their prevalence, position as influence, characteristic in the domain, related activities and the role they play in the ecosystem.

Table 1. Actor Types and Characteristics

Characteristic	Actor Type		
	Keystone	Niche-player	Dominator
Prevalence	Few	Numerous	Numerous/few/none
Influence	Powerful	Low	Powerful
Task/Activity	Regulation, change initiation, guiding	Specialization, expertise	Controlling, destruction, exploitation, value draining
Ecosystem supportive	Yes	Yes	No

Table 1 provides an overview of the findings and the classification based on common characteristics. A dimension that is relevant for the modelling artefact and the design of the metamodel relates to the contextualization of an ecosystem. Context as the domain-specific representation influences the characteristics and their assessment.

Relationships. Although relationships in business ecosystems originate with one actor and end with another one, they are also reciprocal and interactive [13, pp. 158–159]. Tsujimoto et al find that vision sharing and trust are essential elements of business ecosystem relationships [4, pp. 52–55] though literature about business ecosystem relationships offers varying views.

Camarinha-Matos and Afsarmanesh see collaborative relations as central and divide them into organised-collaborative and ad-hoc ones. The former are long-term and strategic, the latter are short-term and focused on specific tasks. The existence of organized-collaborative relations makes business ecosystems possible [14, pp. 2464–2465]. Actors and relationships represent the core concepts considered for the design supporting hierarchy and modularity (as discussed in [5, p. 2260]), boundaries (introduced as interdependencies in [15]) and evolution.

Structural Analysis. Although literature widely discusses collaboration benefits, there is still no suitable way to measure them [16, p. 238]. Iansiti and Levien aim to find factors of a healthy ecosystem and identify these: productivity, robustness and niche creation [2], extended by reciprocity [13] and value alignment [17].

1. Productivity: This could be measured by evaluating the conversion of technology and materials into reduced costs and new products. A traditional way of measuring this is return on invested capital [2, pp. 3–4].
2. Robustness: Organizations in a robust business ecosystem have relative predictability, and buffer external shocks. A metric is the members' survival rate in relation to benchmark ecosystems [2, p. 4].
3. Niche creation: An ecosystem's ability to create meaningful diversity helps to absorb external shocks. One way to assess niche creation is to measure the application of new technologies in organizations and goods [2, pp. 4–5].
4. Reciprocity: Every actor who invests should receive something in return. It is not purely mathematically, as it is intuition or gut feeling and its analysis examines the ratio between providing and receiving. [13, p. 197].
5. Value Alignment: A quantitative way of analysis is the alignment of the system members. Three areas of analysis are proposed: shared core values, positive impact and potential for conflict [17, p. 416].

For the modelling method design these criteria are considered as evaluation and assessment that operate as model-value functionality on the model artefact and utilizes the design results achieved.

2 Modelling Method: BEDe

In this chapter, the conceptual metamodel for the Business Ecosystem Design Environment (BEDe) is introduced based on the related work section above. The concepts identified above are systematically mapped in the Generic Metamodeling Framework introduced in [10], and utilized during various domain-specific modelling method development projects (see [18] for examples). Two areas are considered in the conceptualization: a) the modelling technique (as the metamodel, defining the modelling language and modelling procedure) and b) model-processing algorithms based on the metamodel.

Modelling Language as the Metamodel. The modelling language defines the concepts, characteristics and connectors relevant for the domain of business ecosystem design. The language is constituted as the metamodel, defining notation, syntax and semantic of the concepts and their interdependencies in a formal manner.

The conceptual metamodel defining the language capabilities is graphically shown in Fig. 1. Applying the CoChaCo approach as a domain-specific language for metamodel design (introduced in [19] and applied on conceptual structures in [11]). Concepts are depicted as squares, connectors as ellipses and characteristics as dotted boxes. The relations in the metamodel are defined according to core RDF syntax. A specific aspect in CoChaCo is the assessment of the purpose of metamodel elements, depicted as orange edged squares.

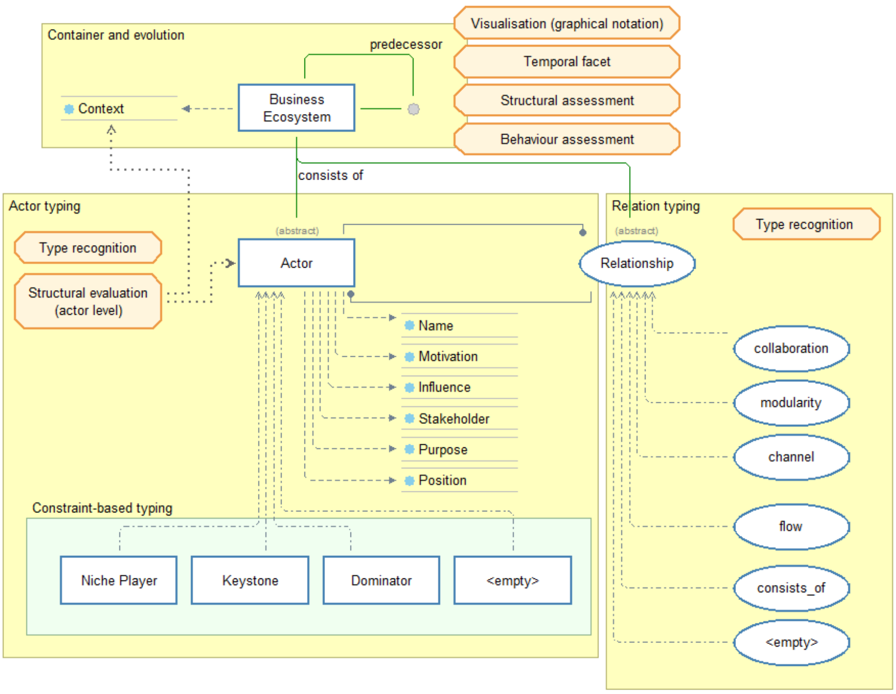

Fig. 1. BEDe Metamodel Design Result

The BEDe metamodel considers at this stage the following aspects:

- Temporal/evolution aspect of a business ecosystem: represented using a predecessor relation
- Composition: general composition logic to support the view characteristic (containment relation between abstract actors and relationships)

- Typing: Actors and Relationships are typed by the domain-specific classification. The tying logic operates upon the characteristics and defined constraints on each concrete type
- Network structure: an ecosystem is characterized by a network structure between Actors applying Relationships. Cardinalities in the structure are currently disregarded but would elevate the constraint logic based on their types.

The metamodel is considered a conceptual structure that covers the structural aspects, but also logical representation as a serialization of the design artefact.

Mechanisms and Algorithms. Model processing in BEDe is established based on the metamodel introduced in chapter 3.1. As a means for structural assessment, a continuous evaluation approach is suggested that informs the business ecosystem designer during the modelling task on the artefact's "health" status. The processing logic uses the contextual information (defined in accordance with semantic lifting approaches introduced in [20]) as a flexible technique to elevate the formal representation. The definition of the assessment logic is shown as pseudo-code for the specific case of modularity in the ecosystem.

Modularity calculation in BEDe

```
calculate_modularity_score
  evaluate_constraints
  if (constraints_satisfied)
    ratio_modularity = count (relation_modular)/count(all_relation)
    modularity_weak_threshold = read_context(weak_modularity)
    modularity_moderate_threshold = read_context(moderate_modularity)
    if (ratio_modularity < modularity_weak_threshold)
      update_actor_modularity ("weak")
    elsif (ratio_modularity < modularity_moderate_threshold)
      update_actor_modularity ("moderate")
    else
      update_actor_modularity ("strong")
    endif
    ecosystem_modularity = "WEAK"
    for actor in:actors_in_ecosystem
      position = assess_position(actor)
      weight = apply_position_weighting(actor)
      ecosystem_modularity = calculate_modularity_score
        (actor_modularity, position, weight)
    endfor
  else
    inform_on_violated_contraints
  endif
```

The example shows the implication of the metamodel concepts and characteristics for the purpose of the calculation and provides an assessment of each actor as well as a weighted, position-based calculation of the overall ecosystem design.

Modelling Procedure. The modelling procedure on how the modelling language is applied during the phase of model creation, evaluation and assessment is based on the business ecosystem design approach by den Ouden (2012), the following procedure for designing and modelling business ecosystems is defined:

1. Get a clear picture of the value proposition: the value proposition is a characteristic in the context of the business ecosystem
2. Define stakeholders: the actors are defined and typed
3. Define stakeholder interests and roles: describing each actors interest
4. Identify relationships between stakeholder: similar as for stakeholders, the relationships are established and typed
5. Structural analysis: during the design, the structural analysis is continuously performed and provides immediate feedback to the designer. The indicators are defined a) as constraints and b) processing logic for specific types of indicators that can be extended dynamically

The procedure definition is based on the work of den Ouden [13], having informed the metamodel design and processing algorithm specification.

3 Evaluation: BEDe Tool Prototype

For evaluation purposes of the modelling method, a prototypical implementation has been performed applying the metamodeling techniques established by the ADOxx platform [21]. From a technical viewpoint, the implementation and deployment represent a proof-of-concept evaluation of the modelling method, elevated by case studies from literature represented with the prototype.

3.1 Case Study: Android

Experiments with different ecosystem were conducted to test the prototype for adequacy of its capabilities. As an indicative example, the Android-Google system based on the case-study developed in [22] is presented. The procedure starts with understanding the value proposition of the system, which in the case of Google's Android is universally accessible information of the world through a standardized open mobile platform in the form of an ecosystem. It forms the basis for the second step, which is to select the stakeholders and assign them to the characteristics of the actors defined in the metamodel and position them according to their similarity. The following step serves to identify the interests of the different stakeholders by formulating it for each of them and evaluating it in relation to the value proposition. The next step is to describe the role and function of each stakeholder in the system. The fifth step is to draw connectors between the actors by using the metamodel relationships. Here, several different relations can operate between two actors. Based on the actors, their characteristics and relations among each other, the analysis is carried out, which continuously evaluates whether the system is in a good or bad status. This procedure's result is presented in Fig. 2.

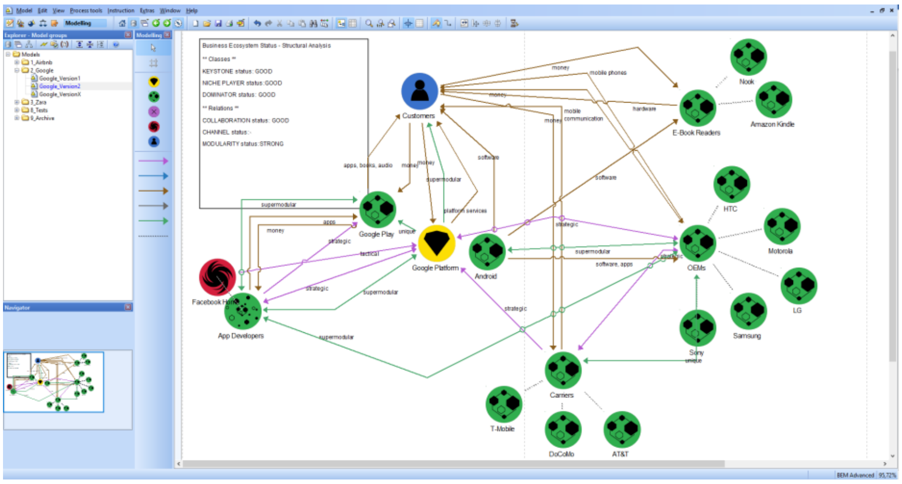

Fig. 2. BEDe Modelling Toolkit: Example Android Case

The implementation results are shown in Fig. 2. The business ecosystem of Android exemplifies the design capabilities (graphical modelling and formal representation), interactive assessment logic (structure performance indicators) and evolutionary aspects (temporal trajectory) of business ecosystems. The implementation follows the programming paradigm of ADOxx as "instantiation" of meta-meta concepts and embedded scripting using the ADOxx language AdoScript for its realization. As a metamodeling technique is applied, the prototype allows for a flexible extension of the base classes of BEDe to capture domain-specific semantics in case required.

3.2 Evaluation and Lessons Learned

As an outcome, we can recognize that the conceptualization of business ecosystems in the form of a metamodel supports a common, structured approach for design and evaluation, whereas domain-specific aspects become feasible and are reflected within the design. This is specifically related to the use of metamodeling concepts and consequently results in a knowledge representation that supports the modelling and design aspects in business ecosystems, depending on the purpose of design and assessment. As such, the BEDe metamodel and prototype tool is positioned as a mediation layer (building on conceptual models) to enable the interaction of domain experts and share their knowledge about the domain collaboratively, but also provide input for machine interpretation as model processing algorithms and service invocation are enabled, without excluding the work on tool and concepts from the research community.

An observation related to the explorative assessment performed, relates to the use of concepts and their understanding when applied in a collaborative manner. The semantic assigned to the concepts in the metamodel can potentially lead to an interpretation by the modeler which impacts the model results and their evaluation.

Consequently, further work is required in the way how concepts can be communicated, and which constraints and rules might be applied on the metamodel concepts. This means that the typing of e.g. actors is not directly related to a designers choice but the outcome of a machine reasoning process based on the structural and relation semantics the actors has been described.

4 Conclusion and Outlook

This paper contributes to the field of model-driven design techniques, specifically in the domain of business ecosystems and aims to provide a conceptual framework as a modelling method to clarify and establish a common understanding within the community on a) how to design and evaluate business ecosystems, b) provide means for digitally sharing innovative new design concepts and c) embed processing techniques as model-value functionality. At this stage, the research performed showcases that modelling concepts are required in the field that are flexible in a sense that domain-specific adaptation is possible as extensions to the core structure established in this research.

Further research direction includes a) domain-specific assessment of the applicability of the proposed concept and comparability/similarity matching techniques, and b) a dynamic assessment of the behavior of business ecosystems. In contrast to the structural aspects demonstrated, behavior view provide means for animating/simulating ecosystems to understand the effects of evolution already during design time utilizing operational data from the system environment as well as behavior definition on actor and relationship level.

References

[1] P. J. Williamson and A. De Meyer, "Ecosystem advantage: How to successfully harness the power of partners," *Calif. Manage. Rev.*, vol. 55, no. 1, pp. 24–46, Oct. 2012.

[2] M. Iansiti and R. Levien, "Strategy as Ecology," *Harv. Bus. Rev.*, vol. 82, no. 3, pp. 68–81, 2004.

[3] J. F. Moore, "Predators and prey: a new ecology of competition.," *Harv. Bus. Rev.*, vol. 71, no. 3, pp. 75–86, 1993.

[4] M. Tsujimoto, Y. Kajikawa, J. Tomita, and Y. Matsumoto, "A review of the ecosystem concept — Towards coherent ecosystem design," *Technol. Forecast. Soc. Change*, vol. 136, pp. 49–58, Nov. 2018.

[5] M. G. Jacobides, C. Cennamo, and A. Gawer, "Towards a theory of ecosystems," *Strateg. Manag. J.*, vol. 39, no. 8, pp. 2255–2276, Aug. 2018.

[6] D. J. Teece, "Business Ecosystem," in *The Palgrave Encyclopedia of Strategic Management*, M. Augier and D. J. Teece, Eds. London: Palgrave Macmillan UK, 2016, pp. 1–4.

[7] G. Parker, M. W. Van Alstyne, and X. Jiang, "Platform Ecosystems: How Developers Invert the Firm," *SSRN Electron. J.*, Nov. 2016.

[8] M. A. Phillips and J. S. Srai, "Exploring emerging ecosystem boundaries: Defining

‘the game,’” *Int. J. Innov. Manag.*, vol. 22, no. 8, Dec. 2018.
[9] P. K. Senyo, K. Liu, and J. Effah, “Digital business ecosystem: Literature review and a framework for future research,” *International Journal of Information Management*, vol. 47. Elsevier Ltd, pp. 52–64, 01-Aug-2019.
[10] D. Karagiannis and H. Kühn, “Metamodelling platforms,” *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, 2002.
[11] W. Utz, “Design of metamodels for domain-specific modelling methods using conceptual structures,” 2020.
[12] R. Adner, “Ecosystem as Structure: An Actionable Construct for Strategy,” *J. Manage.*, vol. 43, no. 1, pp. 39–58, Jan. 2017.
[13] E. Den Ouden, *Innovation design: Creating value for people, organizations and society*. Springer-Verlag London Ltd, 2012.
[14] L. M. Camarinha-Matos and H. Afsarmanesh, “On reference models for collaborative networked organizations,” in *International Journal of Production Research*, 2008, vol. 46, no. 9, pp. 2453–2469.
[15] R. Adner and R. Kapoor, “Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations,” *Strateg. Manag. J.*, vol. 31, no. 3, pp. 306–333, Mar. 2010.
[16] P. Graça and L. M. Camarinha-Matos, “Performance indicators for collaborative business ecosystems — Literature review and trends,” *Technol. Forecast. Soc. Change*, vol. 116, pp. 237–255, Mar. 2017.
[17] P. Macedo and L. M. Camarinha-Matos, “A qualitative approach to assess the alignment of Value Systems in collaborative enterprises networks,” *Comput. Ind. Eng.*, vol. 64, no. 1, pp. 412–424, Jan. 2013.
[18] D. Karagiannis, H. C. Mayr, and J. Mylopoulos, *Domain-specific conceptual modeling: Concepts, methods and tools*. Springer International Publishing, 2016.
[19] D. Karagiannis, P. Burzynski, W. Utz, and R. A. Buchmann, “A Metamodeling Approach to Support the Engineering of Modeling Method Requirements,” in *Proceedings - 2019 27th IEEE International Requirements Engineering Conference*, 2019, pp. 199–210.
[20] R. Woitsch, “Hybrid modelling with ADOxx: Virtual enterprise interoperability using meta models,” in *Lecture Notes in Business Information Processing*, 2013, vol. 148 LNBIP, pp. 298–303.
[21] ADOxx.org, “ADOxx Metamodelling Platform.” [Online]. Available: https://www.adoxx.org/live/home. [Accessed: 22-Mar-2020].
[22] M. Bhattacharya, B. S. Gopal, and A. S. Syed, *Google’s Android: A Threat to Mobile Giants?*, vol. IBS Resear. 2009.