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1 Motivation and Relevance

The twenty-first-century customer no longer asks for standardised products, services and purchases in homogeneous quantities. They increasingly demand integrated and complex **solutions** that meet their specific requirements. However, companies cannot meet the new demand, as they rely too much on the traditional way of doing business by looking at few large, standardised units. Moreover, these companies lack the necessary knowledge and ability to react to emerging requirements. The current situation shows scattered knowledge among the various players in markets, industries and potential players worldwide. If one looks at these trends in today's volatile and rapidly changing environment, both interactive and flexible structures between organisations are required. New structures are the only way to ensure that activities take place quickly. However, a single company cannot meet these challenges (Williamson and De Meyer, 2012, p. 24).

Nevertheless, especially for vertically integrated companies, the only alternative is a market with many participants that respond independently to prices and signals about volumes. These markets have a low degree of coordination and no common evolution of specialised capabilities. Market participants, or markets in general, fail as soon as there is a confrontation with demands that require complex or diffuse knowledge. When exchange and sharing are beneficial they do lack in necessary skills and capabilities – they are only trained in simple, standardised products and services (Williamson and De Meyer, 2012, p. 24).

The idea of "business ecosystems" offers a potential solution to this problem. It is characterized as a network of organisations and individuals who jointly develop skills and roles and coordinate their investments. Corporations create added value and/or improves efficiency. Assuming the rapidly changing competitive environment, this form of organisation can offer advantages in the right context to traditionally integrated enterprises and streamlined supply networks based on the classical principal-agent relationship. Business ecosystems can help solving this dilemma: offering more complex solutions desired by customers without losing the organisation as the centre of focus. It is possible to continuously and flexibly reconfigure activities, assets, and capabilities to respond to unexpected events through a vivid ecosystem. If this system manages to mobilise much idle knowledge, it may help accelerate innovation, improve customer service and focus (Williamson and De Meyer, 2012, pp. 24–25).

Although the concept is not new and has been under investigation for some time (e.g. Iansiti and Levien, 2004a; Moore, 1993; Tsujimoto et al., 2018, pp. 50–51), it is now experiencing a boom in strategy (Jacobides et al., 2018, p. 2256). In recent years, the term ecosystem has developed primarily in the context of the analysis of competitive environments and has thus moved into the focus of corporate research and the scientific field of strategy. When searching the highest ranked strategy journals for “ecosystem”, the term appears seven times more frequently in the title or abstract (Jacobides et al., 2018, p. 2256); significantly since 2010, the number of papers published in academic journals increased strongly (Tsujimoto et al., 2018, p. 50). However, this idea does not only include academic discussion but also business press and practitioners are interested in this approach (Jacobides et al., 2018, p. 2256). A remarkable example of this is the prospect for Alibaba’s IPO in 2014: the company has used the term ecosystem no less than 160 times in its vision, philosophy and growth strategy (Deloitte, 2015, p. 3). In “The Palgrave Encyclopaedia of Strategic Management”, Teece (2016) assumes that “the concept of ecosystem might now substitute for the industry as a useful domain for performing economic analysis.” (Teece, 2016, p. 2).

The scope of business ecosystems is well illustrated by the reaction of the travel and hotel domain to the emergence of Airbnb. Airbnb created an entirely new business model of an online rental platform of private rooms, flats and houses, along with an easily accessible technological infrastructure to allow hosts and guests to match quickly and without barriers to entry. It disrupted the way the domain had previously worked, increased competitiveness, and the travel and hotel industry saw a threat in Airbnb (Guttentag, 2015). The phenomenon was recognised as a business ecosystem, in this case by means of a platform as an enabler (Hein et al., 2018, pp. 1192–1193), although in practice this term is used in diverse contexts with a wide variety of meanings (e.g. Hayes and Boyle, 2021; Wulf and Butel, 2017, p. 1413).

Since business ecosystems receive much attention from the theoretical knowledge base and practitioners, both areas need to be supported stronger with conceptualizations and applicable models. The missing element in the context of business ecosystems undoubtedly is a common, clear understanding of the phenomenon that then builds a shared knowledge base. A strategic design approach using contextual models in the domain of business ecosystems can provide crucial support for academic discussion and practitioners.

2 Methodological Approach

Based on the motivation and the currently existing research gap, this work's objectives are formulated. The closing part of this chapter is the methodological approach that explains the methodology used.

2.1 Research Gap

Since James Moore first named the term Business Ecosystem in 1993, research has developed rapidly, especially in the last decade. Nevertheless, there are many areas of business ecosystem research that need further investigation. In 2019, Senyo et al. looked at this in detail and identified eight subjects that offer the potential for scientific analysis (Senyo et al., 2019, pp. 59–60):

A. analysis and measurement of the interdependence of business ecosystems
B. development of frameworks and models
C. development of platforms and their effective management
D. governance, regulation and security
E. standardisation of technologies
F. integration of new technologies into corporate ecosystems
G. mobilisation of the digital infrastructure and
H. empirical testing of frameworks.

Tsujimoto et al. (2019) explore that so far, the focus of research is on the business context and how to capture and/or create value, limited to ecosystem dynamics and patterns as well as organisational behaviour (Tsujimoto et al., 2018, p. 52). Therefore, it is increasingly important to look into such systems' design and understand how one needs to construct systems to create customer value (Parker et al., 2017, pp. 255–256). There are various approaches and studies on what an ecosystem is and what it is useful for (e.g. Adner, 2017; Moore, 1998; Senyo et al., 2019). However, there has been limited focus on how business ecosystems can be created or designed (Phillips and Srai, 2018, p. 3). According to Senyo et al. (2019), this research trend can and should be supported by modelling artefacts to establish a basis for validation (Senyo et al., 2019, p. 58).

2.2 Research Objectives

This initial situation, based on the current state of research, leads me to my research question for this work. From the potential research areas, a research gap is emerging in defining the relevant structures business ecosystems are built upon and in the design capabilities showing how these structures are being used. These structures need to be tested to determine how successful the concept and design are. For this purpose, an evaluation is carried out so that a statement can be made about how valid the business ecosystem design is or not. These gaps lead to the research objectives of this thesis, which is divided into three sub-questions:

How are business ecosystems designed conceptually
as a value-adding modelling activity?

Question 1: What is the concept behind business ecosystems?
Question 2: How can business ecosystems be designed?
Question 3: How can this design be evaluated?

In this thesis, the term "concept" is understood as all constructs, artifacts and functionalities required to design business ecosystems, summarized as a proposal of a modelling method.

2.3 Structure

This work consists of a theoretical and a practical part. The theoretical part firstly defines the term business ecosystem and considers the origin of the term. An examination of existing organisational theory and known systems such as supply chains or networks give a more precise distinction of business ecosystems. Secondly, the theoretical part strongly focuses on the conceptualisation of business ecosystems. The existing literature is brought together to conceptualise the phenomenon of business ecosystems and then focuses on business ecosystem design. The next part is the practical part, which is realized through metamodeling concepts.

2.4 Methodological Procedure

Hevner and Chatterjee (2010) established the information research framework that assists in answering this work's research questions and adds value to the environment, and the knowledge base. It is a design science research methodology and can be seen in Figure 1, applied to this thesis. The changes in the environment, such as the focus on solutions and the changes in the environment and technology, can be observed and impact people, organisations, and technology. These developments bring about emerging needs for organisations, to be concerned with how the business environment change in such systems (Hevner and Chatterjee, 2010, pp. 272–275).

There are already different theories on what business ecosystems are and how to design them, but still lack a concept and artefacts, as described in the research gap. When bringing together the knowledge base and the environment, this thesis' research topic is the design of business ecosystems. Firstly, I conduct a literature review to conceptualize what business ecosystems are and how to design them. The evaluation of the established framework is done by developing an artefact through modelling and evaluating the outcome on a case study. By employing this framework to the topic of this thesis, I am able to apply my finding to the appropriate environment and to bring additions to the knowledge base.

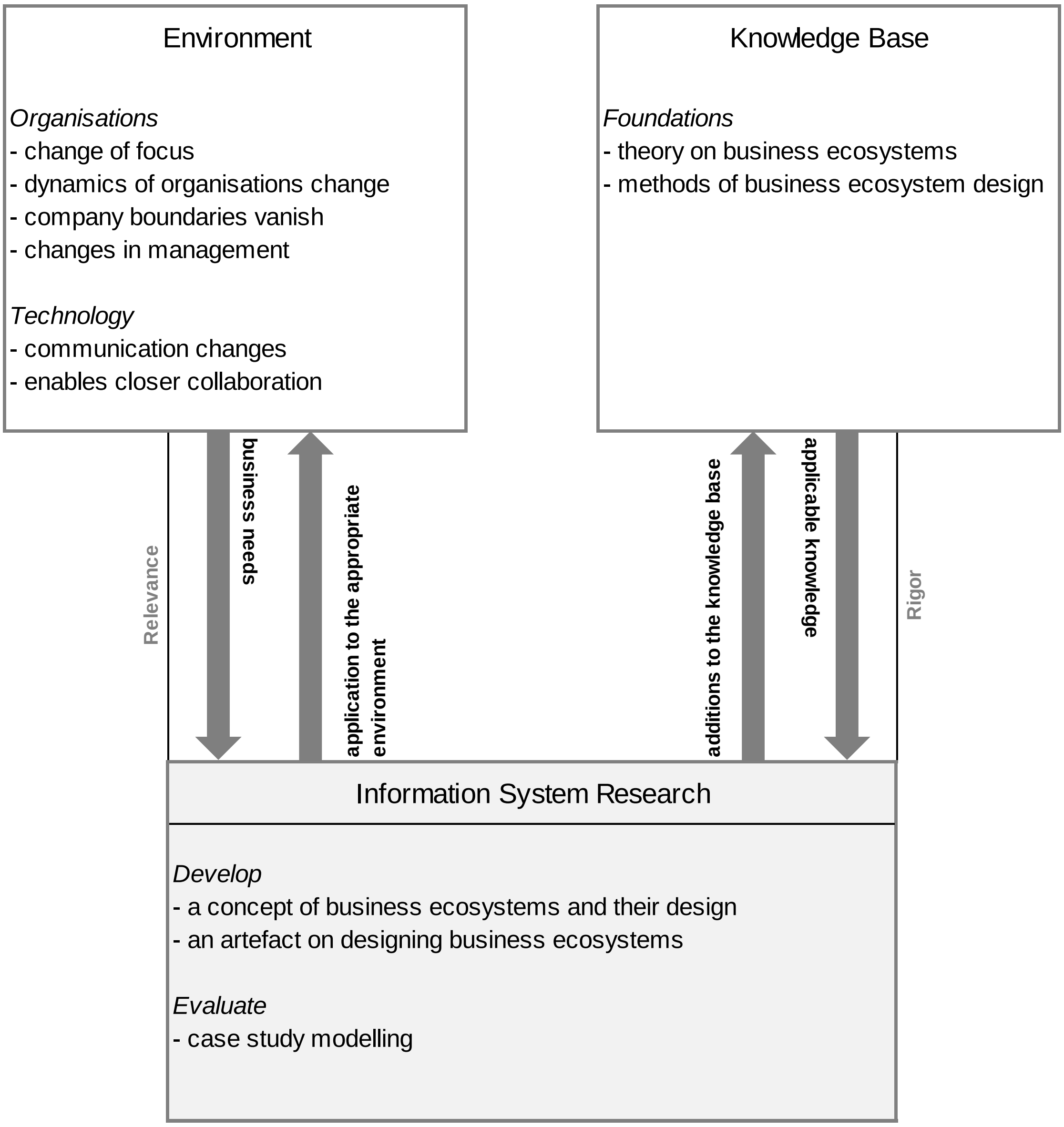


Figure 1: Research framework

based on (Hevner and Chatterjee, 2010, p. 274)

2.4.1 Literature Review

The literature study forms the first section of this thesis and provides input to answering the first and second research question. Senyo et al. (2019) established a literature analysis which is used for this thesis. The authors combine systematic literature research with the method of Wolfswinkel et al. (2013) well-founded theoretical literature research. Following the two approaches, there are five analytical steps (Senyo et al., 2019, p. 53):

1. definition of literature inclusion and exclusion criteria
2. literature search
3. literature refinement
4. analysis of selected articles and
5. presentation of findings.

The first stage of the *definition of literature inclusion and exclusion criteria* ensures that the review is of high quality. The authors Senyo et al. (2019) and Webster and Watson (2002) limit themselves to conferences, scientific journals and high-quality sources in the specific research fields (Senyo et al., 2019, p. 53). Therefore, there is a preference for peer-review journals in the literature section and renowned journals, conference articles and books recognised in the field of research. This thesis excludes dissertations, book reviews and case studies.

The *literature search* starts from the library of the University of Vienna, u:search. That is the starting point to access databases covering important journals and conference papers. To ensure comprehensive research, a forward search is performed using Google Scholar to identify quotations, and a backward search is performed by manually checking reference lists. In the *literature refinement* phase, the filtering of collected articles takes place. This is necessary to delete duplicates and discard literature that does not meet the criteria for inclusion. The filtering is done by reading the selected articles' main parts, namely the title, summary and conclusion. According to the method of Senyo et al. (2019), articles that list the business ecosystem as an example, as a topic to further explain another concept, or only as a keyword are no longer of interest and are excluded (Senyo et al., 2019, pp. 53–54).

There is a close link of the *analysis of the selected literature* to the structure of this work. In this phase the literature is extended with codes. The codes consist of the different chapters of this paper that reflect the different papers (Senyo et al., 2019, p. 54). The relevant literature is thus pre-structured and can then be directly linked and included in a topic-related manner. Based on the previous four steps, the *presentation of the findin*gs takes place in paper form. To perform the method, the structure explained in the following section is used.

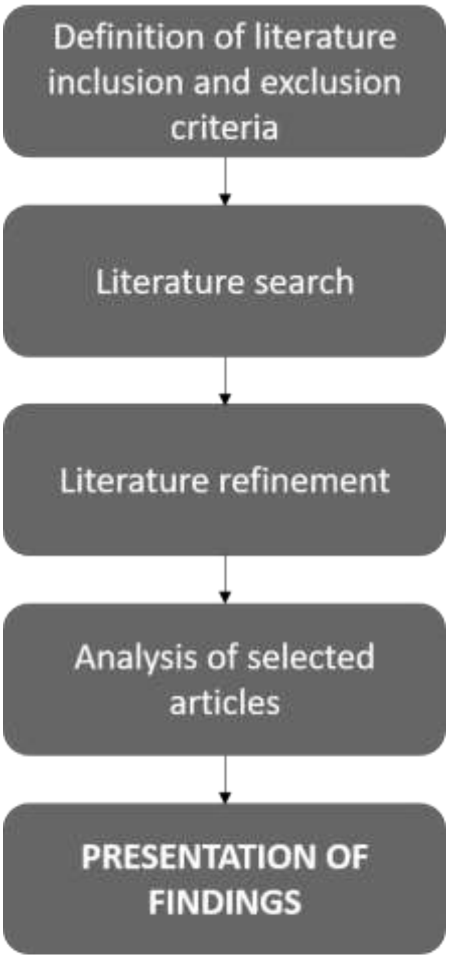


Figure 2: Five stage systematic literature review process based on (Senyo et al., 2019, p. 54)

The results of the first four stages lead to the presentation of findings. The findings of the fifth stage are presented in this thesis and can be found in chapter 4.

2.4.2 Artefact

The implementation of the artefact is conducted with the help of a modelling approach. It answers research question number three and should give support to research question number two. It is realised with the development and modelling toolkit ADOxx ("ADOxx Metamodelling Platform").

3 Business Ecosystem Definition

In this chapter, the terms “model” and “business model” are discussed first, as they are a legitimate entry point to business ecosystems in the business world, insofar as they are the starting point of this consideration. Then, the origin and definition of the term business ecosystem is presented. To classify the term and address its importance, a comparison between business ecosystems, existing systems and organisational theories is conducted.

Before defining the term business ecosystem, this part positions the “model” and the value within the model. Since the 1990s, the term “**business model**” has been increasingly used, especially in connection with whether it is possible to earn money with business on the internet. Although the term had been used more frequently, there was no exact meaning for a long time. On the one hand, the term business model is repeatedly used as a synonym for “strategy”. On the other hand, some voices see a difference between these two, but there is no agreement about what difference these terms might have. However, a common understanding of the term business model makes sense given that leading thinkers believe the two terms can be used equally (Seddon and Freeman, 2004, pp. 427–428). Porter (2001) also notes this lack of consensus:

“The definition of a business model is murky at best. Most often, it seems to refer to a loose conception of how a company does business and generates revenue. Yet simply having a business model is an exceedingly low bar to set for building a company. Generating revenue is a far cry from creating economic value (...).” (Porter, 2001, p. 73)

Following this, the authors Seddon and Freeman (2004) conduct a literature analysis of the definitions of business models and strategy. In doing so, they examine the overlapping points of the terms and present them graphically in Figure 3 (Seddon and Freeman, 2004, p. 428).

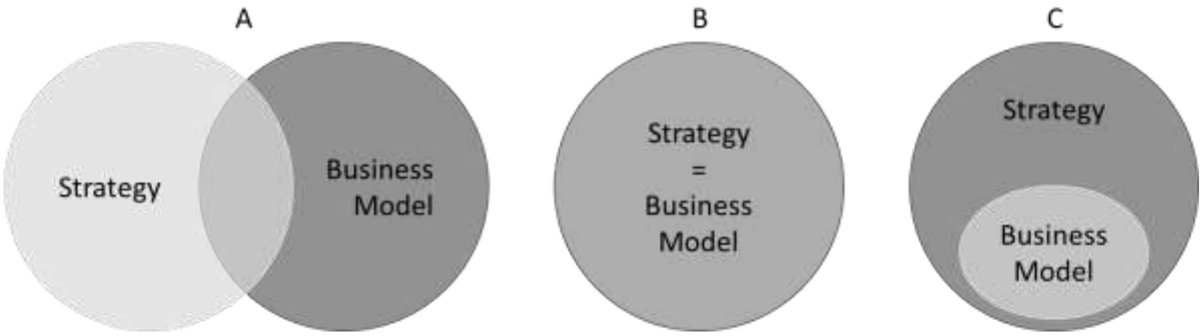


Figure 3: Possible overlap between the concepts “strategy” and “business model” based on (Seddon and Freeman, 2004, p. 428)

Weill and Vitale (2001) focus on business models in their work, and study stakeholders and product and information flow (Weill and Vitale, 2001, pp. 29–31). They miss out to mention strategy in comparison to their models but discuss the topic of e-business strategizing. Thus, Seddon and Freeman (2004) conclude an application of option A in Figure 3 in this case. Harvard school's thinking on strategy can also be grouped to option A. That stream ranges from the SWOT analysis to the five-forces model over to the resource-based view (Seddon and Freeman, 2004, p. 431).

The closer the look at the literature and concepts, the more likely it is to conclude that the two terms are the same. Nevertheless, small nuances of difference are visible. Strategy focuses more on a company's competitive position, whereas business models focus more on value creation. It becomes apparent that people from the IT sector tend to prefer the term business model, while people from the management sector more frequently use the term strategy. If one starts from these overlapping points, then option B in Figure 3 should be supported. It means that the two terms are only two sides of the same coin. At the same time, this means that the term business model brings no added value and is merely a different expression and as a consequence, it is not needed (Seddon and Freeman, 2004, p. 428).

After Seddon and Freeman (2004) have analysed the literature, they concluded that one could see the two terms differently following what experts say. They base their argumentation on the above-mentioned added value and carry it on: *"(...) business models are abstractions of strategy, capturing aspects of individual-firm strategy that can be applied to many firms."* (Seddon and Freeman, 2004, p. 429). In this case, option C in Figure 3 is supported. The authors see the added value of business models in their focus; in contrast to strategy, business models' emphasis is on the internal elements of an organisation, while that of strategy lies in the competitive positioning.

Seddon and Freeman (2004) try to explain the connection between strategy, business model and company in a three-dimensional diagram, it is shown in Figure 4. The vertical axis represents the degree of abstraction that protrudes from the real world into the model world. Along the axis are the company, strategy and business models. The largest ellipse within the representation is the company and is larger than that of strategy. This is because the strategy defines only parts of the company; other parts emerge. Further up the abstraction level, one will find different business models. It becomes clear that models are an abstraction that does not require details. The authors illustrate several business models at this level because there may be different business models for parts of the business strategy (Seddon and Freeman, 2004, pp. 429–430).

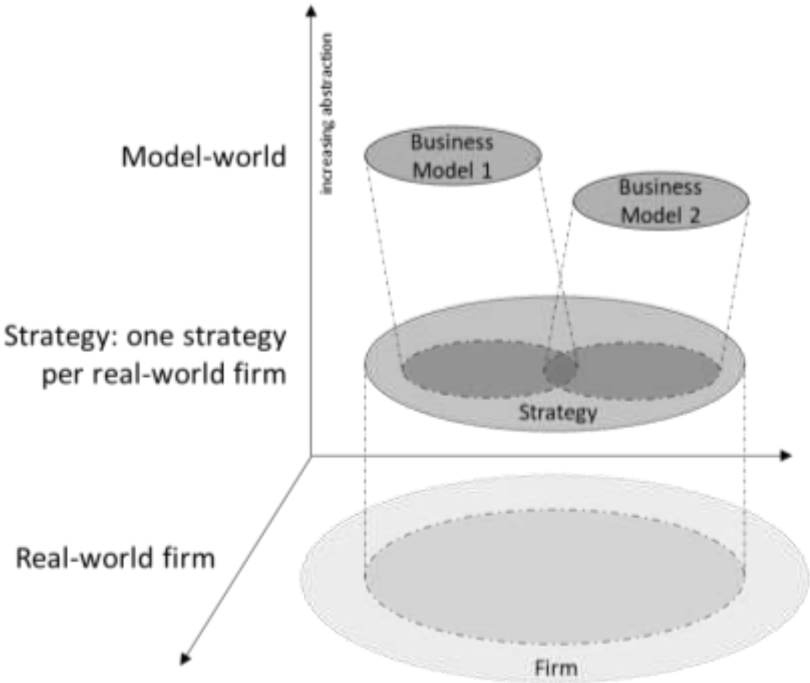


Figure 4: Relation between "business model", "strategy" and the real-world firm based on (Seddon and Freeman, 2004, p. 429)

The authors base their approach on the assumptions of Figure 4, and the term strategy is based on Porter's work (see Porter, 2001, 1996), which has deepened his understanding of strategy and what it is. Therefore they define business models as well as strategy as follows:

"A business model outlines the essential details of a firm's value proposition for its various stakeholders and the activity system the firm uses to create and deliver value to its customers. If Porter [1996, 2001] is used to define strategy, a business model may be defined as an abstract representation of some aspect of a firm's strategy. However, unlike strategy, business models do not consider a firm's competitive positioning." (Seddon and Freeman, 2004, p. 440)

This definition can be assigned to type C in Figure 3. This type has the strategy as a larger circle and a smaller circle of the business model. It means that the business model does not cover the entire strategy (Seddon and Freeman, 2004, p. 430).

Similar to Seddon and Freeman (2004), Osterwalder et al. (2005) see business models as *"(...) the translation of strategic issues, such as strategic positioning and strategic goals into a conceptual model that explicitly states how the business functions. The business model serves as a building plan that allows designing and realising the business structure and systems that constitute the company's operational and physical form."* (Osterwalder et al., 2005, p. 4) This definition focuses more on the concept of a business model than Seddon and Freeman (2004).

Combining these two definitions, one could conclude that a business model is the abstract representation of a business concept.

Applegate (2000) agrees and defines business models as follows:

"A description of a complex business that enables study of its structure, the relationships among structural elements, and how it will respond in the real world." (Applegate, 2000, p. 53)

This description contains several objects and describes their relationships to understand a company's business logic. Finding concepts and relationships is essential in order to describe organisations on the one hand and to represent them on the other. The strategy classic who – what – how, i.e. the customer benefit and the realisation of it and the financial resources required for it should be shown (Osterwalder et al., 2005, p. 5). Then the business model may serve as an analytical unit, and that *"(...) can be built before the real system to help predict how the system might respond if we change the structure, relationships, and assumptions."* (Applegate, 2000, p. 53).

In line with the description of Seddon and Freeman (2004) shown in Figure 3C and the abstraction levels in Figure 4 as well as the definitions of business models by Osterwalder et al. (2005) and Applegate (2000), I see business models as abstractions of real-world firms. Since strategy does not define the whole firm but includes emergent parts, it is shown smaller and moved further towards abstraction than the real-world organization in Figure 5. The business model covers a part of the strategy and allows a focused view on a specific business model. Nevertheless, as described in Figure 3C, business models are a part of the strategy. This is the interpretation of business models that underlies this work and is conceptually represented in Figure 5.

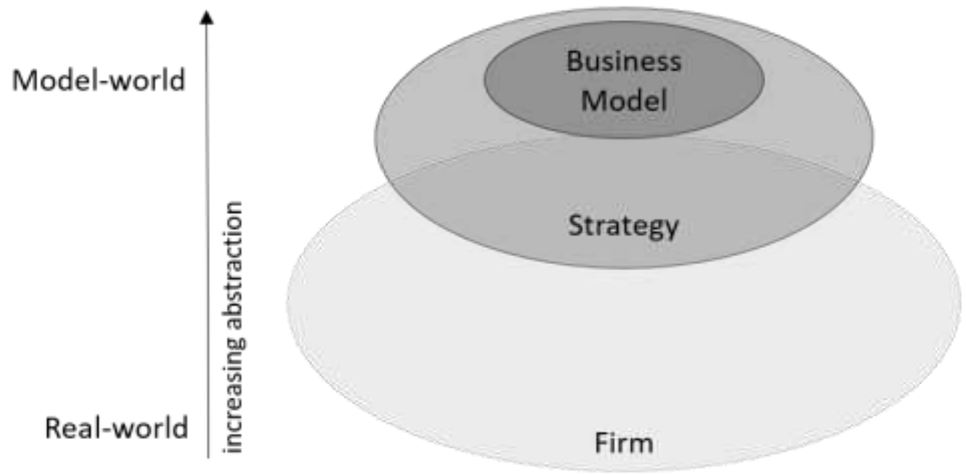


Figure 5: Conceptual representation firm - strategy - business model

3.1 Origin of the Term

The term business ecosystem was coined by the author Moore in 1993. He uses natural ecosystems as a metaphor for business ecosystems, where the latter term comes from. In this new use of the term ecosystem Moore sees companies as members of a cross-industry system in which different elements are in motion. All of them belong to a structured community that occurs randomly in the same place (Moore, 1993, p. 76). One of the key ideas behind this is co-evolution. It is a process in which different beings, species or organisations are incorporated into an existing, ongoing cycle of interdependent change (Teece, 2016, p. 2).

Organisational ecologists *"explain the emergence, growth and decline of populations of organizations, relying mainly on an environmental selection model of change"* (Carroll and Negro, 2018, p. 1280). Though, they assume that companies do not adapt to the corporate environment changes and are satisfied with that insight. Representatives of the business ecosystems concept continue to deal with this topic and find that there are managers and entrepreneurs in the system, in contrast to plants and animals, who can perceive and understand the business ecosystem as a whole. That awareness allows conscious decisions to respond to external threats and target opportunities in the environment. Therefore, from a strategic point of view, there is a particular path dependency on business ecosystems (Teece, 2016, p. 3). However, they reflect *"evolution with design"* (Augier and Teece, 2008, p. 1196). In other words, the strategic processes are evolutionary and emergent by nature and include essential elements of conscious design (Teece, 2016, p. 4).

The focus of strategic management has mostly been on decisions, constraints and competition. What is missing as an essential field and has been neglected until now is cooperation. A company's environment is no strict externality but offers an enormous spectrum of possibilities, that speaks in favour of this. Companies and organisations are embedded in their environment (Astley and Fombrun, 1983, p. 576). Thus, business ecosystems suggest a holistic and dynamic view. Value is not exclusively contained in products themselves but in members creating value in cooperative and competitive environments (Hearn and Pace, 2006, pp. 55–56).

3.2 Definition

After the publication of Astley and Fombrun (1983) on the analysis of joint strategic actions of members of inter-organisational groupings (Astley and Fombrun, 1983), Moore explored this phenomenon in-depth and named it "business ecosystem". He defines it as follows:

Business ecosystems according to Moore (1993, 1996) are *"an economic community supported by a foundation of interacting organisations and individuals – the organisms of the business world."* (Moore, 1996, p. 9). *"In a business ecosystem, companies coevolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations."* (Moore, 1993, p. 76)

Business ecosystems include customers, producers, other stakeholders, and competitors (Moore, 1996, p. 25). Moore's definitions and statements about business ecosystems have changed over time. A later definition is more precise on who is within an ecosystem and who is involved in its creation. He describes it as an *"(...) extended system of mutually supportive organisations; communities of customers, suppliers, lead producers, and other stakeholders, financing, trade associations, standard bodies, labor unions, governmental and quasigovernmental institutions, and other interested parties. These communities come together in a partially intentional, highly self-organising, and even somewhat accidental manner."* (Moore, 1998, pp. 168–169)

Nevertheless, there is an overarching common outcome to which each member contributes, whereby they complement each other. It clearly shows the origin of the term. In natural ecosystems, the individual members fit together in a way that the existence of each individual is meaningful and results in a balanced and working system (Moore, 1998, p. 169).

Moore mentions that the members complement each other. The authors Jacobides et al. (2018) strongly focus on that complementarity within the system in their definition of business ecosystems and bring essential insights into their functioning and distinctiveness.

"The strength of ecosystems, and their distinctive feature, is that 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. From this perspective, ecosystems allow for some degree of coordination without requiring hierarchical governance precisely because of the ability to use some standards or base requirements that allow complementors to make

their own decisions (in terms of design, prices, etc.), while still allowing for a complex interdependent product or service to be produced" (Jacobides et al., 2018, p. 2263).

Modularisation is considered as one of the most important aspects of distinction for business ecosystems to other systems, such as networks. The assumption is that greater modularisation is accompanied by an increasing spread of ecosystems in several sectors, e.g. telecommunications, financial services and mobility. Sectors that have already been studied more deeply in the context of business ecosystems, such as IT, telecommunications, and video games, tend to be more modular. These studies suggest that ecosystems can be a stand-alone solution to the problem of coordination between firms, as opposed to alliances, supply chains or market-based interactions. Thus, there is the assumption that modularity enables the coordination of independent but interdependent firms across ecosystems. Modularity is necessary for a business ecosystem to function, but it is not exclusively sufficient (Jacobides et al., 2018, p. 2260).

Recently, there is an increase in usage of the term *digital business ecosystem*. The new term's formation happens by adding the word *digital* to the described concept business ecosystem. "Digital" refers to developments in information technology and is an extension of the term business ecosystem. It gives greater significance to digital technologies in these systems (Senyo et al., 2019, p. 53; Stanley and Briscoe, 2010, p. 3). Thus, in the following, the term is used as a synonym to business ecosystems, and studies using the same definition for digital business ecosystems are cited as well.

To join the definitions, I filtered the characteristics of business ecosystems. It gets visible that these are not coherent at first sight, as some might exclude each other when thinking in traditional organisation theory. Figure 6 gives a summary of the before discussed characteristics of business ecosystems. The next chapter will show that this is not the case, and such systems can bring more value in specific cases than prevalent forms of organisation.

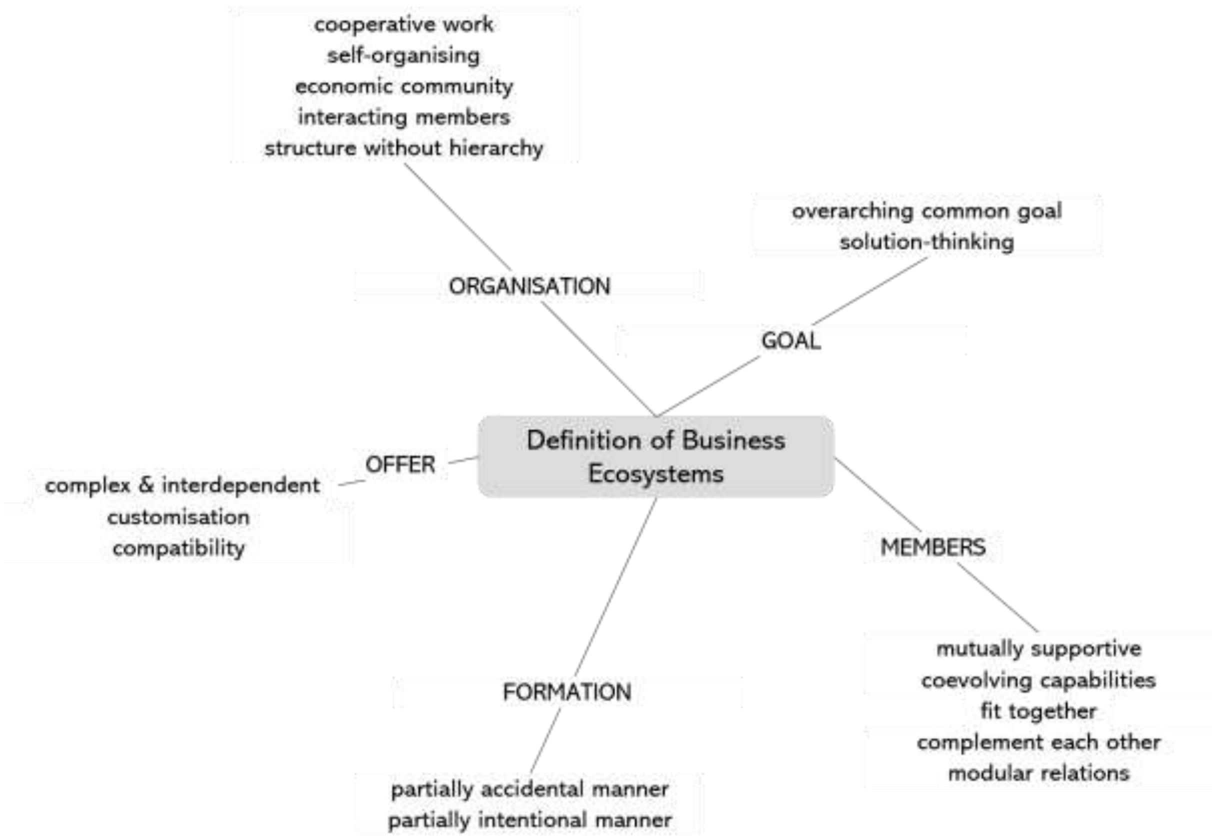


Figure 6: Definition of business ecosystems

3.3 Related Theoretical Work

A brief explanation of organizational theory follows and its differences to operational ecosystems are highlighted. Furthermore, there is a theoretical clarification of why it is necessary to establish business ecosystems. For this purpose, a comparison between various other systems and ecosystems brings more details.

3.3.1 Organisation Theory

One of the most decisive competitive advantages that organisations can possess is control over valuable resources (e.g. Barney, 1991; Teece, 1986). Companies in control of key resources show higher survival rates and exert pressure and influence on companies that need those resources. Simultaneously, weaker organisations seek to gain access to these resources or substitute for them by pursuing strategies such as partnerships, alliances, joint ventures, mergers and acquisitions, or political activities. These usually occur under the shadow of a contract to minimise spillovers or moral hazards (e.g. Bresser, 1986; Hillman and Hitt, 1999; Kale, 2019). Accordingly, organisational theory predicts that companies will strive to be independent whenever possible. Though, they may have to join cooperation specific key resources are in control of others. If one is forced into cooperation to reduce uncertainties in the environment to gain access to relevant resources or in case they are specialised in some aspects of the supply chain, they do collaborate and establish partnerships (Alexy et al., 2013, p. 270; e.g. Cook, 1977; Galaskiewicz et al., 2006). To solve resource-related issues to ensure access to key resources and create relatively predictable environments, organisations try to shape relations with other actors strategically. Scholars have found an increased willingness for strategic cooperative relationships, especially in connection with innovations (Alexy et al., 2013, p. 274; e.g. Chesbrough, 2003).

This focus of organisational theory has certainly provided vital insights. From today's point of view it could be said that it restricted the discourse. Alternative views may lead to different conceptions of organisations and their environments or boundaries, where the logic of equilibrium and exchange efficiency is less prominent. In turn, such views may lead to a new understanding of the relationships between businesses and the environment, new organisational theories, and possibly new theories of the firm (Santos and Eisenhardt, 2005, p. 491).

3.3.2 Theory on Business Ecosystems

The definition of business ecosystems shows that there is a need for complementary products or services. These providers might not belong to the same industry, and there is no need for contractual regulations. Nonetheless, interdependence is essential. Taking these points into account, the concept of business ecosystems does not fit into the classical relationship between companies and suppliers (Jacobides et al., 2018, p. 2258). Thus, this chapter works out the difference to classical systems.

Research in the business ecosystem area has undoubtedly formulated important challenges for companies. These range from competitive and collaborative to organisational issues. A useful theoretical classification of the topic was formulated by Adner (2017), who gave an overview of how research on business ecosystems relates to established views. The article also guided the differences in the phenomenological focus between ecosystem research and other streams. Adner (2017) summarised already existing research results to elucidate possible fundamental mechanisms behind ecosystem formation and dynamics (Jacobides et al., 2018, p. 2256).

Indeed, as Jacobides et al. (2018) state, research on ecosystems has not been isolated from mainstream literature, although the focus is still firmly on its uniqueness and novelty. Few studies have attempted a theoretical classification and have tried to build a bridge between existing perspectives and ecosystems. In these attempts, the phenomenon of business ecosystems has always been accepted as a given and has been viewed from a specific theoretical perspective (Jacobides et al., 2018, p. 2259). The works of Venkatraman and Lee (2004) and Iyer et al. (2006) take networks as a starting point and see a characteristic feature of ecosystems in a central firm, which is understood as the hub within the system. This allows for an interesting description but does not show how the additional complexity of ecosystem observation provides new insights (Jacobides et al., 2018, p. 2259). A vital contribution to this and how business ecosystems relate to existing theories provides Adner (2017). The author suggests that *"the ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise"* (Adner, 2017, p. 42). Alignment structure, defined as *"the extent to which there is mutual agreement among the members regarding positions and flows," becomes the objective, pursued through a firm's "ecosystem strategy"* to *"secure its role in a competitive ecosystem"* (Adner, 2017, p. 47). The value proposition requires alignment of partners and is ensured by the specific role of the keystone. In business ecosystems, the value proposition or specific customer need can be reached through superior performance which in turn requires the alignment of actors. The focal actor has the power to ensure that alignment (Adner, 2017, pp. 42–47).

Research to date leaves essential questions unanswered. These comprise the factors that make ecosystems *"increasingly critical"*, those who make an ecosystem possible, and what ecosystem thinking brings in terms of added value compared to existing literature streams (Adner, 2017, p. 53; Jacobides et al., 2018, p. 2259).

3.3.3 Difference to Other Systems

The focus of awareness has generally changed from initially the firm's level to supply-chains, to platforms and now towards business ecosystems. Together with several related ideas, such as business models, platforms, coopetition, multi-sided markets, networks, technological systems and value chains, business ecosystems have contributed to the understanding of new ways of creating value. The mentioned examples of value creation are similar and related to each other. However, this and the considerable number of constructs created confusion, and it is unclear where the differences in terms of boundaries, overlaps, redundancies and applicability are. This ambiguity has contributed to the fact that the usability of ideas is inhibited or limited (Adner, 2017, pp. 39–40). Although business ecosystems overlap with other systems in the real world, research reflects differences in research focus (Jacobides et al., 2018, p. 2258). Thus, distinguishing business ecosystems (as seen in Figure 8) from classical value systems and their other closest systems in Figure 7 makes sense.

The authors Jacobides et al. (2018) and Adner (2017) consider business ecosystems as distinguishable from other systems and are therefore distinctive because of their structure and how coordination challenges are solved. In Figure 8 the structure of hierarchy-based and market-based value systems can be seen. A comparison to ecosystem-based value systems in Figure 8, shows a structural difference. Comparing hierarchy-based and ecosystem-based value systems, the former ones process components from different suppliers into one output as seen in Figure 7 left-hand side, whereas Figure 8 shows that system complementarities are created and offered in addition to a central product through cooperative ties in business ecosystems. Comparing the market-based and ecosystem-based value systems, the difference lies in the complementarities that are offered. In the former, generic complementarities are offered independently by suppliers and can be assembled by end consumers as shown in Figure 7 right-hand side. In contrast, in ecosystem-based value system in Figure 8 specific complementarities are predominant and developed close to the focal firm product (Jacobides et al., 2018, pp. 2260–2261).

What distinguishes ecosystems from traditional buyer-supplier relationships is that end-users in ecosystems can choose between the delivered components or supply elements from each participant. In some cases, they can also choose how to combine. A shift from products to solutions becomes visible. An example is the Android smartphone ecosystem, where the end-user chooses which apps to buy from which supplier instead of choosing a single combined and given offer by a single company. Business ecosystems differ from market-based agreements as the end consumer chooses from several complementors linked by certain interdependencies, such as compliance with specific standards (Jacobides et al., 2018, pp. 2260–2261). Jacobides et al. (2018) propose that business ecosystems are distinct from other forms of organisations as linkages of activities are denoted by complementarity (Jacobides et al., 2018, p. 2256).

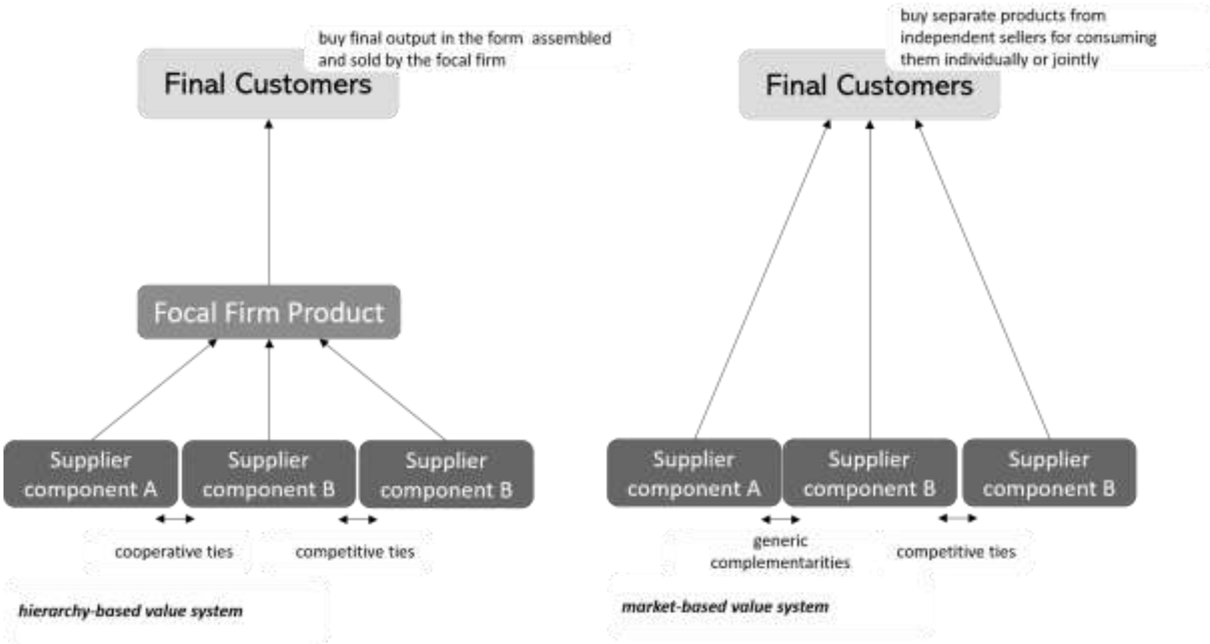


Figure 7: Hierarchy-based and market-based value systems based on (Jacobides et al., 2018, p. 2261)

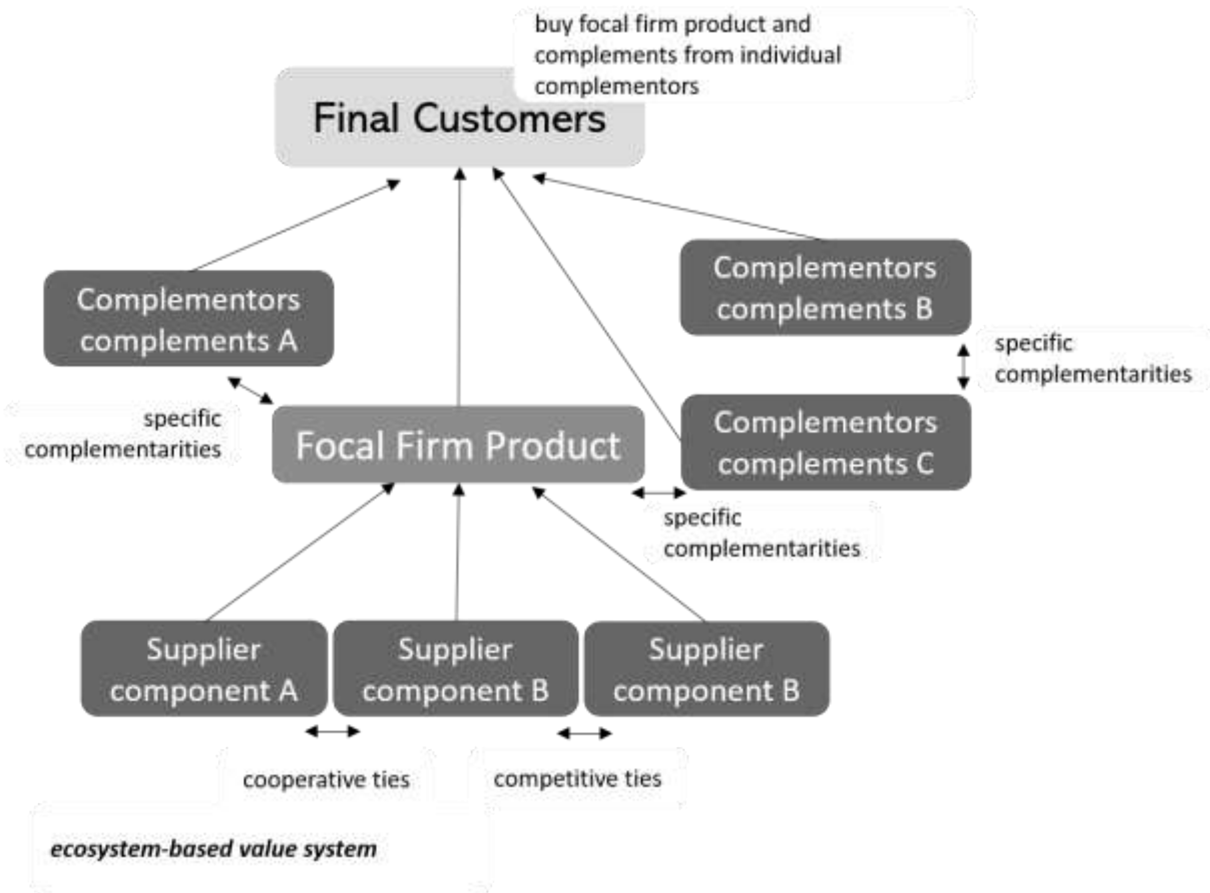


Figure 8: Ecosystem-based value system based on (Jacobides et al., 2018, p. 2261)

3.3.4 Difference to the Classical Value System

The classical relationship between companies and suppliers, Porter's (1980) value system, provides an ordered sequence to the end customer, or strategic networks of a company. Thus, it differs from business ecosystems. Ecosystems require complementary innovation, products, or services from various industries and are not necessarily subject to contractual agreements, yet they are highly interdependent. As a result, business ecosystems do not fit into the classical relationships as described above (Jacobides et al., 2018, p. 2258).

3.3.5 Difference to Networks, Alliances and Platforms

The main focus of networks and alliances are actor ties and information flows. It is not about the purpose or the value proposition per se, as it is for business ecosystems (Adner, 2017, pp. 50–51). Additionally, they differ from networks (Powell, 1990, p. 300) in that ecosystems allow consumers to choose from a range of interdependent products. Networks are standardised alliances between participants that may be formal or informal. For instance, complementors select their product or service from a fixed range of possibilities and each consumer is treated the same way. In contrast, customers in ecosystems must *"affiliate"* (Hagiu and Wright, 2015, pp. 163–164) a group or platform themselves in order to satisfy and complement their specific needs, such as the use of various apps (Jacobides et al., 2018, p. 2261). The central strategic priority of platforms is to grow the relevant sides of the market, and create value through direct and indirect network externalities. In the absence of these communities on either side of the market, the characterisation of a supply chain with the platform as distributor would be suitable (Adner, 2017, p. 50).

3.3.6 Difference to Supply Chains

Supply chains involve multiple parties, but a division of their relations into bilateral ones is feasible. When considering the flow of activities, it becomes clear that the positions, the flow of activities, and the critical path are well determined. It is fixed who is upstream and who is downstream, as it is in contrast to business ecosystems (Adner, 2017, p. 52). Furthermore, the definition of ecosystems suggests that they are not subject to one-sided hierarchical control. The full power that one actor can exercise, if at all, lacks hierarchical controllability. The single members in ecosystems retain their control and claim their assets. No one in the system can independently determine conditions such as quantities, prices or norms for all participants. Jacobides et al. (2018) assess that decision-making processes are fundamental in ecosystems. These are partially distributed, and there is no need for hierarchical coordination. However, coordination is the key, whereas a central actor often sets standards, rules, processes, and interfaces. The lack of hierarchy results in the decisive difference to supply chains since hierarchical control is given in this form of organisation – not by the fact that the central player owns the suppliers, but by the complete determination of what is delivered and at what cost (Jacobides et al., 2018, pp. 2266–2267).

4 Business Ecosystem Conceptualisation

This section describes and structure the different approaches and dimensions of business ecosystems. To answer research question 1, namely the concept behind business ecosystems, this section deals with the aspects of the phenomenon itself. For this purpose, the different views, elements, limits, visualisation possibilities, evolutionary stages, evaluation possibilities and hierarchical characteristics are discussed.

4.1 Views

The business ecosystem concept can roughly be divided into two main views, as Adner (2017) suggests into ecosystem-as-affiliation and ecosystem-as-structure. The first view, ecosystem-as-affiliation, focuses on communities consisting of related participants sharing a standard network and platform. The ecosystem-as-structure perspective focuses on the value proposition, and the activities form the ecosystem to fulfil it (Adner, 2017, p. 40).

Ecosystem-as-affiliation is a description of the ecosystem's macro level. The perspective focuses on the interdependence of actors and relationships in productive ecosystems. Traditional industry boundaries are disappearing. The perspective poses the question of openness and access to the ecosystem, the number of cooperation partners, the density of the network and the position of the actors in larger systems. An ecosystem-as-affiliation strategy is to increase the number of actors connected to a central actor or platform, thus strengthening its centrality and expected power. An increasing intensity and number of participants in this perspective increases the central actor's bargaining power, the system's value and the interactions of the partners, which could lead to new interactions and combinations that create an overall value for the ecosystem (Adner, 2017, p. 41).

Adner (2017) explains that, compared to other approaches such as networks and platforms, this view has its limitations regarding characterisation and recommendations. Due to the macro level, the strategy's focus is on improvements in state and society. There is a lack of understanding of the peculiarities of the value creation process (Adner, 2017, p. 41).

Ecosystem-as-structure, the second perspective called by Adner (2017), is based on the definition offered by the author: *"The ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise."* (Adner, 2017, p. 42). It is a complementary approach that starts with the promise of benefits. Then, the interacting actors are identified so that they can produce the value proposition.

The definition of Adner (2017) contains four different elements, namely alignment structure, multilateral, the number of partners and the performance promise to be realised. Each member of the system has a specific, defined position and carries out different activities. This alignment shows how high the degree of agreement in the system and between the actors is. An ecosystem thrives if all players are pleased with their position. So, alignment is about appropriate incentives. However, it must create a uniform interpretation of the allocation of activities. In definition, multilateral means that an ecosystem consists of several partners and relationships that manifest themselves in bilateral interactions. The set of partners stands because the common goal is a membership of an ecosystem with shared value creation. The perspective represents the service promise at the centre of the system but also creates its limits (Adner, 2017, pp. 42–43).

The ecosystem-as-affiliation approach concentrates on actors, whereby their positions are derived from connections and subsequently lead to its characterisations in the ecosystem. In comparison, the ecosystem-as-structure view focuses on activities, and their linkages are based on the alignment requirements. The approach results in the positions in relation to the overall value plan (Adner, 2017, p. 43).

The answer to which view or approach is more appropriate than the other one, depends on the specific question. For strategic purposes, the ecosystem-as-structure approach explicitly extends the strategic view because it contains indirect links over which the focal actor has no direct influence. The ecosystem-as-affiliation approach focuses on those directly connected to the central actor or the organisation (Adner, 2017, p. 44).

Table 1: Elements of ecosystem structure of the different views based on (Adner, 2017, p. 44)

Elements	**Ecosystem-as-structure**	**Ecosystem-as-affiliation**
Activities	Discrete actions to be undertaken in order for value proposition to be created	Not applicable
Actors	Entities that undertake activities	Entities that are tied to the focal actor
Positions	Specified locations in the flow of activities across the system	Derived from links to the actor
Links	Transfers across positions, which may or may not include the focal actor	Ties between the focal actor and other actors

In this thesis, I follow the ecosystem-as-structure approach, as it extends the strategic view and serves as the primary view for a modelling structure. For designing, it is necessary to carry out specific activities that fulfil a value proposition. As Table 1 shows, that can only be achieved with the ecosystem-as-structure view. Hence, this approach should be pursued with respect to the actors, although units tied to the central actor are considered too. Since a design approach assumes that systems can be formed, the ecosystem-as-structure view is to be followed. It also accounts for positions, since these are in the activity flow and not derived from the links as in the ecosystem-as-affiliation view. In general, the ecosystem-as-structure view is more of a top-down approach, which in turn supports a design methodology, whereas the ecosystem-as-affiliation view can be assigned to a bottom-up approach and thus supports the emergent point of view.

4.2 Elements

Several studies deal with the elements of a business ecosystem. There are two main trends in the literature on how to look at different elements. The first one looks at the types of companies or interest groups and is based on Moore's work , who is a pioneer in the field of business ecosystems. The general view on business ecosystems has evolved over the years, so the second stream looks at the business ecosystem's diversity of functions in the meaning of activities.

4.2.1 Elements According to Type

Moore (1996) focuses on the elements of a business ecosystem starting from classical stakeholder and industry analysis elements. The author highlights that thinking a company in terms of species or organisms is essential to progress in today's sophisticated world. Organisms could be a process, department, business unit, or an entire company. Based on that, the author sees customers, market intermediaries, companies with complementary products, suppliers and the company as part of the ecosystem. The author does not focus on roles and networks, but on the classical fulfilment purpose of actors. Business ecosystems are initiatives of small businesses or collections of businesses with unclear or blurred boundaries (Moore, 1996, pp. 25–29).

4.2.2 Elements according to Functions

The publication by Moore (1996) focuses strongly on the elements of companies' traditional views, with different types of companies as a characterisation. Recent appearances have a distinct approach: they take a closer look at the functions, actors and the structure in the system and accordingly characterise the elements. Adner (2017) states that business ecosystems consist of four elements. These were chosen from a structural perspective and form the characteristics, activities and actors to fulfil a strategic purpose and demonstrate how value is or could be created. The four elements are (Adner, 2017, pp. 43–44):

- activities,
- actors,
- positions, and
- links.

Activities in an ecosystem are the special measures taken and implemented to lead to the objective. Actors are entities involved in the implementation of these activities. One actor could be entrusted with several activities and vice versa, that several actors carry out one activity. An actor's location is determined by the position and by which actor hands over to another one. The position characterises the actor in the flow of activities that take place in the entire ecosystem. Material, influence, fund or information transfers between the different actors are specified by links, which do not necessarily require a direct connection to the system's central actor (Adner, 2017, p. 43).

4.3 Actors

The actors of a business ecosystem can predominantly be seen as Moore (1996) does. Also, den Ouden (2012) describes actors based on their specific types like service providers, goods providers or suppliers, customers, financiers, regulators and other stakeholders (den Ouden, 2012, p. 155). A different approach is used by Iansiti and Levien (2004a), who adopt a position that focuses more on business ecosystems' specifics. In the following, these various forms of actors are described in more detail and related to their biological ecosystem counterparts. The results are mainly based on Iansiti and Levien (2004a) and are supported by Moore (1993), Teece (2016) and Williamson and De Meyer (2012).

4.3.1 Keystones

Iansiti and Levien (2004a) use the analogy of biological and business ecosystems to describe the roles of different actors. The presence of an important hub characterises both systems. For the coastal biological ecosystem in the Pacific Northwest, such a central actor is the sea otter. It consumes sea urchins that overgraze various invertebrates and plants, among others including algae. It is one of the supporters of a food web that enables nearshore productivity. In the 19th and 20th centuries, the population of the sea otters declined as they were hunted for their fur. It had a significant negative impact on coastal fish and other organisms (Iansiti and Levien, 2004a, p. 5).

The otter in this biological system is a keystone and its most crucial element. The same applies to business ecosystems. There exists a vital species in ecosystems and is crucial for survival, as Iansiti and Levien (2004a) describe it (Iansiti and Levien, 2004a, p. 5). Moore (1993) also identifies a keystone for business ecosystems but calls it the business ecosystem leader. Each of these systems has a leader who is responsible for the customers' added value. It is responsible for creating change and improvements for the entire system. The actions of the keystone are critical to the overall performance of the system. Its power over the entire ecosystem lies in the fact that the actions of the leader or keystone have a significant impact on individual members. It is possible that the centre of the system changes, but the members are always dependent on the leader. Conversely, it means a keystone needs following organisations so that the customer benefit it addresses can be achieved (Moore, 1993, p. 76). The authors Williamson and De Meyer (2012) also see a leading organisation in ecosystems that drives their creation and actively steers and promotes positive development. They name this species lead firm, which corresponds to the findings of the authors mentioned above. Teece (2016) sees an organisation as a driving force as advantageous and an opportunity to establish standards; he names it as an ecosystem manager or captain (Teece, 2016, p. 2). In terms of number, the keystones represent only a small proportion of the members (Iansiti and Levien, 2004a, p. 5).

Although only a few, removing a keystone may have dramatic effects on the whole system. If a member of a different species is removed, it has fewer effects. As explained above, keystones have a significant influence on the ecosystem's survival but are also dependent on it for their survival. Keystones behave to support the whole system's health and create a sustainable system. To realise that, keystones may enhance productivity by providing a foundation on which other species rely on but leave the value creation to the network (den Ouden, 2012, p. 151). The keystone's challenge is to bring a complex system to customer value. To do so, components and complements need to be combined to deliver a valuable solution to the consumer (Adner and Kapoor, 2010, p. 329).

Microsoft in the computer software industry is a frequently mentioned example of a keystone in business ecosystems. Microsoft as the keystone is responsible for providing platforms and tools that are being used by the niche players. These specialised partners build their business on Microsoft's possibilities (den Ouden, 2012, p. 151).

4.3.2 Dominators

In addition to the already discussed leader, the biological ecosystem also contains weeds, the so-called dominator. This dominator displaces other species in the system and acts more traditionally than other ones because they try to exploit critical positions. The goal is to take over the network or suck out the value of the system. They aim to take over the system or reduce its value. The dominator can appear in various forms. One is the physical dominator, which attempts to control most of the ecosystem vertically or horizontally directly. As a result, no sustainable business ecosystem can emerge. A second form is the value dominator. It occupies a single point in the system, but direct control extends across the entire system. This dominator takes up most of the value created by other members and deprives the entire system of as much value as possible. What remains is too little to maintain a sustainable ecosystem. The whole system may even collapse, which means that the value dominator goes down with it as well (Iansiti and Levien, 2004a, pp. 5–8). Dominators can be small or large in size and number. They play their dominant role as they take over other species' functions or eliminate those functions by integrating horizontally or vertically. Through that, modularity is lost, and the system becomes vulnerable to disruption. Dominators want to increase their value and leave little opportunity to develop ecosystems (den Ouden, 2012, p. 151).

An example of an ecosystem dominator is visible in the early days of video recorders. Sony aimed to control the system with Betamax, but instead the open standard VHS was the survivor (den Ouden, 2012, p. 151).

4.3.3 Niche players

In nature, niche players are the most common type measured by number. This also applies to business ecosystems. They have specialised functions and abilities and differ from other organisations. Niche players contribute significantly to a functioning system because they offer and use complementary resources among themselves or with the keystone. Niche players focus all their energy on their narrow area of competence and are thus responsible for most value creation and innovation in a business ecosystem. The keystone offers its knowledge and resources so niche players can take advantage of them. Nevertheless, there may be a dominator working on exploiting or displacing them. Niche players are dependent on the ecosystem as a whole and thus, on other system actors. They need to analyse the ecosystem to find out the characteristics of other members. In particular, it is crucial to identify whether there are one or more keystones, what their and their own strengths are and whether a dominator exists or not (Iansiti and Levien, 2004a, pp. 5–9). Although niche species do not influence others remarkably, they make most of the system in numbers. They leverage the system's resources for their purposes and are highly dependent on the keystone (den Ouden, 2012, pp. 151–152).

For the evaluation, I chose to take a ratio. In an ideal business ecosystem, niche players make at least half of the actors. On the one hand, I assume that niche players are vitally important, and a lower ratio than 50 percent speaks against their relevance in the system. On the other hand, small business ecosystems exist, and therefore, more than 50 percent of niche players make small systems impossible.

4.3.4 Characteristics of Actors

To have an overview of the different actors in business ecosystems, I compared their characteristics. As criteria, I chose prevalence, influence, tasks and whether an actor type is ecosystem supportive or not. A basic comparison is in Table 2.

Table 2: Comparison of ecosystem actor characteristics

Characteristics	*Actor*	*Actor*	*Actor*
	Keystone	***Niche player***	***Dominator***
Prevalence	Few	Numerous	Numerous/few/none
Influence	Powerful	Low	Powerful
Tasks	Regulation, change initiation, guiding	Specialisation, expertise	Controlling, destruction, exploitation, value draining
Ecosystem supportive	Yes	Yes	No

Also, I assessed the specific differences. To do so, I did a formal concept analysis with the help of a concept lattice. I conducted a qualitative analysis and investigated the exact differences between the types of actors. In the light of that there are many actors in literature; this analysis should give more insights as these are partly very similar. The results should show a clearer picture of the similarities and differences between the actors. The method and my approach refer to the formal conceptual analysis conducted based on the publication by Wille (1992). For this purpose, I used the freely available program Lattice Miner 1.4[1]. I have collected the different types' characteristics and listed them in a table. As a next step, I matched the characteristics

[1] https://lattice-miner.soft112.com/

to the actors, which is shown in Figure 9. The assumptions made when matching are described next.

As keystones, business ecosystem leaders, ecosystem captains and lead firms are responsible for creating change and improvement for the whole system, these actors are assigned the characteristic initiating change. These actors are a driving force and establish standards to create a foundation for other actors. Thus, business ecosystem leaders, captains, lead firms and keystones are classified as regulating. Keystones, business ecosystem leaders, ecosystem captains, lead firms as well as dominators are small in number, instead niche players are the most common type and are therefore classified as numerous. The power of lead firms, ecosystem captains or leaders and keystones is that their actions have significant impact on other actors and I then assume them to be powerful. Dominators have the power to displace other species in the system, they are also classified as powerful. Niche players have no significant influence on others. Since keystones, business ecosystem leaders, ecosystem captains and lead firms are at the centre of change in the system, other members depend on them and they need followers, I assume them to be guiding. Dominators I suppose to be exploitative, value-skimming and controlling because they displace other species, exploit crucial positions, thus take advantage of the value of the system by occupying and controlling individual points in the system. They are therefore not classified as ecosystem enhancing, unlike all other actors. These are drivers of value creation, promote positive development and contribute to the functioning of the system. Dominators are classified as destructive, as they simply want to increase their own value and have no motivation for ecosystem development. Niche players are characterised by specialisation and expertise, as they have specialised skills and a narrow area of competence. I classify niche players as dependent, as they rely on the central player to create value. Based on these assumptions I did a formal concept analysis. With Lattice Miner 1.4, the concept lattice has been created automatically, which is in Figure 10.

	initiating change	regulating	few	powerful	guiding	exploitative	value draining	controlling	ecosystem supportive	destructive	specialized	expertise	dependent
keystone	X	X	X	X	X				X				
business ec...	X	X	X	X	X				X				
lead firm	X	X	X	X	X				X				
ecosystem c...	X	X	X	X	X				X				
dominator			X	X		X	X	X		X			
niche player									X		X	X	X

Figure 9: Screenshot of actors and characteristics in Lattice Miner 1.4

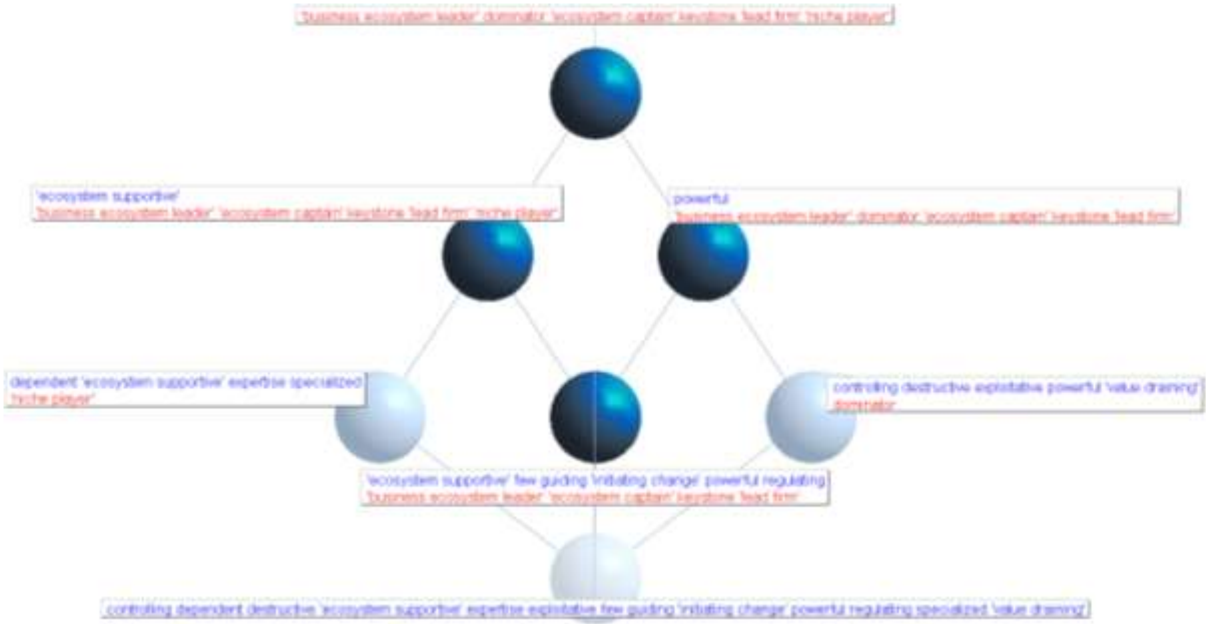


Figure 10: Formal concept analysis of business ecosystem actors

The formal concept analysis makes visible that the following actors have the same characteristics:

- business ecosystem leader,
- ecosystem captain,
- keystone and
- lead firm.

Thus, these actors are grouped into one and used as “keystones” in this work. It is also visible that the dominator and keystone share quite similar characteristics; they only differ in controlling, destroying, exploiting, and value draining. Niche players are quite different from the other actors but overlap with keystones in being ecosystem supportive.

In relation to the metamodel, I assume constraints in the existence of actor types. At least one keystone must exist in the system, but a maximum of two central actors can exist. Dominators suck out the system and can only occur in small numbers in the system; otherwise, they destroy it. I assume here that a maximum of one dominator may exist in the system. Niche players should occur in as large numbers as possible, because they create modularity and consequently, the value multiplied by the keystone. Therefore, niche players must account for at least 50 percent of the total number of players. This number could be much more extensive for large ecosystems, but I would like to keep the option for modelling small ecosystems as well.

4.4 Relationships

Relationships in business ecosystems originate with one actor and end with another but are also reciprocal and interactive (den Ouden, 2012, p. 158). Relationships are an essential element because by looking at these, one can conclude the consequence from one firm's action to other participants. It shows the close interconnectedness of the actors (Iansiti and Levien, 2004b, p. 8). Relationships cover what Adner (2017) describes as links and activities.

According to Selander et al. (2010), one should think of three dimensions of relationships. In their literature review, the authors see that business ecosystems rely on symbiotic relationships that can be defined when analysing the three dimensions: boundary definition, mode of control and locus of innovation. First, an organisation needs to define the boundaries of its activities concerning the ecosystem, referred to as the boundary definition. The mode of control involves the mechanisms used by an actor to capture value from its resources in the system. The third one is the locus of innovation, specific to innovation ecosystems (Selander et al., 2010, pp. 2–3). Tsujimoto et al. (2018) find that vision sharing and trust are essential elements of business ecosystem relationships and essential for its functioning (Tsujimoto et al., 2018, pp. 52–55). Reciprocity is central for relationships, which can be direct or indirect, and occurs through exchanging values with others (den Ouden, 2012, p. 159).

Relationships are to be considered from many different angles. Existing literature about business ecosystem relationships offers many different views. In the following, some of these are shown in detail to give the current status of research and options for modelling business ecosystem relationships. The challenge is that there are different types of relationships, and it is difficult to compare them directly (den Ouden, 2012, p. 159).

4.4.1 Collaborative Relationships

The authors Camarinha-Matos and Afsarmanesh (2008) divide collaborative relationships into two main categories, namely into organised-collaborative and ad-hoc collaborations. The former comprises long-term strategic relationships within collaborative networked organisations, such as business ecosystems. Ad-hoc relationships are short-term, pointed at specific task alliances, and spontaneous, but there is no common plan for their activities. According to the authors, long-term strategic relations enable business ecosystems (Camarinha-Matos and Afsarmanesh, 2008, pp. 2464–2465). In strategy, long-term relationships last for years or decades. The dedication of short-term relationships is to a specific purpose and end after its fulfilment. Its duration could range from a day to some weeks (Jerbi et al., 2012, p. 1744).

For modelling collaborative relationships, the time horizon is quite important. The figures for the time horizons are chosen according to the publication by Jerbi et al. (2012). Ad-hoc relationships are short-term and up to weeks, whereby here I assume six weeks. As to have no gap in the time frame and to be more flexible, I decided to add a tactical type of relationships, that starts from six weeks to a year. The strategic relationships are long-term and start from one year and could last for decades. Thus, I leave the time frame open.

For evaluating collaborative relationships, ad-hoc relationships are seen as unfavourable when occurring frequently. This is because connections are lost after short-term collaboration. If that happens with a considerable number, too many connections are lost after a few weeks. Similarly, tactical relationships have a medium time horizon and end after one year. Therefore, I expect these to be negative for ecosystems, but to a lower degree than ad-hoc relationships. Still, both types of relationships may be needed. I assume that ad-hoc relationships are harmful to the system as a whole if they occupy more than 10 % of collaborative relationships and for tactical relationships in case they own more than 15 %. In total, these types of relationships are allowed to hold 25 %, while in turn, strategic relationships must hold at least 75 % of collaborative relationships in the system. The mathematical description of the evaluation criteria is in Table 3.

Table 3: Evaluation of collaborative relationships

Collaborative Relationships	**Positive**	**Negative**
Ad-hoc	< 10 % of total	>= 10 % of total
Tactical	< 15 % of total	>= 15 % of total
Strategic	>= 75 % of total	<= 75 % of total

4.4.2 In/-Visible Relationships

Baggio and Del Chiappa (2014) conduct a study of relationships in tourism business ecosystems. They analyse three Italian tourism destinations with their core stakeholders and the links between them. The authors tried to classify the relationships into two main groups: physical and virtual ones. The results show that the tourism business ecosystem relationships consist of the two investigated elements, which means that there were real elements such as active companies and organisations, and virtual ones that are the digital representation of physical elements. The interrelationships between the real and virtual world are very tight, and a separate consideration is nearly impossible if not pointless. As the influence between these two related elements is very tense, Baggio and Del Chiappa,(2014) see it as a characteristic of their investigated business ecosystems. The virtual dimension of relationships has become essential for structuring, just as important as the physical dimension (Baggio and Del Chiappa, 2014, pp. 8–17). Tsujimoto et al. (2018) highlight the dynamic of relationships and that one actor's behaviour affects others. Similar to Baggio and Del Chiappa (2014), the authors describe the connections of business ecosystem members with each other through visible and/or invisible resource flows (Tsujimoto et al., 2018, pp. 52–55).

To model the dimension of visible and invisible relationships, the evaluation criteria is a comparison between the occurrence. I introduce physical and virtual relationships and, following the findings by Baggio and Del Chiappa (2014), these two dimensions are equally important. Thus, I check for the same amount of visible and invisible relationships in the system. I accept a variation of 20 %. The mathematical description of the evaluation of this relation type is in Table 4.

Table 4: Evaluation of visible and invisible relationships

In- /Visible Relationships	**Positive**	**Negative**
Physical	N(Physical) = N(virtual)	N(Physical) != N(virtual)
Virtual	N(Virtual) = N(physical)	N(Virtual) != N(physical)

4.4.3 Modular Relationships

Ecosystems coordinate autonomous organisations that are interconnected. The coordination is achieved through a modular design. The system's parts are organisations and separated from each other by *"thin crossing points"* (Baldwin, 2008, p. 156), which represent independent elements of a production process. Modularity makes it possible to produce interdependent components of a system by different organisations or actors while keeping coordination at a limited level (Jacobides et al., 2018, p. 2260). This form of organising happens under the premise that complementarities exist (Jacobides et al., 2018, pp. 2261–2263). An example of modularity can be found in smartphone-app ecosystems, for example, in the google-system. Some of the available apps are pre-installed on smartphones, but the user can select the majority according to their wishes, it is their own choice (e.g. Fautrero and Gueguen, 2013, p. 1).

Adner and Kapoor (2010) looked at the relation of different actors to the focal firm. The authors propose that there are different roles in the system that are linked together. Suppliers produce outputs, and these serve as input for the focal actor. The focal actor bundles the inputs which serve as input for the customers. Besides the focal actor's offer, consumers may want to bundle additional products to use them in the desired way. These additions are called complements. Thus, components and complements are defined according to where their bundling occurs in the stream of activities. This flow is in Figure 11 (Adner and Kapoor, 2010, p. 309).

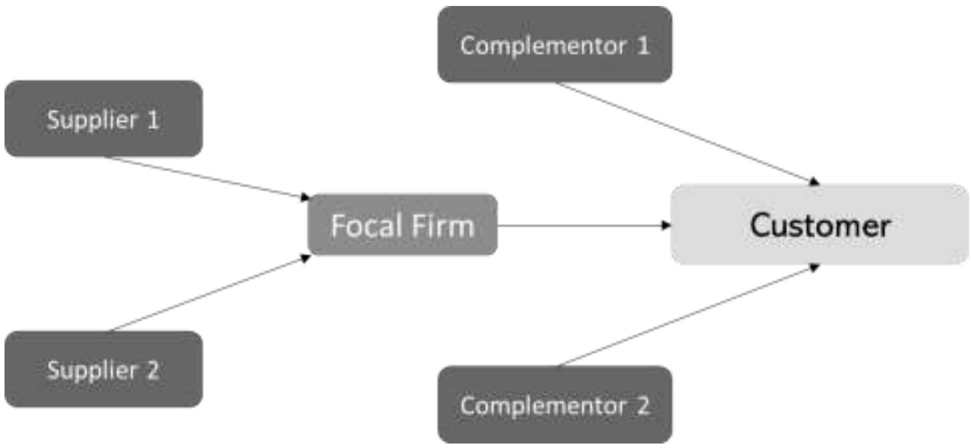


Figure 11: Relationship between focal firm and suppliers, complementors, customer based on (Adner and Kapoor, 2010, p. 309)

Jacobides et al. (2018) investigate different types of complementarities and assess these under the aspect of business ecosystems. The first type is unique complementarity which says that "A does not function without B" or in a more general version "A is maximized with B". This relation may be a matter of degree and can be one way ("A requires activity or component B, but not vice versa"), or it can be two ways ("A and B both require each other"). An example of unique complementarities is found in the OS platform or application system. The unique complement arises from the fact that an app does not work without the OS operating system but OS works without most apps (Jacobides et al., 2018, pp. 2261–2264).

Complementarities may also be generic. A specific good might be needed to create a complex offer backed by a multi-dimensional value proposition. This good or service can be generic, e.g. standardised, and in this respect be sufficient for companies to draw on. At the same time, organisations do not have to be concerned about the structure or consider misappropriation as a risk. The generic nature of complementarities means that coordination does not have to happen in a particular way or be tailored to a particular alignment structure (Jacobides et al., 2018, pp. 2261–2262; Teece, 1986, pp. 288–290). An example is a teacup, boiling water, and a teabag to make a cup of tea. These items are generic complementarities. Consumers can buy these elements on the market and combine them into a *"product system"*, but there is no coordination of the producers needed to create value for the customer (Jacobides et al., 2018, p. 2262). Another type of complementarity is supermodular complementarity and is about "more of A makes B more valuable". This type can be found in production as well as in consumption. For production, this complementarity means that when coordinated, both A and B yield higher returns or lower costs than uncoordinated or independent investments into A and B. In the context of consumption, supermodularity can be one way or two ways, and may coexist. In the OS platform or application system there is also supermodular complementarity: the availability of apps increases the value of the OS and vice versa – the more OS installations there are, the higher the value of the app (Jacobides et al., 2018, pp. 2262–2264).

The authors Jacobides et al. (2018) see non-generic unique and supermodular complementarities as essential business ecosystem elements. It requires a particular structure of relationships and alignment of elements to create value for the customer and/or system. Generic complementarities are not included in relation to business ecosystems, as actors have no interest in alignment or group action for generic complementarities. They do not capture what is unique for business ecosystems (Jacobides et al., 2018, pp. 2262–2264). The different types of complementarities exist in sets of roles. These sets have either unique, supermodular or generic relationships. As opposed to the traditional way of analysis to look at dyads, ecosystem members are a web of alliances. These affiliations are standardized and set for the specific roles in an ecosystem (Jacobides et al., 2018, p. 2265). Den Ouden (2012) looks at relationships in a similar way, namely on compatibility. The author classifies whether actors are positive, neutral or not compatible with other system members (den Ouden, 2012, p. 156).

As literature states that business ecosystems need complementarity, the evaluation criteria is "the more the better". A system with actors connected via many complementarities is highly interwoven and interconnected, but, as Jacobides et al. (2018) state, there is no need for much traditional coordination. Thus, for the evaluation, the number of modular relationships is considered. In association with den Ouden (2012), I classify unique and supermodular complementarity as positively compatible with the system. To evaluate complementary relationships, they are counted. These are then compared to the total number of existing relationships to determine the strength of the ecosystem. The more complementary relationships exist, the stronger the system is. Since this evaluation component refers directly to the overall system, the total system relationships ratio is calculated. If this ratio is below ten percent, the system may function but is described as weak in terms of modularity. Above this ten percent and below 50 percent it is moderate. More than 50 percent of complementary relationships concerning the total system relationships, the modularity can be described as strong and it is shown in Table 5.

Table 5: Evaluation of modular relationships

Modular Relationships	**Weak**	**Moderate**	**Strong**
Unique + Supermodular complementarity	< 10 % of total relationships	<= 50 % of total relationships	> 50 % of total relationships

4.4.4 Transactional Relationships

The focus of den Ouden (2012) regarding relationships in business ecosystems is on transactions. Flows of transactions happen between two different actors and exchange content. That content can appear in different forms, namely, goods and services, money and credits, information or intangibles (den Ouden, 2012, p. 159).

The most visible transactions are physical goods when exchanged, but also services can be part of the value proposition. The goods or services can flow in or out. The same is applied for money and credits. It involves revenue streams from customers and monetary transactions between business actors as well as loans and credits. Information can be shared across actors in different forms: knowledge, advice, information about something important regarding the value proposition or simply raw data. Generally, information plays an essential role in business ecosystems, and its sharing creates value. Thus, it is displayed as a separate relationship. Intangibles are values such as benefits of assets like reputation, exposure, attention or increased well-being. The difficulty in the context of modelling stream relations lies in the non-comparability of the different flow types (den Ouden, 2012, p. 159).

4.5 Boundaries

Business ecosystems are characterized by the fact that knowledge and resources are shared and used across industry boundaries. Crossing traditional boundaries enables open and flexible co-operation and competition (Senyo et al., 2019, p. 52). Knowing who is in the system, and what competencies and resources someone has, is crucial for understanding competition, collaboration and the shaping of an ecosystem strategy (Adner, 2017, p. 46; Adner and Kapoor, 2010, p. 308). Santos and Eisenhardt (2005) also conclude in their study that *"boundaries reflect the* *essence of the organization"* (Santos and Eisenhardt, 2005, p. 505). This raises a crucial question: What are the boundaries of a business ecosystem?

The system is an economic community consisting of interconnected actors whose mutual influence is visible through their activities (Jacobides et al., 2018, p. 2257). Cilliers (2001) notes that complex social systems have no clear boundaries. Once they emerge, they are diffuse in general. They can neither be found and defined to remain forever nor can they be described objectively, as this depends on perspective (Cilliers, 2001, p. 139). Iansiti and Levien (2004a) believe, that a precise definition of system boundaries is impossible (Iansiti and Levien, 2004a, p. 2). To attempt to define boundaries, we first look at natural ecosystems. Biological organisms maintain themselves by a stream of molecules that enter and exit. The boundaries of the system are only vague and it is difficult to say what and who belongs to the system or is outside it. The same applies to corporate ecosystems, a clear and unambiguous classification is a challenge (den Ouden, 2012, p. 150).

One approach to explore business ecosystems boundaries is to look at the *nature of the activities* or processes. The assumption is that a change in activities will result from an individual change as soon as they cross system boundaries (Scott et al., 2007, pp. 153–154). Iansiti and Richards (2006) find a distribution of value generated across several industries. They recommend defining a business ecosystem's critical areas where specific groups of actors are bundled sharing attributes or characteristics and solve similar customer problems. Hence, boundary analysis focuses on one or more core domains (Iansiti and Richards, 2006, p. 79).

Several studies determine the boundary based on *actors* and ask for the "who". That approach includes the definition of who is and who is not a member of the system. These members likely share attributes such as interests, goals, strategies or structures (Scott et al., 2007, p. 153). Adner and Kapoor (2010) agree and focus on actors; they set the company limits (Adner and Kapoor, 2010, p. 307). Suppose the system boundaries are to be determined from the actors' perspective. The closest organizations are identified first, and possible future dependencies that are decisive for the ecosystem's success can be determined subsequently. The result could be hundreds or thousands of organizations into related groups (Iansiti and Levien, 2004a, p. 2). Another approach is to explore social relationships and identify the actors involved. Indicators for this are the frequency of interaction and relatedness (Scott et al., 2007, p. 153).

Santos and Eisenhardt (2005) developed four conceptions to have different angles to determine organizational boundaries: boundaries of efficiency, power, competence and identity. The boundary of efficiency defines the transactions within the organizational context, which is the business ecosystem. The view of power demarcates the domains over which the organization has influence. The third view from the angle of competence emphasises the delimitation of the resources an ecosystem owns. The last boundary conception focuses on the dominant mindset of the “who we are”, which is identity (Santos and Eisenhardt, 2005, pp. 491–502).

The authors Phillips and Srai (2018) conducted a study on determining boundaries in emerging ecosystems and base their investigation on the findings by Santos and Eisenhardt (2005). The ecosystem in focus is the emerging medical technology ecosystem in the UK. Their research design comprises two phases. In the first one, the authors conducted 23 interviews plus four follow-up interviews with managers and executives. The findings were used to map ecosystem designs and were then complemented by other findings such as observations from conferences and workshops as well as scientific, economic and industrial documents. The second phase focused on the analysis of five case studies from sub ecosystems. In the development of ecosystems, the authors took snapshots by the respondents from their perspectives. Also, they examined specific questions, mostly concerning actions and interactions. If they identified patterns, they coded them to explain how the boundary perspective evolves (Phillips and Srai, 2018, pp. 5–6).

The analysis used a combination of the frequency of identified actors and the stakeholder attributes perceived by respondents. The investigation divided the actors into groups of similar types, which was an initial structuring. Also, they developed a rough map and identified a boundary. As a result of this analysis, the authors drew a meta-ecosystem map shown in Figure 12. It illustrates the most important clusters of involved actors and forms a landscape for the investigated case (Phillips and Srai, 2018, pp. 7–14).

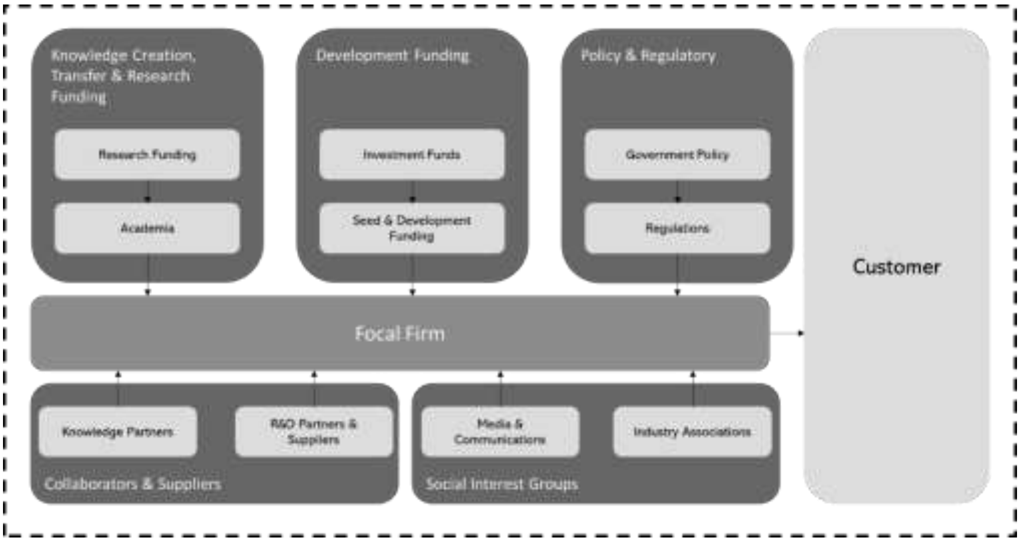


Figure 12: Example of high-level ecosystem map
based on (Phillips and Srai, 2018, p. 10)

In the second phase, the authors implemented their approach to the five case studies. Here, too, actors and critical relationships over time and their development were mapped. Individuals who tried to understand their ecosystem reported on structured search issues and that the establishment of relevant actors was complex. One of the most important findings of the study is that identity alone is insufficient to determine a member and thus the boundary. Contributions and relationships proved to be particularly relevant for the border specification. Even large companies had to understood as legitimate or credible to be seen by others as part of the ecosystem. While the study focused on emerging ecosystems, the authors noted that the relationships between members have changed over time. In the early stages of evolution, partnerships were established and terminated quickly, as it is essential to find partners with the necessary skills and potential long-term partners (Phillips and Srai, 2018, pp. 7–14).

Phillips and Srai's (2018) main findings are that identity is essential for developing ecosystems with few actors and limited information. The authors discover that an appropriate research method for identifying early-stage boundaries is to conduct interviews. After the first period, the number of actors in the system increases, where building relationships and understanding them in terms of credibility, such as legitimacy or competence, is essential. Interviews are still a valuable source but should be complemented by approaches of stakeholder or network analysis. When actors position themselves advantageously, relationships can change, which is why power becomes increasingly important. Thus, the mapping of ecosystem boundaries also depends on the stage of evolution. It is proposed to consider the business ecosystem in a life cycle context. The focus can shift from identity to competence to power and efficiency as actors move from credibility to advantage (Phillips and Srai, 2018, pp. 14–17).

4.6 Static Visualizations

Some scientific papers show visualizations of business ecosystems. Two different approaches are identified based on the views of business ecosystems described in chapter 4.1, whereby both are static ones. The part below shows one visualization possibility per view; each one comprises established representatives of ecosystem research. Moore (1996) is shown first, who looks at it from the perspective of ecosystem-as-affiliation. Iansiti and Levien (2004a) take the ecosystem-as-structure approach in their paper.

Visualization according to Moore (1996)

Moore (1996) structures business ecosystems and their members within three different groups: the core business, the extended enterprise and the business ecosystem. The core business includes key contributors, which are the central actor’s direct suppliers and distribution channels. The extended enterprise comprises suppliers of the suppliers, standards bodies, suppliers of complementary products and services, direct customers and customers of customers. The broad business ecosystem includes government agencies and other regulatory organizations, stakeholders such as investors, owners, trade associations and labour unions, as well as competitors with similar product and service characteristics, processes and organisational conditions. The system is broader than the core business and the extended enterprise and not limited to traditional industry boundaries (Moore, 1996, p. 27). A visualization of the described business ecosystem structure is presented in Figure 13.

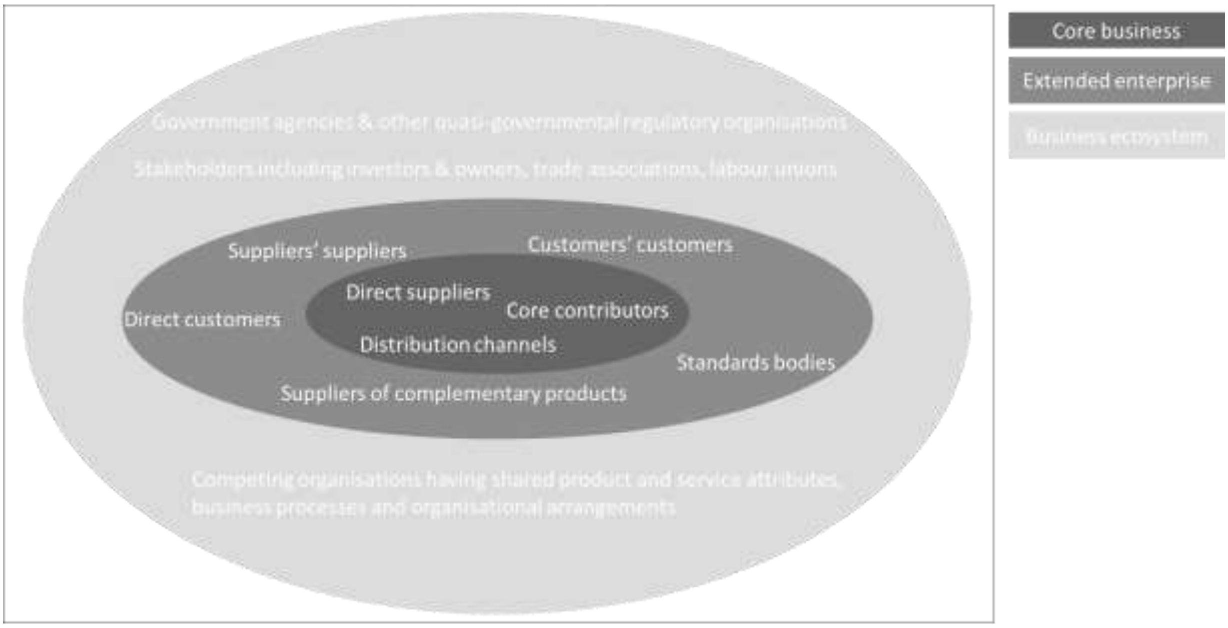


Figure 13: Business ecosystem structure according to Moore based on (Moore, 1996, p. 27)

Visualization according to Iansiti and Levien (2004a)

The formulation of the structure is essential for creating or designing business ecosystems. Iansiti and Levien (2004a) describe a business ecosystem's structure based on the elements: keystones, dominators, and niche players. Figure 14 illustrates the authors' schematic representation. The thick lines and large nodes stand for the part of the system that the keystones occupy. As described above, it is not necessarily a significant part of the system. These nodes serve as a hub in the network, as they are most connected and lie at the system's core. The remaining smaller nodes and thinner lines are available for other actors: niche players or dominators (Iansiti and Levien, 2004b, p. 73).

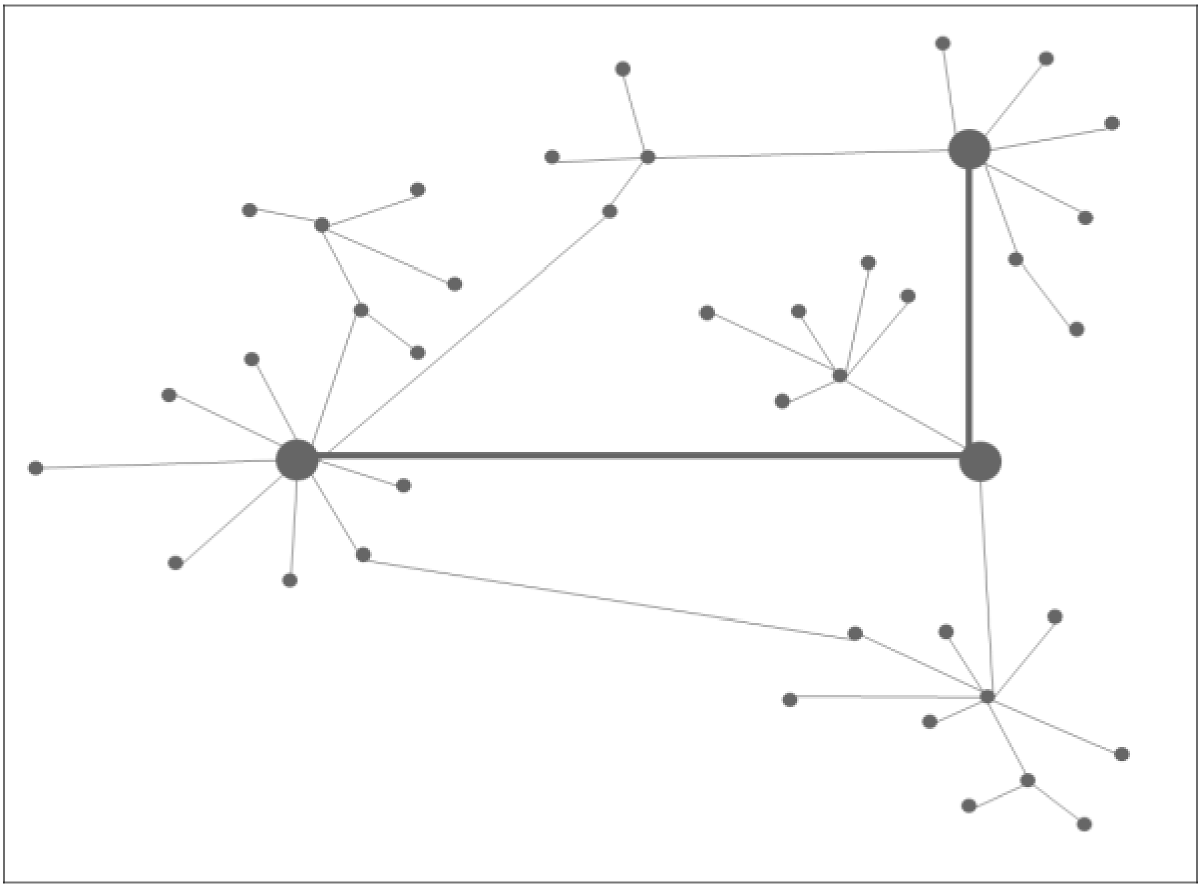


Figure 14: Business ecosystem structure according to Iansiti and Levien based on (Iansiti and Levien, 2004a, p. 73)

In this thesis, I use visualisation as communication and static visualization tool. In relation to the metamodel, the visualisation approach by Iansiti and Levien (2004a) seems more obvious, as it supports the ecosystem-as-structure view better. The visualisation by Moore (1996) focuses on business functions and lacks in adding value to represent the structure or relations of a business ecosystem. Iansiti and Levien (2004a) focus on graphs and nodes, which are the relations and actors, and pictures the structure in a suitable way. I already defined the elements used in the metamodel and Iansiti and Levien see those as relevant too. For modelling, I take and adapt their approach as the basis of visualisation for the needs of the presented metamodel. I assume the nodes to be the actors and the graphs to be the relations. Also, the position can be defined with the help of that approach and the specific structure of business ecosystems becomes visible.

4.7 Time Perspective: Evolution

According to their nature, ecosystems are dynamic. They change continuously, adapt to new conditions resulting from changes in their environment. The setting may change so much that the ecosystem is no longer attractive to an actor. If the actor leaves the system, it must adapt to the new situation. Moore (1996) contributes to findings of the evolution of business ecosystems and classified it into four stages (den Ouden, 2012, p. 185).

Stage 1: Birth/Emergence

The birth of a business ecosystem happens with the formulation of a vision. An individual or a group aims to solve a problem using a new product or service, with the customer’s needs at the centre of considerations. Compared to traditional organizations, birth can take a similar course up to this point. The difference between traditional companies and business ecosystems lies in the importance and necessity of cooperation. Business partners are needed to implement the whole package of value and bring it to the customer. These evolving organisations need leadership to enable them to work towards the vision in a focused way. It ensures a process of development and improvement, and secures that each member works towards the common goal. Working together is challenging in this phase, especially when the joint value proposition should be realised with other stakeholders. The network is condensed at this point. The business environment poses the challenge of protecting the idea from others’ exploitation of the environment (Moore, 1996, pp. 106–136).

In addition to Moore, other authors have dealt with the emergence or birth of business ecosystems. Jacobides et al. (2018) see modularity and various complementarities as essential prerequisites for the emergence of these systems. It is more likely that modularisation and the associated reduced friction will bring about the emergence of markets. For business ecosystems to be meaningful, there must be a significant requirement for coordination. It cannot be met by the traditional structures of a market but at the same time does not require definite authority structure. Jacobides et al. (2018) see that studying the nature, direction, and intensity of complementarities and the actions of system organizations to influence the formation and structure of ecosystems helps to explain different value chains and dynamics (Jacobides et al., 2018, pp. 2256–2260).

Of course, ecosystems do not simply arise spontaneously and are, at least in part, the result of conscious planning including experimentation and design (Jacobides et al., 2018, p. 2263). By looking at software developers in smartphone-app-systems this decision becomes visible. Developers are niche players in those systems. Suppose they want to participate in the ecosystem. In that case, they have to decide at a certain point in time to write their application in the programming environment, interface or even language prevailing in the system (e.g. Fautrero and Gueguen, 2013, p. 6). Organizations may as well choose to modularize a process or stop producing complementary products. On the one hand, this can make the supply less interchangeable. On the other hand, it may result a business ecosystem to create more value overall. The keystones mentioned above play a central role in this process, as they are responsible for the processes of system development and rules. Their challenges and goals are to find complementary organizations and integrate them into the system (Jacobides et al., 2018, p. 2263). Here the circle to the economic view, which strongly focuses on a planned process, closes again and here a link to the previously described view of Moore (1996) can be found.

Stage 2: Expansion

Expansion characterises the second stage, where value proposition is intended to conquer new territories and thus increase influence. The business ecosystem becomes stronger than in the previous stage as more customers use the product or service, and more organizations become active members of the system. For expansion, a business concept is necessary, which users consider important and useful and brings potential for expansion. Thus, a broad mass of customers can be reached. During the expansion phase, established, large companies may put enormous pressure on emerging business ecosystems and want to nip them in the bud. One of the essential tasks of management is to stimulate the demand for the value proposition to the extent the system can meet. During this stage, the biggest cooperative challenge is to establish the demand in a large market and achieve the maximum possible market coverage. In terms of competition, this stage is characterized by defeating alternative products or services from competitors and dominating important market segments (Moore, 1996, pp. 137–188).

Stage 3: Leadership

If the ecosystem has grown strongly enough, it is profitable and the value-adding components are stable, leadership battles may take place in the third stage. Stability enables suppliers to make use of some aspects of value creation and compete for leadership. At the same time, these members are encouraged to take over activities or organizations close to them. Dependence on the original leader changes, making them more independent. The organizations of the system deal with standards, interfaces and modular organizations. Central organisations can strengthen their role in the system by making important contributions to performance, and their supporters appreciate the key organisation because of its influence on customers. During the leadership phase, the cooperative challenge is to offer a convincing vision of the future and to encourage the members to work together for further improvements. The environmental challenges revolve around strong negotiation power that includes the key stakeholders of the system (Moore, 1996, pp. 189–229).

Stage 4: Self-Renewal or Death

The last stage is self-renewal or death. New ecosystems or innovations increasingly threaten established business ecosystems. The system could be under entirely new conditions comparable to an earthquake in a biological ecosystem. It finds new conditions in the environment, such as government regulations, abruptly changing customer behaviour or macroeconomic conditions shift. A combination of these factors may put enormous pressure on the business ecosystem. To survive, the ability to continually renew is crucial. It may involve integrating innovations into the system or fundamentally restructuring it to respond adequately to the new reality. The collaborative challenge is to work with innovators. Competition brings about questions concerning the system's general existence and the realisation of new ideas for products or services (Moore, 1996, pp. 230–264).

The modelling will not have a dynamic aspect, but will be static. This means that the change in time is not primarily considered. The behaviour of the actors and their relationships can also change the structure of the system. Therefore, it is important to look at the model in terms of having a specific point in time and reviewing it under new conditions in the environment or changing customer behaviour.

4.8 Hierarchy

In business ecosystems, there is only limited need for hierarchical structure. The various actors want continued participation in the system, which leads to little opportunism. In general, supervision is more successful if carried out by colleagues instead of superiors. It is because individuals who are not willing to cooperate are punished by those who are. In this context, an actor's reputation is crucial; it serves as a signal of reliability. If this signal or trust is disturbed, the other participants' willingness to enter into a long-term relationship decreases. The need for some form of formal agreement increases as the cooperative characteristics turn into calculative ones (Powell, 1990, pp. 300–305). Therefore, trust is one of the most important aspects of control structures. That knowledge must be taken into account, especially when designing business ecosystems (den Ouden, 2012, p. 146).

Recent work on this topic tends in the same direction and shows that formal mechanisms are essential tools to motivate, discipline and encourage members. These formal mechanisms include standards and interface management (Baldwin, 2012, p. 20), cross-system governance (Cennamo and Santalo, 2013, p. 1347; Wareham et al., 2014, p. 1195), rights over intellectual property and other contractual forms (Brusoni and Prencipe, 2013, p. 181; Jacobides et al., 2018, p. 2259; Leten et al., 2013, pp. 58–59). Ecosystems' members all retain some control and entitlement over their assets. Neither party has unilateral control over conditions such as pricing, quantities or standards. It means that decision-making processes in ecosystems need to be distributed. (Jacobides et al., 2018, pp. 2266–2267). In terms of hierarchy, it is necessary to emphasize a central feature of business ecosystems, namely their ability to coordinate interrelated actors, but with a high degree of autonomy. Baldwin (2008) attributes much of this to modular ecosystem architecture (Baldwin, 2008, pp. 179–180). Organizations in ecosystems are separated by thin intersections that allow different manufacturers to produce dependent components. The central actor defines the overarching design parameters of the architecture by creating processes, rules, standards and interfaces that enable it to run. Modularity is a prerequisite for the central actor not having to exercise explicit hierarchical coordination (Jacobides et al., 2018, p. 2260).

4.9 Evaluation

To assess a business ecosystem, it makes sense to consider whether it is healthy or not. Although literature widely discusses collaboration benefits, there is still no suitable way to measure them using performance indicators. Those existing relate mainly to organizational units or companies, rarely to entire systems. Especially for business ecosystems, there is a lack of performance measurement possibilities (Graça and Camarinha-Matos, 2017, p. 238). Iansiti and Levien (2004a) try to find the factors of a healthy system and an unhealthy one. They identify three critical metrics: productivity, robustness and niche creation.

Productivity

In biological ecosystems, the key competence is to transform non-biological inputs (sunlight, minerals) into biological outputs (biomass, organisms) This ability is crucial for assessing the health of an ecosystem. Projected onto business ecosystems, the equivalent is the conversion of technology and raw materials into reduced costs and new products as outputs. A widely used and traditional way of measuring this is return on invested capital. Iansiti and Levien (2004a) compared three different ecosystems, software, biotechnology and internet services, using return on invested capital . The aggregate return on capital employed varied over a decade across the three systems: the return on invested capital in the software industry was ten percent, that of biotechnology companies was slightly negative at minus five percent, and that of internet companies was negative at minus 40 percent. The differences in productivity were particularly remarkable over time. In the software and biotech industry the parameter has not changed significantly over the years. In contrast to that, the productivity of internet services fell dramatically from 1996 to 1997. The drop is because companies like Yahoo and AOL have started charging high fees for the traffic that other companies seek from their portals. The negative numbers in this industry spanned more than three years and collapsed in 2002. Assessing this ecosystem's health before it collapsed could have helped to reduce dependence on it beforehand (Iansiti and Levien, 2004a, pp. 3–4).

Due to the characteristics of business ecosystems, it may not be possible in the future to use productivity as described by Iansiti and Levien as a performance indicator for evaluation. The unit of analysis in ecosystems is changing from the traditional industry view to the ecosystem view (e.g. Teece, 2016, p. 2). By blurring industry boundaries, it may no longer be possible to use the return on investment to evaluate a cross-industry ecosystem. In my opinion, productivity can only be used as a valuation indicator for ecosystems when it is calculated explicitly for the ecosystem.

Robustness

An ecosystem should provide sustainable and durable benefit to the species within the system, especially those who depend on it. It has to persist variation in the environment and unpredictable technological change. Companies that are part of a robust business ecosystem have relative foreseeability, and strong relations buffer external shocks. A method to measure the robustness of a whole ecosystem is the members' survival rate over time in relation to benchmark ecosystems. Again, Iansiti and Levien (2004a) looked at the software, biotechnology and internet services ecosystem in robustness. The software ecosystem grew strongly over the decade, with a contraction around the recession in 2001. The number of actors in the biotech ecosystem is relatively constant with new start-ups to replace companies leaving the system. The internet ecosystem that collapsed in 2002 does not need analysis in this section because it was dealt with in the context of productivity (Iansiti and Levien, 2004a, p. 4).

Niche creation

The definition of business ecosystems states that variety is needed and diversity is supported. The idea of diversity absorbs shocks that are external and brings innovation potential. A measurement of an ecosystem's ability to create meaningful diversity through valuable new features or niches is a key evaluation topic. One way to assess niche creation is to measure the application of new technologies in organisations and products. Old niches do not need to remain in the long term. It is more essential to promote and pursue declining diversity in one area by creating niches in other system areas (Iansiti and Levien, 2004a, pp. 4–5).

Reciprocity

A non-classical economic evaluation possibility is reciprocity, which originates from sociology. It is about the balance of values. It means that every actor who invests should receive something in return. The testing of reciprocity is not purely mathematically, because it is intuition or gut feeling, an intangible value, that can hold a monetary value. The calculation of reciprocity in modelling examines the relationship between providing and receiving. For this purpose, a comparison between the outgoing edges and the incoming ones is conducted. A value assessment makes sense since the edges represent different types of relationships. The perceived value or balance must correspond to the motivation and values of the individual members. In the long run, the ecosystem's existence depends on the health of individual actors. Hence, reciprocity is a central factor for the entire business ecosystem (den Ouden, 2012, p. 197).

Value Alignment

A quantitative way to analyse business ecosystems is the method of Macedo and Camarinha-Matos (2013). They examine the alignment of the entire system and its members. For this purpose, they define three areas as a basis for the analysis (Macedo and Camarinha-Matos, 2013, p. 416):

- shared core values
- positive impact and
- potential for conflict.

If it is vital in a system that there are shared fundamental values, then the alignment is exceptionally high. For business ecosystems, based on the initial analysis of the characteristics in this work, it can be said that this is true. If there is a strong positive influence between two core values, then their influence is more remarkable. It affects ecosystems positively. If this is not the case because two core values have a strong negative influence on each other, then the potential for conflict is high. Consequently, it is harmful to the entire system. With this qualitative analysis, it is possible to make statements about whether the business ecosystem's values are aligned or differ strongly (Graça and Camarinha-Matos, 2017, p. 244; Macedo and Camarinha-Matos, 2013, pp. 416–423).

Concerning the performance indicators for business ecosystems, it is visible that there is a definite need for generally accepted criteria. The evaluation options provided show initial opportunities for further development and approaches in a wide range of fields to investigate in detail. Graça and Camarinha-Matos (2017) see potential in finding a research strategy towards the establishment of indicators. For this purpose, an analysis of business ecosystems is useful to get to know their structure better. To identify mechanisms and metrics, one could investigate value systems, social network analysis, collaboration benefits, enterprise performance indicators, and supply chain collaborations. The usage of simulations of models gives insight into evaluating indicators' suitability (Graça and Camarinha-Matos, 2017, pp. 253–254).

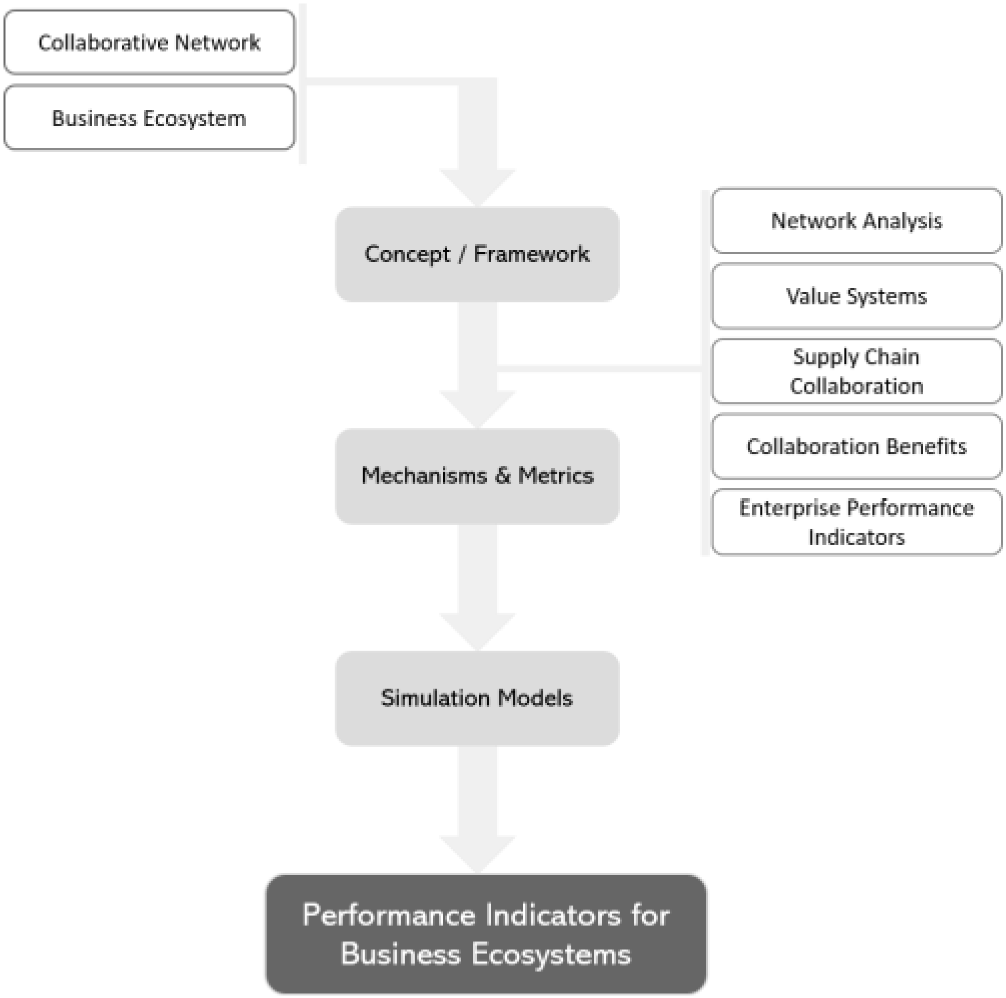


Figure 15: A research strategy for performance indicators of business ecosystems based on (Graça and Camarinha-Matos, 2017, p. 254)

This thesis positions itself in the first grey square, the concepts and frameworks, transitioning into the second grey square, the mechanisms and metrics.

Based on the findings of this chapter, the evaluation of the model of business ecosystems is derived from the three elements proposed by Graça and Camarinha-Matos (2017) (Graça and Camarinha-Matos, 2017, p. 254):

- structure of business ecosystems
- mechanisms used by value systems, enterprise performance indicators and social network analysis and
- assessment based on the model.

To get the structure of the business ecosystems for evaluation, I use the described characteristics. The mechanics and metrics are derived from these, and those discussed in this chapter will go into the evaluation.

4.10 Summary

In this chapter on conceptualizing business ecosystems, two different views came across: ecosystem-as-affiliation and ecosystem-as-structure. The first view focuses on the number, density, and interaction of system participants and keystones' central role. By combining the interactions of (potential) partners, the overall value for the system is created. The second perspective starts with the solution to a customer need. Based on this, actors, positions, links and activities are defined. The two views already indicate possible building blocks of business ecosystems, which leads to the chapter on the different elements. The view by types of companies or interest groups and their elements are similar to the traditional view of industries. Elements subdivided by function add value to the discussion in that they focus on relationships. This work uses the functional approach to define activities, actors, positions and links. If actors are classified to reflect the specifics of business ecosystems, one can identify three different ones. Keystones play the central role in the system and act as multipliers of value creation. In an ideal system, there are many niche players taking on tasks of specialization and expertise, which makes modularity possible in the first place. There may also be dominator-type players who want to extract and exploit value. The actors' conceptual representation in this thesis has shown that keystones and dominators are very similar in some characteristics, which allows a sliding transition from one actor to another. Yet there are crucial characteristics for the ecosystem, namely the ability to support, guide and regulate – without dominating and draining value. The prevalence is important for actors because of their specific functions. The system cannot tolerate too many keystones, and too few niche players cannot create the necessary complementarity. Too many dominators suck out the value and subsequently destroy the business ecosystem.

Regardless of the type, some relationships arise through the evolution of the system or via planned actions between different players. In this thesis, different types of relationships are presented, which differ in their point of view and meaning. First of all, collaborative relationships are presented, which consider different time horizons. It is not essential for the functioning of business ecosystems that only one form of these relations exists. What is decisive is the type of relationship, namely that most collaborative relationships are strategic. The second type of relationships explained consists of virtual and physical ones. The conclusion from the studies presented is that both forms are equally necessary for a system to function. The third type of relations shown is relatively well established in the literature and is a characteristic of business ecosystems –modular relationships. In particular, the existence of unique modularity and supermodularity is crucial for the success of ecosystems. The more relationships of this type, no matter what their nature, the stronger the system. The fourth type of relationships presented is transactional ones. These comprise goods and services, money and credits, information or intangibles. The visualization of these relations in models is beneficial when creating business ecosystems, but with the constraint, the different types are not comparable.

Closely related to the relationships, but also the actors, is the question of boundaries. There are various approaches to define borders, with activities, relationships, actors or their definition via identity providing a legitimate starting point for this. Based on the possibility of defining actors, relationships and boundaries of business ecosystems, different authors have developed different visualisation methods. These relate to the different perspectives presented in this paper.

The evolution of business ecosystems begins at birth, the emergence of a business ecosystem that differs from traditional organizations by a high degree of cooperation and complementarity. Expansion follows that phase, which leads to leadership. It either ends in the death of the system or the system succeeds in creating self-renewal. Also, hierarchy is a central topic to business ecosystems, mainly as it works differently to prevailing economic structures. The most important mechanism is trust, but also formal ones are established.

When looking at a system, a critical issue to look at is evaluation. There are different possibilities for assessment: quantitative or qualitative ones originating from different disciplines. A review of traditional economic quantification could add value for finding new methods for business ecosystems. Sociology offers possibilities to assess the balance of a system. The shown qualitative method can give more insights into the alignment of members' value expectations and the strength of the value proposition.

The described interaction of individual components is particularly relevant for business ecosystems and characterizes them. It is vital for the design as it forms the basis for it. Elaborating the concept as conducted in this chapter is essential to create the basis for the designing and modelling of ecosystems. The design of business ecosystems will be discussed in more detail in the next chapter.

Question 1: What is the concept behind business ecosystems?

The first research objective asks for the concept behind business ecosystems. Chapter 4 addresses this purpose and analyses scientific findings in detail. I have shown that business ecosystems consist of elements, actors who have relationships, boundaries can be identified; it is feasible to visualize them; they have a process of evolution, and it is possible to evaluate them. There are distinct approaches for the different characterisation elements. A consistent and continuous characterization was found and presented. Thus, a clear concept was developed and is summarized in the mind map of Figure 16.

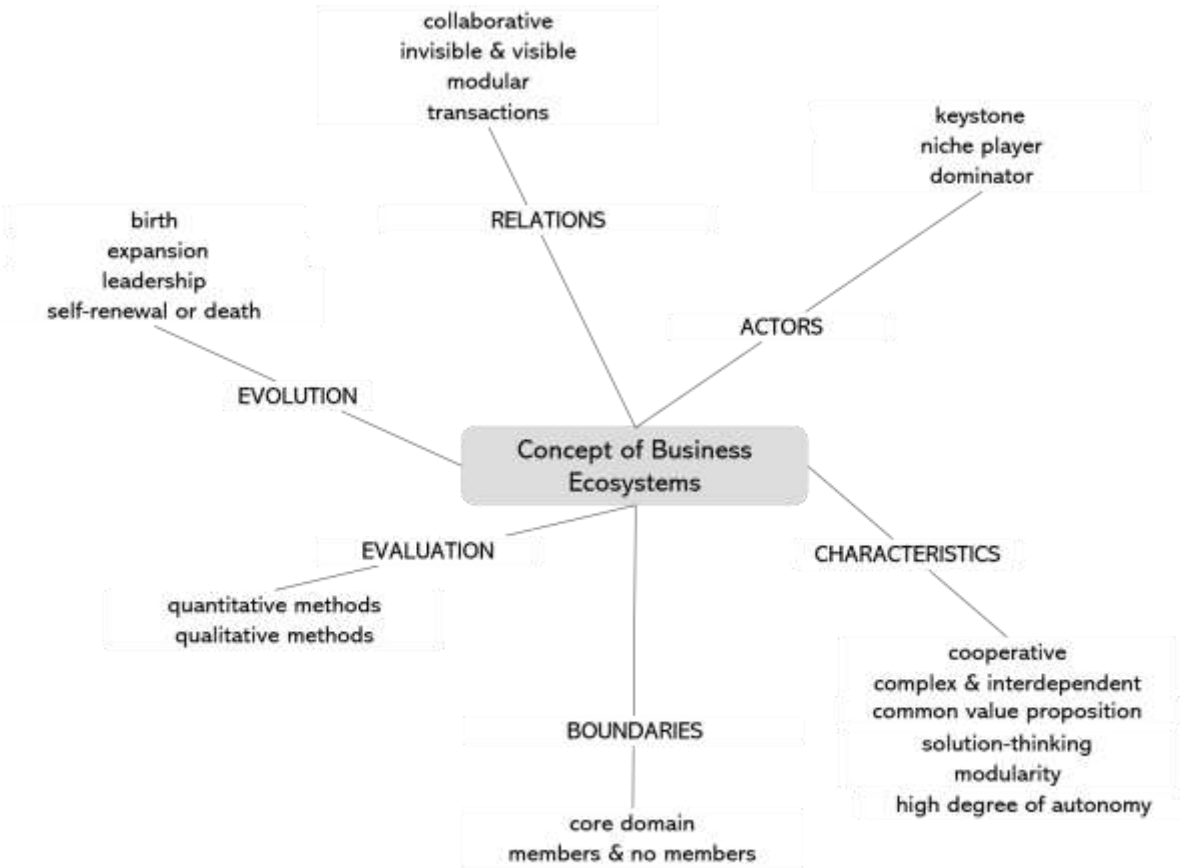


Figure 16: The concept of business ecosystems

Business ecosystems have different actors connected via different types of relations. The core domain determines its boundaries and who is a member and who is not. The evolution of business ecosystems has four stages. Business ecosystems are distinct from other systems, as they have particular characteristics. For business ecosystems, quantitative as well as qualitative methods are suitable for evaluation.

5 Business Ecosystem Design

To offer modular solutions for consumers, this work has shown that the concept of business ecosystems is a suitable answer. The question in this chapter is how to design such systems. It is crucial to design the system in a way that emphasizes the specifics of ecosystems. This part of the thesis contributes to the achievement of the second research objective: How can business ecosystems be designed?

5.1 Consideration and Positioning

Business ecosystem design is assigned to the evolutionary stage of birth but not limited to that. As already described, these systems do not merely emerge spontaneously but are partially deliberately planned, supporting the design approach (Jacobides et al., 2018, p. 2263). I would like to start with the possibility of emerging systems. Modularity, the nature of complementarities and fungibility, can be shaped to some extent. However, it is not always possible in advance. Companies, especially those that allow and support modular technologies, can unconsciously form business ecosystems. An example are manufactures of inkjet printers, confronted with unauthorised ink cartridge manufacturers. Another example is when hackers developed the first apps for Apple's iOs. They ended up in court until Steve Jobs realized that an ignorant ecosystem could be turned into a regulated one. They benefitted collectively (Jacobides et al., 2018, pp. 2263–2264).

The conscious decisions of actors become visible when processes are actively modularized, complementary products are offered and participation is possible, as demonstrated above by the example of iOS app developers (Fautrero and Gueguen, 2013, p. 6; Jacobides et al., 2018, p. 2263). The purpose of design as a prescriptive step is to implement the desired solution and then offer it to a customer in a sustainable way (den Ouden, 2012, p. 143). Traditional design processes focus on the company itself, which is changed under business ecosystems to a value proposition for the customer (Ballon, 2007, pp. 567–574).

As described above, business ecosystems cannot be structured and managed hierarchically. Though, Gulati et al. (2012), among others, note that a designer's presence is essential to design a business ecosystem. This architect sets a goal, defines the differentiation of individual members and roles, standards, interfaces and the value of the system (Gulati et al., 2012, pp. 573–576). Jacobides et al. (2018) support the findings that a central actor can set overarching design parameters. Still, companies have a much autonomy in terms of design, price and operation of their modules, provided they connect with others in agreed and prespecified ways (Jacobides et al., 2018, p. 2260). The architect or central actor's function described here can be assigned to that of a keystone, demonstrating its importance in design. This role is not uncontroversial but double-edged. Already in the conceptualization phase, the fluid boundaries between keystone and dominator were addressed. On the one hand, there is the danger that the keystone or architect will adopt a dominating style. On the other hand, the system can benefit significantly from visionary leadership, inspiring others to work together towards a common value (den Ouden, 2012, p. 152).

5.2 Design Process

The design process of business ecosystems does not require an individual to consider the entire system at once. Literature states that it is not essential to plan the whole system and decide on positions. However, the ability to keep an eye on the interdependencies and be aware of the emergent part is crucial. An example of this is the option that an actor decides to leave the system, which affects other positions in the system (den Ouden, 2012, pp. 150–151; Moore, 1996, pp. 25–26). It comes apparent that most emerging ecosystems are by definition dynamic; therefore, a single snapshot map is not sufficient. A constant review of actors and subsystems is useful as they evolve. There is a need to study the landscape regularly and map the ecosystem in terms of key actors, relationships, issues, and opportunities (Phillips and Srai, 2018, p. 17).

Two different design approaches are derived from the perspectives discussed in chapter 4.1. For the ecosystem-as-affiliation approach, the following procedure can be outlined (Adner, 2017, p. 41):

1. actors are defined based on their commitment to the keystone
2. define relations between the actors and
3. derive the value proposition from this.

The ecosystem-as-structure approach follows the opposite direction in design (Adner, 2017, p. 42):

1. definition of the value proposition
2. definition of the activities and
3. definition of the structure.

The customer-as-affiliation approach is comparable to a bottom-up strategy and broadly involves emergence but partly formation. The ecosystem-as-structure approach is compared with a top-down strategy. This procedure is similar to that of den Ouden (2012) in that the starting point is the value proposition. The choice of actors, activities, and structure is following the value proposition.

Den Ouden (2012) divides the process of designing business ecosystems into five steps (den Ouden, 2012, p. 154):

1. initial value proposition
2. elect parties for ideation and enrich the value proposition
3. choose stakeholders and know their interests
4. define roles and relationships and
5. select parties for the implementation.

Figure 17: Business ecosystem design process
based on (den Ouden, 2012, p. 154)

Although the process is shown here sequentially in Figure 17, it is a highly iterative procedure. This process starts with the initial value proposition. It means that a goal is defined that requires a modular solution. This solution needs ideation and refinement in the next step, for which other parties can be helpful. The actors involved in the design process, or more precisely, in defining the value proposition and structure that the ecosystem creates, are not necessarily permanent members of the system. Some parties may withdraw from the creation process if they do not see sufficient value for themselves in the ecosystem. Some may join if their knowledge, experience or technology is needed, and they see value for themselves. The third step comprises identifying stakeholders and their interests (den Ouden, 2012, pp. 144–154), which raises essential questions about potential members: who? why? (Ledwith and Coughlan, 2005, p. 372). The fourth step defines stakeholders' roles and relations. It may be that an actor has several different roles, such as being a provider and consumer at the same time. One example is the Genius function of Apple's iTunes. Users contribute to the automatic generation of playlists. At the same time playlists are analysed based on their listening habits to get an idea of what songs people generally listen to and how they fit together (den Ouden, 2012, pp. 155–175).

In a final step, the parties for implementation are determined. It asks for stakeholders' skills. The abilities of the individual stakeholders are decisive for whether cooperation is beneficial or not. The collaboration can only be successful if the skills agree with the goals (den Ouden, 2012, p. 155; Ledwith and Coughlan, 2005, p. 372).

Den Ouden (2012) uses several elements in their value flow model to design a business ecosystem. At the start of a business ecosystem design process, **actors** are essential for realizing such a project. The author emphasises that looking at roles in early stages instead of actors is helpful, as specific functions are relevant to creation and not specific organisations. Roles can be customers, services, goods providers or suppliers and other stakeholders like financiers or regulators. The actors can occur in different forms: as individuals, small groups or large communities. It is not always possible to identify actors. An example is again the Genius function of Apple's iTunes. Users can upload their created playlists; Apple analyses them to see which songs users consider to fit together. Through this, users contribute to the automatic generation of playlists (den Ouden, 2012, p. 155).

The second element in the model is closely connected to actors as it is their **motivation**. It means that interests and intentions as well as their goals should be described. It gives a picture of the actors and enables the clustering of them into similar interests. Customers may be split into groups where one is more interested in quality and the other one in price. As already described, shared goals are specific and vital to balanced and long-existing ecosystems; it is crucial to choose parties with aligned motivations (den Ouden, 2012, p. 155).

The next element of the model is **compatibility and influence**. Compatibility focuses on the actors' main motivations and whether they are positive, neutral or not compatible with the value proposition. The influence of an actor on the decision-making process is part of the third element and is dependent on their power in the system. A scale could be implemented to change size according to influence (den Ouden, 2012, p. 156).

The fourth element of the model developed by den Ouden (2012) contains **investments and throughput** time. To roughly estimate the required investments for realizing the value proposition, analysing the different business actors may help. The value flow model intends not to draw a detailed business case but gives a basic picture of the biggest investments and sees whether there is a balance between investment and revenue. The author suggests that throughput times for realising the offering may be useful in practice (den Ouden, 2012, pp. 157–158).

The next element is transactions and covers the components of **transactional relationships** described in chapter 4.4.4. These flows start with one actor and end at another one, whereby these actions may involve resources, information or items (den Ouden, 2012, p. 159).

The sixth element of the business ecosystem design model is the **core value proposition**. It is important to have clarity over planned and potential complementary products. The value proposition is the guide and comprises customers, users and those exchanging value with these actors (den Ouden, 2012, p. 159).

Closely connected to the core value proposition is the next element, which is **complementary offerings**. It is possible to offer bundles of goods through complementary products, which is more attractive to customers. Although actors offer complementary products, these are not at the centre of the value proposition. It is because of their position relative to the value proposition: it could work without their offerings, although making it more appealing. An example of complementary offerings is Apple's iPad. Complementary products can be covers, connectors or apps, but it can still be used without them. It becomes visible that the iPad is a component of the core value proposition and it is undoubtedly needed to create an offer for customers as the operating software does (den Ouden, 2012, pp. 159–161).

The **supplying or enabling network** includes actors and transactions involving supply hardware components, platforms or regulatory authorities. It promotes the integration into the value proposition or its enabling. The roles are specified as supplying or enabling networks in the first place. The actual organization's determination happens during the development process (den Ouden, 2012, p. 161).

The last element in the den Ouden value flow model is **other stakeholders**. Although they have no direct influence on the value proposition, it is still essential to include them. It is to ensure that the value proposition does not have unintended or undesired external effects. An example of another stakeholder is the society which is included as an actor. However, these can be stakeholders affected by the value proposition and important for design (den Ouden, 2012, p. 161).

5.2.1 Initial Value Proposition

The first step of business ecosystem design is the initial value proposition, which is a strategic tool to show how value is added to customers (Payne et al., 2017, p. 467).

It should contain those dimensions that are appreciated by the consumer. For this purpose, the value offered must contain functional, economic, emotional and symbolic elements which are developed based on the value proposition. The central point is that the gap between the consumer's perception and the system's perception of the offer is precisely analysed (Rintamäki et al., 2007, p. 621).

5.2.2 Value Proposition and Parties for Ideation

The second step is the selection of parties for ideation and the enrichment of the value proposition. The main focus is on understanding the value proposition and how the expected benefit meets the needs of the intended users. The system has to deliver the customer value to the consumer in the most attractive way possible by fixing the core benefit and creating valuable complementary offers (den Ouden, 2012, pp. 162–164).

It is executed by a team of experts, although they do not have to become members of the ecosystem later on. Those forming the business ecosystem under construction are named ecosystem members. The project team itself does not need to be constant. Depending on skills and knowledge, participants can join or leave the process at different stages. There are usually no contracts between the individual contributors, apart from non-disclosure agreements. They work together to motivate their commitment that pays off in the future. This phase includes getting an overview of those organisations or individuals who can potentially contribute. Scenarios can be useful and may provide further insights. To do so, the required resources must be identified (den Ouden, 2012, p. 162), whereby people, technology, products, equipment, information, channels, partnerships, alliances or brands are particularly relevant for the value proposition (Johnson et al., 2008, pp. 50–54).

During this phase, different roles can bring particular added value. The creator acts as an architect and visionary, inspiring and directing the team. Knowledge experts contribute to the given direction of the visionaries with their expertise in service and infrastructure. The so-called resource providers are responsible for delivering critical resources. Collaborators coordinate and organize tasks around design and test activities. The communicator is responsible for the involvement of the relevant participants at the right time. They function as a mediator ensure that all members have a common understanding of the goal and contribute to their maximum. It also functions as a problem solver and is responsible for the culture of cooperation. If there is an agreement about the value proposition in the team, it takes the next step in the design process (den Ouden, 2012, pp. 162–164).

5.2.3 Stakeholders and their Interests

The stakeholder approach is an extension of the organisation's view as a unit of analysis by including political and social aspects. Stakeholders can be seen as an extended organisation and influence the company itself. They are involved in various activities and connected to organizations or individuals that may have potential positive or negative impact on the company or the ecosystem (den Ouden, 2012, p. 165; Post et al., 2002, pp. 19–20). In the classical organizational analysis, the company is the starting point, but this is not possible in business ecosystems due to the substantial variation in structure and characteristics. Therefore, the value proposition is the starting point for identifying stakeholders and their influence (den Ouden, 2012, p. 165).

To identify stakeholders, a classification into primary and secondary stakeholders can be useful. Stakeholders contributing directly to the value proposition are primary stakeholders. These comprise, among others, customers, suppliers, financiers or communities. Secondary stakeholders have no direct influence on the proposed value but are indirectly affected. In terms of analysis, these are important as they can still damage the system. They include for example the media, competitors, interest groups, political groups, and governments (den Ouden, 2012, pp. 165–167).

Once identifying the stakeholders, examining the three indicators is important: their motivation, how consistent their behaviour is with the value proposition and the investments they are willing to make. When being aware of these factors, one can define a strategy for the actors who are not yet actively involved in the system (den Ouden, 2012, pp. 167–169).

The various stakeholders have different expectations of the business ecosystem. For example, consumers expect a product or service that they can buy. As long as this need is met satisfactorily and the alternatives are less attractive, they will remain loyal to the ecosystem. Suppliers have an interest in the system doing well and having a long-term source to supply. Also, some stakeholders may be more potent than others, or have different means of acting their power, such as economic or political power. There is a close connection between stakeholders' influence on the actor's legitimacy in the whole system. In the early phases of the business ecosystems, this may be subtle, but an business ecosystem culture may develop over time (den Ouden, 2012, pp. 167–169).

During the creation of an ecosystem, one has to ensure that all relevant stakeholders pursue the common goal. Only if sufficient value, wealth or satisfaction is created in the system, it can survive. Only under that condition, the stakeholder groups can benefit positively and remain part of the business ecosystem (Clarkson, 1995, pp. 108–112).

The team working on the value proposition and the creation of the ecosystem is put together depending on the various stakeholders' attitude towards the value proposition, their interests and the influence they can exert on it. The group must decide on its activities to address the various stakeholders. There are several ways to do this (Clarkson, 1995, pp. 100–110; den Ouden, 2012, p. 170; Green and Hunton-Clarke, 2003, pp. 293–298):

- active involvement: The key players with high impact on the system should actively be involved. It can lead to the need to modify the value proposition. This can be advantageous if the key players can thereby better satisfy their needs and contribute more to the system's realisation. It can create opportunities for more significant mutual benefit and the key stakeholders to participate in the decision-making process.
- keep satisfied: Stakeholders who have significant influence on the development of the business ecosystem but show little interest must be satisfied. It is to ensure that they do not take inhibiting actions. If they are not satisfied, they may use their power against the system, which may be sufficient for the project's failure. These actors do not need to be actively involved, but they need to be informed about current statuses and ask for their views on relevant issues.
- keep them informed: Stakeholders who have high interest in the system but have little influence should be kept informed. Nevertheless, it is not necessary to analyse their values and attitudes in depth.
- minimal effort: Stakeholders with little influence and interest need little attention. Nevertheless, it makes sense to monitor their actions.

Dealing with different interest groups shows that it may be advantageous to modify the value proposition and adapt it to the relevant stakeholders. When new stakeholders enter the process, they bring new motivation, insights, perspectives and resources (den Ouden, 2012, p. 170).

5.2.4 Role and Relation Definition

The value proposition aims at the central actor, the consumer or user of it. Customers are the target of the whole intention, but they can also be actively involved and contribute to the creation. When defining roles, it is helpful to ask different questions about relationships (den Ouden, 2012, pp. 171–173):

- customer ownership: *"Which actor(s) will have direct contact with the customers? Will there be an intermediate role, or will the providers of systems, goods and services directly access the customers? If more than one actor is facing the customer directly, how will the customer experience be orchestrated?"* (den Ouden, 2012, p. 173)
- customer relationship: *"Will the service proposition be mainly transactional, or does it involve a continued relationship? Which actor will maintain the relationship with the customers?"* (den Ouden, 2012, p. 173)
- network openness: *"Who is allowed to join the network? Will it be open for everybody to participate, or is it a walled garden? If the network is not open, who decides if new parties with new, complementary products or services can join?"* (den Ouden, 2012, p. 173)
- collaboration with competitors: *"To what extent is collaboration with competitors necessary (...)?"* (den Ouden, 2012, p. 173)

It may be useful to develop different scenarios. For this purpose, different roles, related decisions, their consequences and effects on the model or the business ecosystem can be analysed (den Ouden, 2012, p. 173). The relationships between the individual actors are determined next. These may cover the whole spectrum of chapter 4.4 relationships. If these transactions are determined, it can trigger creativity between actors and open up new possibilities. The design process is iterative, not purely sequential. The following decisions must be made at this stage (den Ouden, 2012, p. 174):

- relationships: One has to decide whether the interactions are based on relationships or transactions and to what extent reciprocity can be guaranteed.
- cost-sharing: It involves deciding whether costs should be shared centrally among all participants or whether they should distribute to those who need them.
- revenue sharing: It raises the question of the distribution of revenues among the members.

The ecosystem to be developed is under ongoing discussion and is continuously being put to the test by various members and actors. The picture of actors, value flows, and contributions are under constant checks with the help of modelling. For this purpose, creating various scenarios is established and one can evaluate which option best fulfils the value proposition. One way to check is to examine whether all the elements required for the value proposition are contained in the model and reciprocity exists in the system (den Ouden, 2012, p. 175).

5.2.5 Parties for Implementation

The final step in the business ecosystem designing process by den Ouden (2012) is the election of parties for implementation. Up to this point, the system's release plan stands, but now it is time for the actual implementation. The implementation of the development of goods or services starts. Production facilities, infrastructure and distribution channels have to be set up. The previously defined roles are now assigned to the executing actors who can perform these roles. If these positions are known, the balance in the system is particularly relevant. Reciprocity is central: do the actors perceive the entire system as fair? All business ecosystem parties should be in a better position than in one of the established, known systems. Specific arrangements can contribute to this by securing the parties' position in the long term thus contributing to the system's prosperity in the development phase and beyond (den Ouden, 2012, pp. 181–183).

During this phase, relations between the actors are also established and strengthened. Trust is a central topic here. Dilemmas can arise in this process, which is caused by the risk of cooperation. The trust process, in which all parties are involved, starts right at the beginning of a relationship. If all actors are involved in defining the problem situation or the target picture, trust is built. Also, the various parties' sentiment should be incorporated into the entire process, so that fears, attractions and temptations are addressed (Cardinal et al., 2001, pp. 697–698; den Ouden, 2012, p. 184).

Question 2: How can business ecosystems be designed?

The second research objective asks for the design of business ecosystems. Chapter 5 addresses this question and analyses the design process in detail. I have shown the basics and key considerations when designing business ecosystems. Then the process of business ecosystem design is described in detail. The following procedure is found:

1. get a clear picture of the value proposition
2. choose stakeholders
3. know stakeholders' interests
4. define roles
5. define relations and
6. conduct analysis.

Thus, this research objective is achieved with the literature review of this chapter and the presented procedure. The modelling part that follows gives more insight into how strong the design approach is by evaluating the method.

6 Business Ecosystem Modelling

This chapter introduces the metamodeling concept as a realisation approach for the above conceptualisation, describing metamodeling in theory based on the publication by Karagiannis and Kühn (2002). The metamodel implementation is built on the theory and applied to the findings of the business ecosystem concept and design procedure.

6.1 Metamodeling Concept

Metamodeling means creating a *"[…] model of a modelling language"* (Karagiannis and Kühn, 2002, p. 2). The metamodel defines the various elements relevant for the implementation of a modelling language. Modelling methods consist of two different parts: the modelling technique and the mechanisms. The modelling technique includes the modelling language and the modelling procedure. The language contains all elements required to describe a model. The procedure describes the steps to perform when using the language to achieve a result. Mechanisms comprise, as it states, mechanisms and algorithms as model processing functionality operating on the model content and realized on the metamodel level (Karagiannis and Kühn, 2002, p. 2).

The metamodel is defined in the meta-metamodel. Karagiannis and Kühn (2002) state that the abstraction level is essential for a modelling hierarchy. The lowest level is the original, which is built based on language level 1. Level 2 is the metamodel and is built using the metamodeling language. The next level is the meta-metalevel, which presents the concepts for creating metamodels (Karagiannis and Kühn, 2002, pp. 3–4). This architecture is shown graphically in Figure 18.

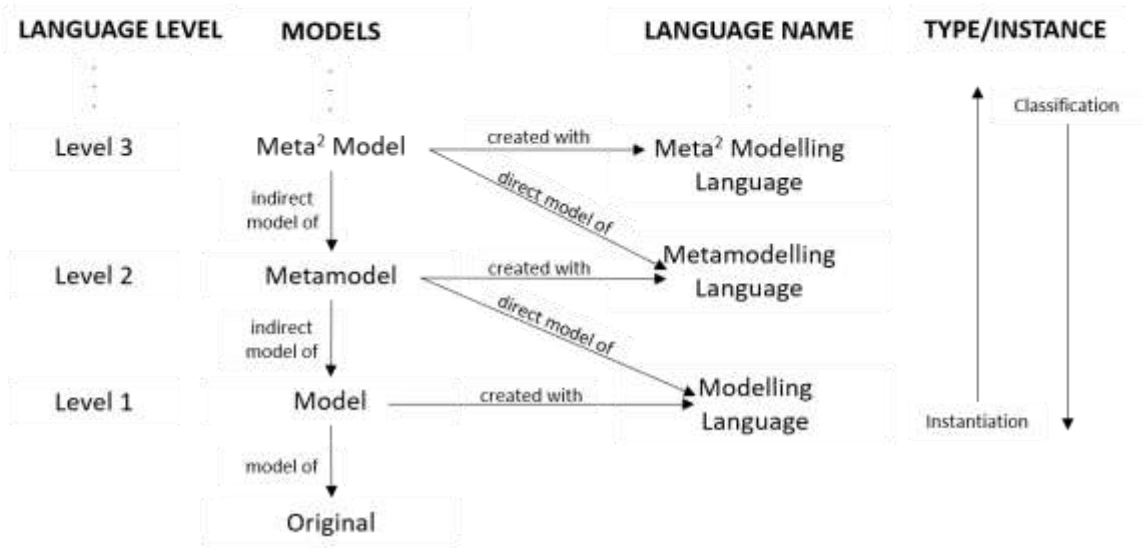


Figure 18: Metamodeling based on language levels
based on (Karagiannis and Kühn, 2002, p. 3)

The following three elements describe a modelling language:

- syntax
- semantics and
- notation.

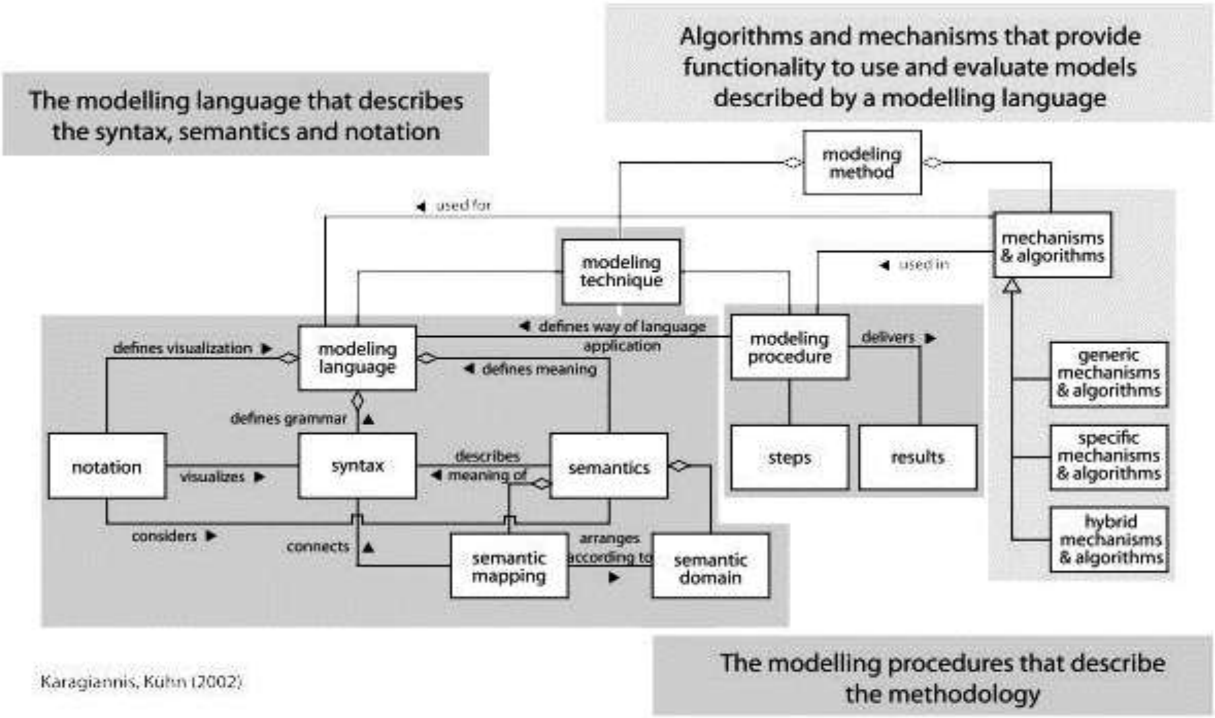


Figure 19: Modelling method framework
(Karagiannis and Kühn, 2002, p. 182)

The elements and rules necessary for (graphical) model creation determine the syntax of a modelling language. Semantic is the meaning of the modelling language and includes semantic domain and mapping. Ontologies or mathematical descriptions define the meaning, which is the semantic domain. The semantic mapping is necessary to connect the syntactic constructs with their meaning, which is defined in the semantic domain (Karagiannis and Kühn, 2002, p. 4). The third element, notation, is the description of a modelling language's visual representation, whereby there are static and dynamic approaches. Static ones define the symbols for the visualization of the syntactical constructs, e.g. by vector or pixel-based graphics. However, they do not take into account the state or progress of the modelled constructs during modelling. In dynamic approaches, the state of the model is taken into account by dividing the notation into a representation and a control part. The first-mentioned part, representation, is attributed to the static approach. The second-mentioned part, control, defines rules that query the model and influence the representation depending on the model state (Kühn et al., 1999, pp. 85–86).

The visual representation is an essential part when designing a language for software engineering. Moody (2009) formed principals on developing optimized visual notations for human communication and problem-solving. After the author, there must be a one-to-one correspondence between the semantic constructs and the graphical symbols. If no one-to-one analogy is present, an anomaly can occur such as a symbol overload, excess, deficit or redundancy. The symbols used should also be distinguishable from each other with, for example, a visual distance, selected shape, textural differentiation, and more. Closely connected to that is the principle that the visual representation should reflect the class or relation's meaning. In this context, icons are a useful way to do so, symbolic or iconic signs. Notation can reduce complexity by creating subsystems or hierarchies and by helping to integrate information from various diagrams into a summary diagram. Using the full possibilities of colours and shapes to create visual variables improves visual expressiveness. If one wants to extend graphs, text is an appropriate mean. Despite using the full potential of visuals, the number of different graphical symbols should not be overwhelming, but cognitively processable. It may make sense to use different visuals for different tasks or target groups (Moody, 2009, pp. 756–772).

When one wants to realize a modelling language based on a meta modelling approach, a standard procedure is to define the metamodel. It contains the basic elements that the metamodel covers. A possibility to implement the metamodel is to use the ADOxx approach (see "ADOxx Metamodelling Platform"), which has evolved from the conception of the business process management toolkit ADONIS[2]. For academic purposes, ADOxx is for open use, which is advantageous for this work. ADOxx developers have realized the ADOxx meta-metamodel's implementation in the programming language C++ (Fill and Karagiannis, 2013, pp. 6–7).

Based on the meta-metamodel, the ADOxx metamodel is instantiated. The tool offers many predefined constructs for creating an ADOxx metamodel. The meta modeller creates their metamodels from the provided classes of the ADOxx metamodel using the ADOxx Library Language (ALL). The language describes the constructs predefined in the meta-metamodel. Starting from the created user-specific metamodel, the modeller instantiates the actual models, the originals. These can be described either in the ADOxx export format ADL or as XML (Fill and Karagiannis, 2013, p. 7). The languages, elements and roles are shown graphically in Figure 20.

[2] https://www.boc-group.com/de/adonis/

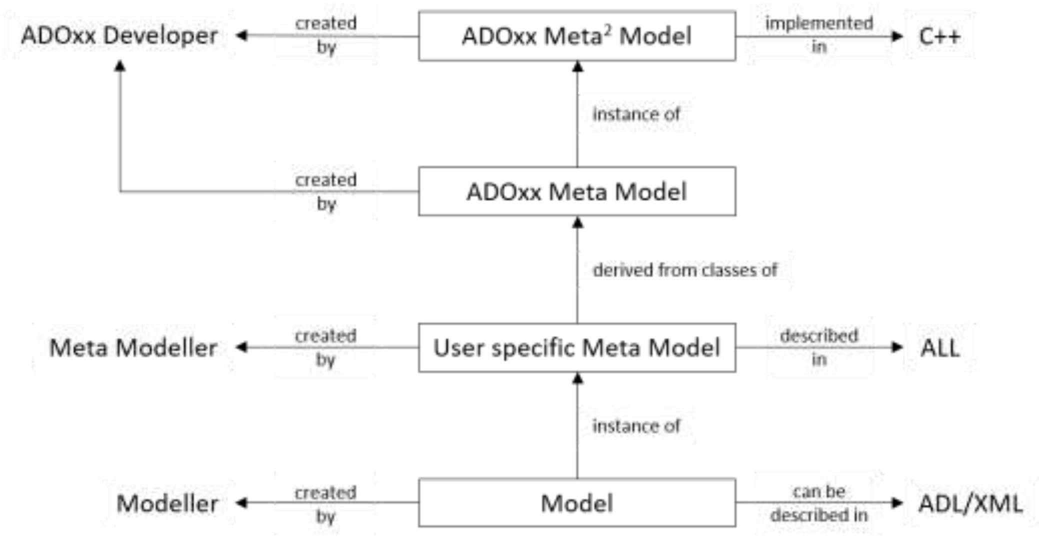


Figure 20: Roles and languages in the modelling hierarchy of ADOxx based on (Fill and Karagiannis, 2013, p. 6)

The constructs provided by ADOxx for instantiating metamodels are classes and relationship classes grouped by model type. Each model type is assigned at least one class. These classes and the relationship classes have attributes; their facets can help text or regular expressions. This level of detail further restricts the attribute values. Class attributes are a particular form of attributes, with two predefined ones: the notebook and the graphical representation. The class attribute notebook is to define the attribute representation in the ATTREP grammar. It determines which attributes are visible to the modellers in the dialogues of modelling objects. The graphical representation defines the dynamic visual representation of classes and relationship classes in the GRAPHREP grammar. The instance attributes can be of various types, including single-value or multi-value data types such as string, float, and integer, as well as the special types interref and record class. The attribute type interref refers to other objects in the same or another model, and other models as a whole. Record class attribute types are represented in a table and consist of collections of attributes of other types. It is possible to arrange classes in a hierarchy by defining subclass relationships between them; the attributes of a subclass inherit from its superclass. Relationship classes must define one class for their target (is to-class) and one class for their source (is from-class). It is possible to use classes and relations predefined or user-defined. If they are predefined, they constitute the ADOxx metamodel. User-specific metamodels can be defined and grouped in a user-defined class hierarchy. ADOxx offers additional functionalities based on the constructs defined in the meta-metamodel. They include acquisition, analysis, evaluation, process cost calculation, external coupling, modelling, simulation, transformation, import/export and document generation, which support the conceptualisation of modelling methods (Fill and Karagiannis, 2013, pp. 7–8).

6.2 Business Ecosystem Metamodel Implementation using ADOxx

Using the metamodeling as the basis, the implementation of the theoretical findings on business ecosystems is conducted in this part. The metamodel is based on the modelling method framework by Karagiannis and Kühn (2002) in Figure 19. In the following, syntax, semantic and notation of the classes and relation classes are presented and the necessary adjustments are shown. Furthermore, the model type, procedure and the structural analysis are described.

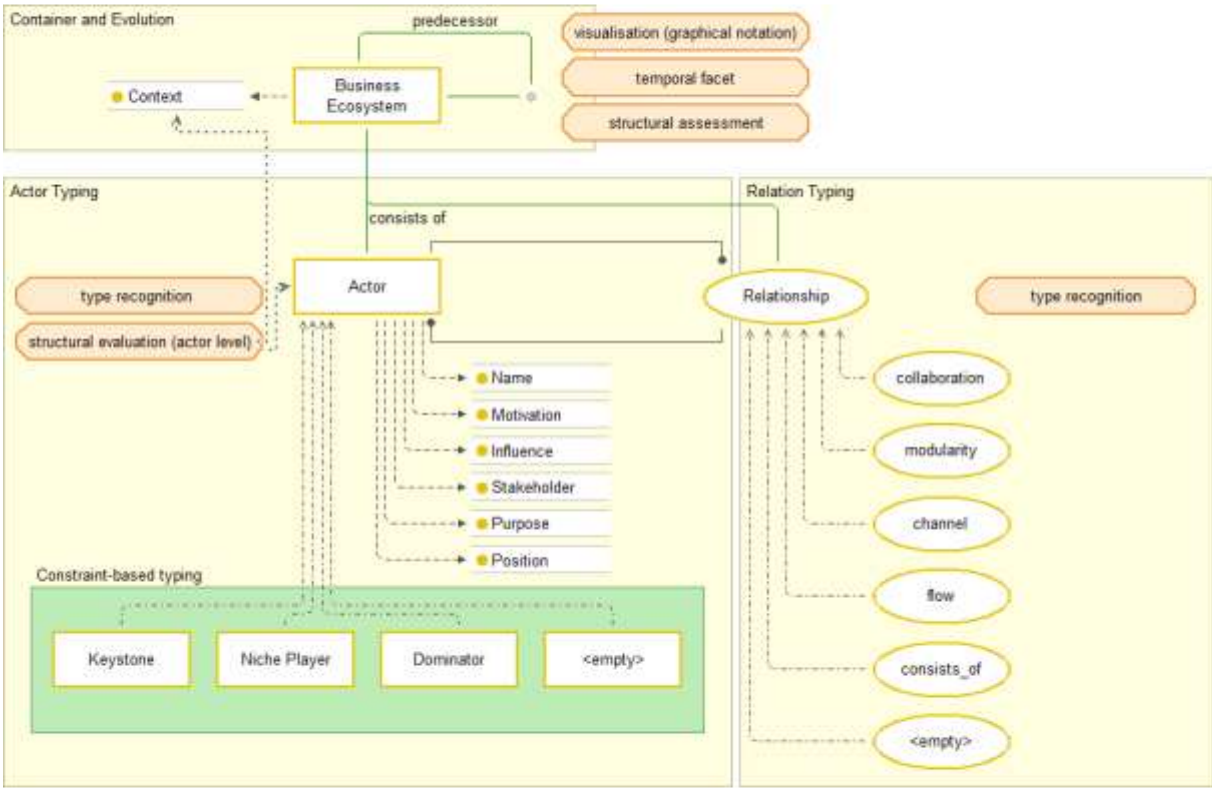


Figure 21: BEDe Metamodel Design Result
based on (Schoder and Utz, 2021)

The CoChaCo (see Karagiannis et al., 2019) approach is applied as a domain-specific language to perform metamodel design. For this, concepts are represented as squares, connectors are in elliptical form and characteristics are marked with dashes above and below the text . The orange outlined polygons evaluate the purpose of the elements in the metamodel, which is a particular consideration in CoChaCo.

Figure 21 shows that the concepts of “keystone”, “niche player”, “dominator” and “empty” are applied, which specialise “actor”. All actors have the characteristics name, motivation, influence, stakeholder, purpose and position. The purpose of actor typing is type recognition and structural evolution at actor level. The connectors include “collaboration”, “modularity”, “channel”, “flow”, “consists_of” and “empty”. The purpose of these elements is type recognition.

The business ecosystem concept links all the predecessors. The purpose of the elements in the container and evolution aggregation is visualisation, a temporal facet and structural analysis.

The modelling of the artefact is implemented using ADOxx ("ADOxx Metamodelling Platform,"). It is the indirect model of the business ecosystem metamodel, which is created in the ADOxx library language. The business ecosystem metamodel is the direct model of the business ecosystem modelling language and is the language in which business ecosystem models are created. These in turn are the abstraction of a real-world business ecosystem. In this thesis, language levels one and two are implemented. It means the business ecosystem metamodel is created with the ADOxx library language and one or more business ecosystem models are created with the resulting business ecosystem modelling language.

The metamodel for business ecosystems is derived from the modelling method framework by Karagiannis and Kühn (2002), Figure 19. Notation, semantics and syntax are derived from the theoretical findings and extended by metamodeling related disciplines. Combined, it results in the business ecosystem modelling language. The elaborated design process is reflected in the modelling procedure and, together with the modelling language, forms the business ecosystem modelling technique. What has been described so far can be seen in Figure 22 in the area marked in yellow and pink. The modelling method framework provides algorithms and mechanisms which, when applied to business ecosystems in this work, is the structural analysis and can be seen in the area highlighted in green. The modelling technique and the structural analysis are combined to form the business ecosystem modelling method. This is shown in the form of a tree in Figure 22. The modelling focuses on the structural analysis and thus includes the relevant characteristics that are presented in chapter 6.2.1. The aim is to propose a prototype that reflects the structural analysis.

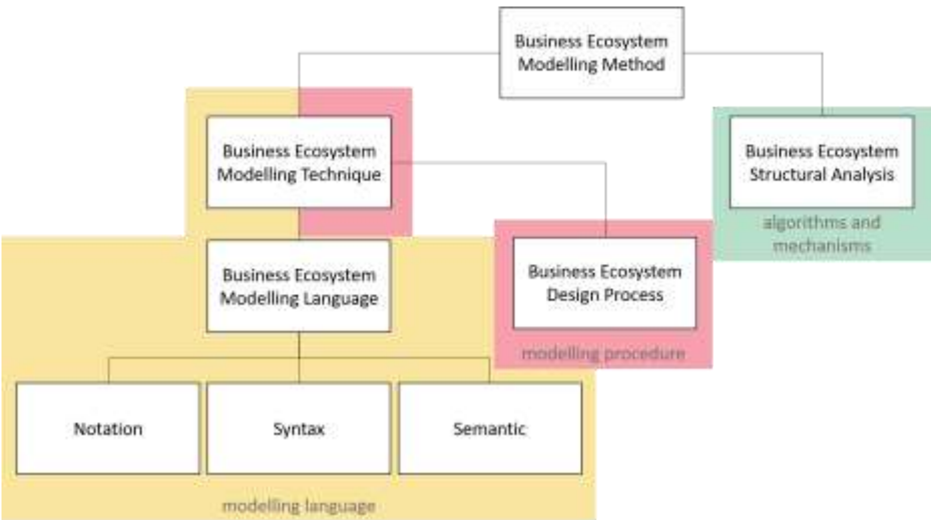


Figure 22: Business ecosystem modelling method

6.2.1 Modelling Language

For the implementation of the metamodel, the details are shown in this section. The business ecosystem's defined elements are used for the artefact:

- activities
- actors
- positions and
- links.

To have a clearer link to the business ecosystem conceptualization, Table 6 connects the elements and the chapter.

Table 6: Business ecosystem elements linked to chapters
based on (Adner, 2017, p. 44)

Elements	Ecosystem-as-structure	4. Chapter Conceptualization	6. Chapter Modelling
Activities	Discrete actions create value proposition	4.4 Relationships	6.2.1.2 Activities and Links 6.2.2 Adjustments
Actors	Entities that undertake activities	4.3 Actors	6.2.1.1 Actors 6.2.2 Adjustments
Positions	Specified locations in flow of activities	4.5 Boundaries 4.6 Static Visualizations	6.2.1.3 Position
Links	Transfers across positions	4.4 Relationships	6.2.1.2 Activities and Links 6.2.2 Adjustments

Keystones, niche players and dominators were identified as actors and implemented and described next. It is followed by the links and activities, which are discussed under relationships in the business ecosystem theory. This section is closed with positions, that are relevant for the metamodel as well. The described iconisation determines the notation of the elements.

6.2.1.1 Actors

D-construct is the superclass of _actors_ of which all classes are derived. The artefact uses the classes keystone, niche player and dominator. An undefined class is included which is useful when the artefact should be extended. Literature shows that some attributes are relevant to actors in a business ecosystem. These are specified in the metamodel and applied to keystones, niche players, dominators, and the undefined class.

The design process shows that motivation is fundamental, mainly that it is compatible with the different actors. Therefore, the artefact offers the possibility to write down the motivation of each actor in text form. Secondly, the motivation evaluation is a rating with a range from positive to neutral to negative. To include the influence of an actor, the attribute influence covers high, moderate and low. Depending on the influence power, the notation changes; for little influence, the icon of the respective actor is the smallest, for moderate medium and strong influence the icon is the largest.

The attribute role is a list of classical actors. It is supported by Moore's view on business ecosystems, which works with a traditional view. It can be defined whether it is a customer, supplier, distributor, standard body, government, investor, trade association, competing organisation, consumer or platform. The attribute stakeholder can also be used to specify whether it is a primary or secondary stakeholder, and the attribute supporting_or_enabling shows whether the stakeholder supports or enables the system. The attribute reciprocity is part of the evaluation and gives a ratio on how the relationship between incoming and outgoing relations is.

Table 7: Attributes of actors

Attribute	*Type*	*Action*	*Characteristics*
name	string	definable	text
motivation	longstring	definable	text
motivation_evaluation	enumeration	definable	positive, neutral, negative
influence	enumeration	definable, notation change	high, moderate, low
role	enumerationlist	definable	customer, supplier, distributor, standard body, government, investor, trade association, competing organisation, consumer, platform
stakeholder	enumeration	definable	primary, secondary
supporting_or_enabling	enumeration	definable	supporting, enabling, none
reciprocity	expression	ratio	EXPR type:double expr:fixed: (set (in, aval("connectors_incoming")), set (out, aval("connectors_outgoing")), set (sum, aval("connectors_overall")), ((out) / (sum)))

Keystone

Syntax: A keystone may connect to every other class using every single relation. From the class keystone, a relation-type may enter and exit each relation only once.

Semantic: The keystone is used for a regulating, guiding actor. It initiates change, is responsible for the value proposition and controls that the entire system works. It represents the central actor of the business ecosystem that multiplies the value.

Notation: To define the keystone's notation, a stone is used as a symbolic image that establishes a connection to the meaning. The icon is in the centre of a circle, which provides a colour differentiation to the other actors. It ensures the visual expressiveness even more and is visible in Figure 23.

Figure 23: Notation of class keystone

Niche Players

Syntax: A niche player may connect to every other class using every available relation. From the class niche player, a relation-type may enter and exit each relation only once.

Semantic: One uses the niche player class if the player has specialization and expertise in a specific field. This actor must stand out from other organizations and contribute to the functioning of the system. A particular dependency on the ecosystem as a whole must also exist for niche players. It is the enabler for the necessary modularity of a business ecosystem.

Notation: The notation of the niche player is an icon. It is placed in the centre of a green circle. The differentiation of the colours gives another possibility of distinction. The notation is represented in Figure 24.

Figure 24: Notation of class niche player

Dominator

Syntax: A dominator may connect to every other class using every available relation. From the class dominator, a relation-type may enter and exit each relation only once.

Semantic: The class dominator represents the dominators of business ecosystems, which are value draining elements. Only actors who act in a controlling, destructive or exploitative way are dominators in the tool.

Notation: The notation of the dominator uses an icon to represent a black hole. It symbolizes that the value of the whole system is taken and withdrawn. The icon is in the middle of a red circle and visible in Figure 25.

Figure 25: Notation of class dominator

Undefined

Syntax: Undefined may connect to every other class using every available relation. From the class undefined a relation-type may enter and exit each relation only once.

Semantic: There is also an undefined class. Based on the semantics, in case no suitable class can be found, the undefined one is taken.

Notation: For the notation, an icon with a big “x” is chosen and stands for undefined. In order to be distinguishable, the symbol is in a purple circle.

Figure 26: Notation of class undefined

6.2.1.2 Activities and Links

All relations connect _D-construct_ to _D-construct_. The relations collaboration, channel, flow, and modularity are used for the artefact based on the literature review. Furthermore, an undefined relation shall be included to simplify an extension of the tool user-specifically.

The literature shows that some attributes are relevant to relations in a business ecosystem. These are specified in the metamodel and applied to all the relation classes but in different forms. Like for all classes, the attribute name exists. Most importantly, the attribute type must be specified, which has different characteristics for all relation classes described in the specific relations. Those types can be presented in the model as well.

Collaboration

Syntax: The relation collaboration can connect every class, but may start from an element only once and enter only once. It also means that a relation can be incoming and outgoing only with a specific type attribute.

Semantic: The relation collaboration represents collaborative relations in business ecosystems, which are defined by the relationship's duration. For its precise definition, the attribute type is essential and is in Table 8. The relation collaboration with type strategic is chosen for collaborations of long-term and strategic nature and lasts for at least one year or even decades. Those collaborations of type tactical are selected in case the relation is from six weeks to one year. The ad-hoc type of collaborative relations should only be chosen if the time horizon is short, namely up to six weeks, and pointed to a specific task or spontaneously.

Notation: The notation of the relation class collaboration is a purple arrow and shown in Figure 27. The modeller changes the notation with the help of the attribute representation; this is in Figure 28.

Figure 27: Notation of relations class collaboration

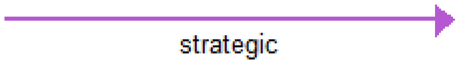


Figure 28: Relation collaboration with type representation example

Table 8: Attributes of relation collaboration

Attribute	*Type*	*Action*	*Characteristics*
name	string	definable	text
type	enumeration	definable	strategic, tactical, ad-hoc
representation	enumeration	definable, notation change	no_representation, left/right, above/below

Channel

Syntax: The relation channel can connect every class, but may start from an element only once and enter only once. It also means that a relation can be incoming and outgoing only with a specific type attribute.

Semantic: The relation channel represents physical or virtual relations in business ecosystems and defines where a relation occurs. For its clear definition in the model, the attribute type is essential and is in Table 9. The relation channel with type virtual is for relations that take place through virtual channels. In contrast to that, those of type physical is for relations taking place physically.

Notation: The relation class channel's notation is a blue arrow and is in Figure 29. With the attribute representation, the modeller changes the notation so that the type is included as text. This is in Figure 30.

Figure 29: Notation of relations class channel

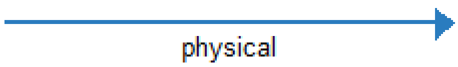


Figure 30: Relation channel with type representation example

Table 9: Attributes of relation channel

Attribute	*Type*	*Action*	*Characteristics*
name	string	definable	text
type	enumeration	definable	physical, virtual
representation	enumeration	definable, notation change	no_representation, left/right, above/below

Modularity

Syntax: The relation modularity can connect every class, but may start from an element only once and enter only once. It also means that a relation can be incoming and outgoing only with a specific type attribute.

Semantic: The relation modularity represents the core relations of business ecosystems that are interdependencies and complementary connections. To define the type of modularity in the model, the attribute type is essential and are in Table 10. The relation with type unique is for relations of type “A does not function without B”. For relations of type “more of A makes B more valuable” the type supermodular for modular relations has to be chosen.

Notation: The relation class modularity is a green arrow and is in Figure 31. With the attribute representation, the notation can be changed so that the type is included as text. This is in Figure 32.

Figure 31: Notation of relations class modularity

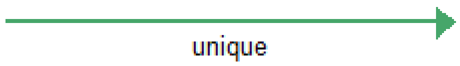


Figure 32: Relation modularity with type representation example

Table 10: Attributes of relation modularity

Attribute	*Type*	*Action*	*Characteristics*
name	string	definable	text
type	enumeration	definable	unique, supermodular
representation	enumeration	definable, notation change	no_representation, left/right, above/below

Flow

Syntax: The relation flow can connect every class, but may start from an element only once and enter only once. It also means that a relation can be incoming and outgoing only with a specific type attribute.

Semantic: The relation flow represents transactional relationships in business ecosystems and shows classic economic operations. To define the type in the model, the attribute type is essential and is in Table 11. The types are quite self-explaining: good or service is for flows of merchandise, money or credit for monetary transactions, information for knowledge transfers, and intangibles for flows like benefits, reputation, attention or increased well-being.

Notation: The relation of class flow is a brown arrow and is in Figure 33. With the attribute representation, the notation can be changed so that the type is included as text. It is in Figure 34.

Figure 33: Notation of relations class flow

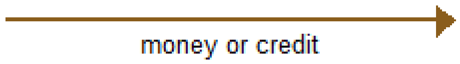


Figure 34: Relation flow with type representation example

Table 11: Attributes of relation flow

Attribute	*Type*	*Action*	*Characteristics*
name	string	definable	text
type	enumeration	definable	good or service, money or credit, information, intangible value
representation	enumeration	definable, notation change	no_representation, left/right, above/below

Empty

Syntax: The relation empty can connect every class, but may start from an element only once and enter only once.

Semantic: The relation empty is used if no suitable relation class can be found, based on the semantics.

Notation: The notation of the relation class empty is a grey arrow and is in Figure 35.

Figure 35: Notation of relations class empty

6.2.1.3 Position

The position an actor holds in the system is of importance. Analogous to Iansiti and Levien (2004b) and Adner (2017), I also define the position's meaning. The position of an actor has two meanings. On the one hand, the closer the position of actors, the closer is their connection. On the other hand, an actors' position should be around similar actors, which means that they fulfil similar system responsibilities. Also, the position in the whole system is relevant. The further away from the keystone or core system an actor is, the less important it is for the whole business ecosystem.

6.2.2 Adjustments

To continuously check whether the metamodeling and modelling can fulfil the purpose, I have chosen an example for continuous testing. The example used is the business ecosystem of Airbnb and can be found in the Appendix in detail. With the modelling language I created the model for Airbnb using the details from the case study and is presented in Figure 36.

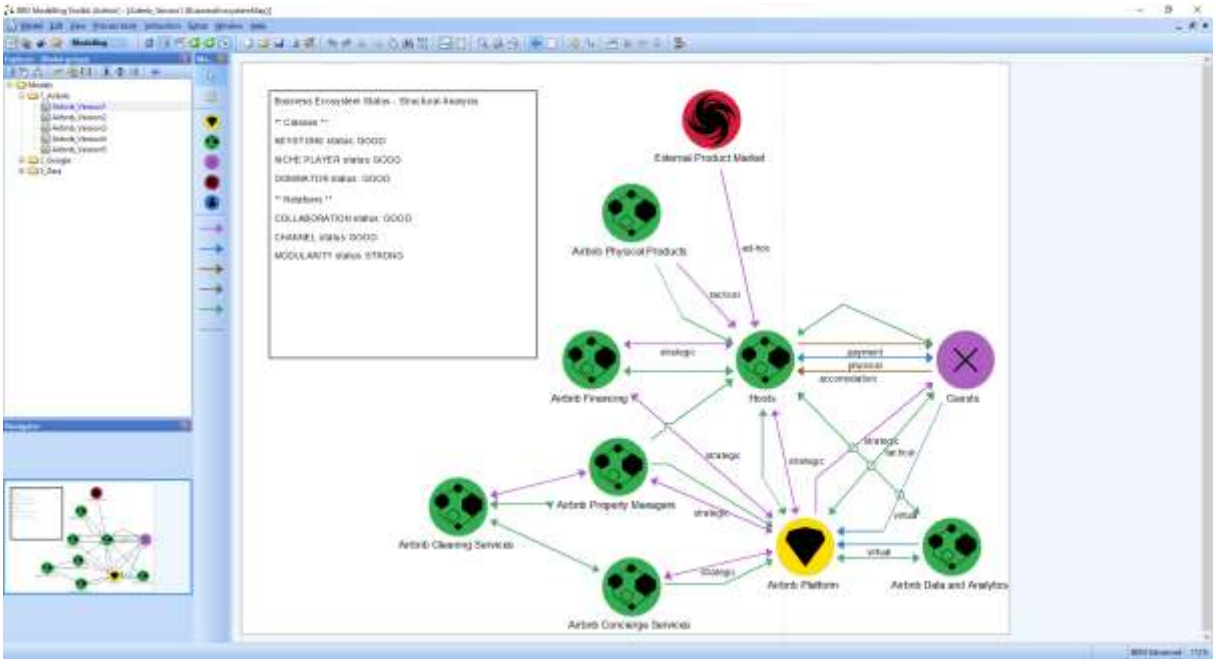


Figure 36: Version 1 Airbnb business ecosystem model

6.2.2.1 Size

As already announced, the different actors have different levels of influence. For this purpose, a separate attribute was implemented, called “influence”. It is possible to choose for each actor in the notebook whether its influence is high, moderate or low. Depending on this, the notation changes: actors with little influence are displayed smaller than those with moderate influence. Actors with strong influence have a larger icon than those with moderate influence. The logic is: low < moderate < high. The attribute gives the model a higher degree of self-explanatory capability. Thus it can be seen at a glance, whether it is a big and influential player or a small player, which turns out to be minor in the system. The changes in comparison to Figure 36 are in Figure 37.

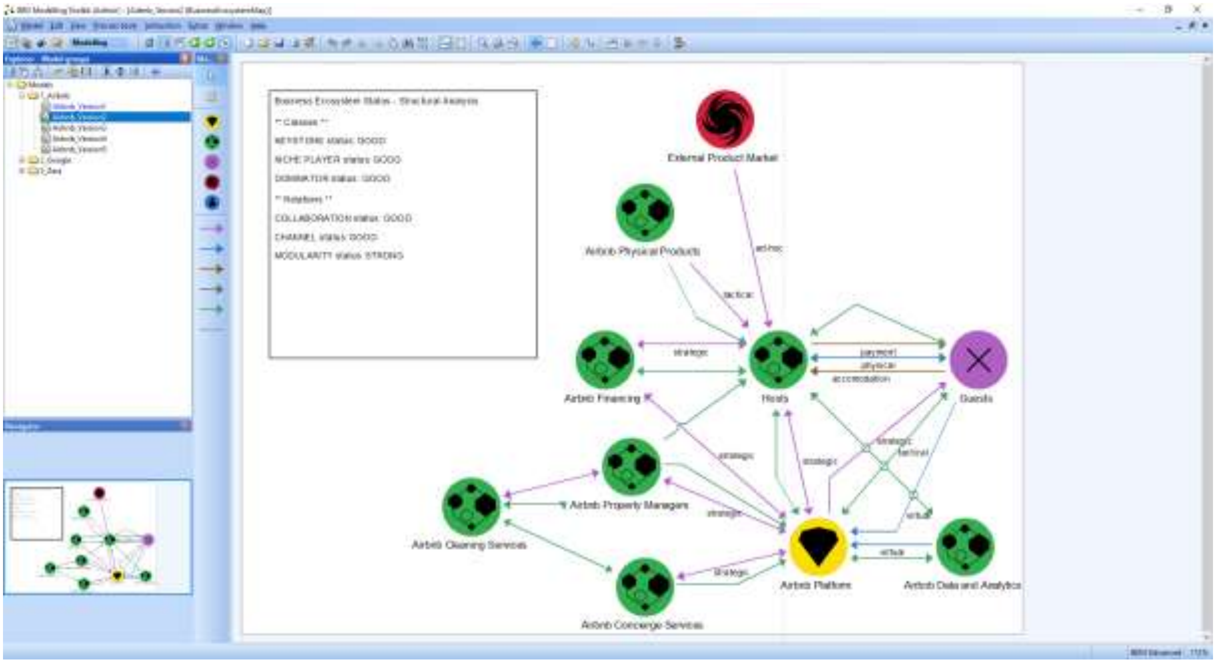


Figure 37: Version 2 Airbnb business ecosystem model

6.2.2.2 Niche Player Representation

In modelling Airbnb (but also other business ecosystems) it became clear that niche players can be organised very differently in their organizational structure. An example is the comparison of Airbnb financing and hosts. Although both players are assigned to niche players they are very different in their structure. Airbnb financing could be one institution, but the hosts are diverse and many individual units. Therefore, I created the attribute “distribution” for niche players, which affects the notation. The expressions of this attribute are “one_actor” or “many_individuals”. It means that Airbnb financing gets the attribute “one_actor” and the hosts “many_individuals”. The symbol of the notation changes for the many individuals as in the updated representation in Figure 38.

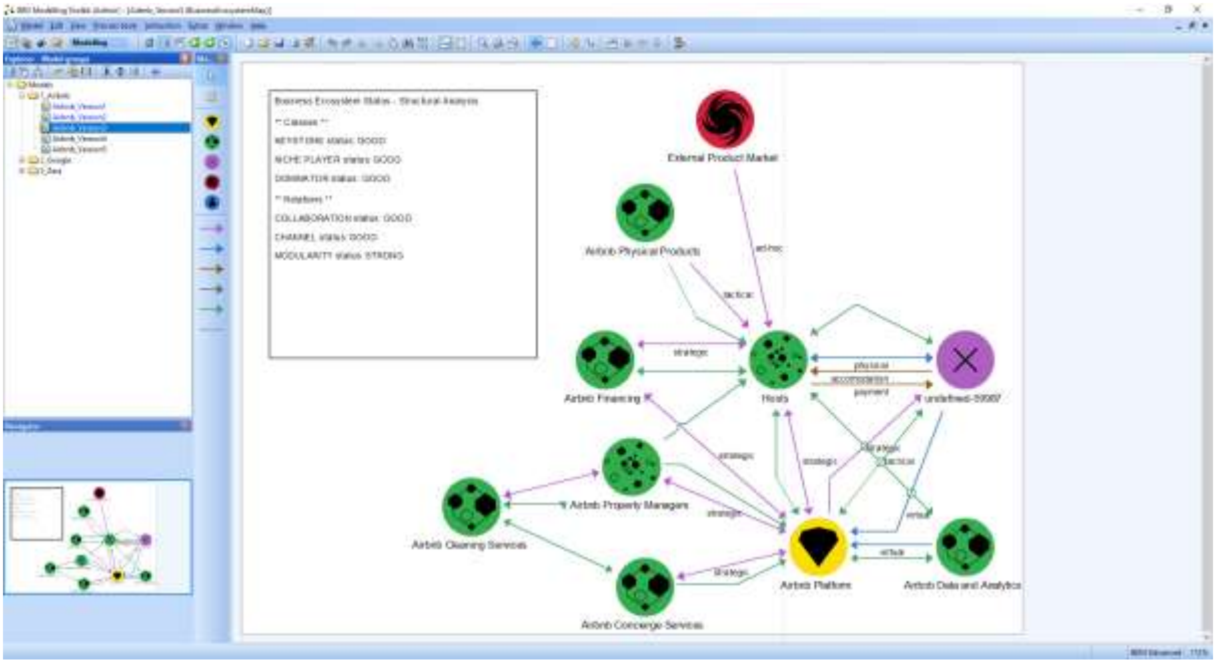


Figure 38: Version 3 Airbnb business ecosystem model

6.2.2.3 Consumer

Throughout the entire modelling process, it was challenging to assign consumers to one actor. Until now, I used the undefined actor for this. Because every business ecosystem will have an end customer, I have added an actor, the consumer. It is useful because the entire value proposition orients ultimately towards the customer. So, the new class has been implemented, and the result for Airbnb is in Figure 39.

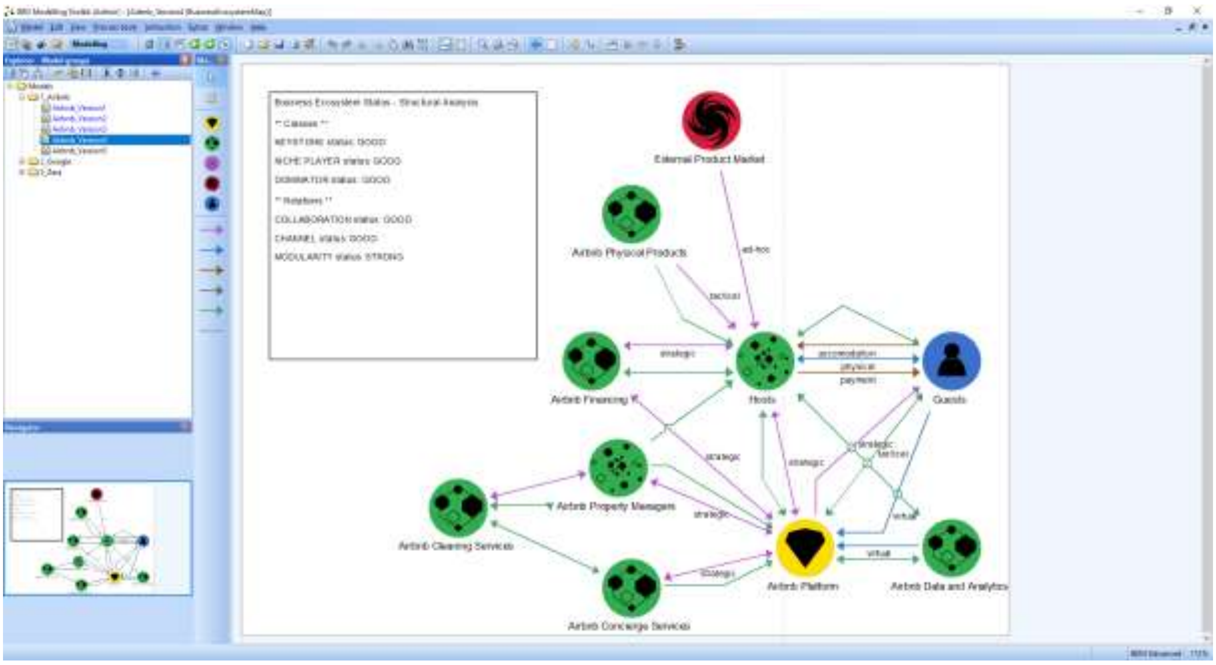


Figure 39: Version 4 Airbnb business ecosystem model

Syntax: A consumer may connect to every other class using every available relation. From the class consumer, a relation-type may enter and exit each relation only once.

Semantic: The consumer is used when a class that specifies someone who uses the end-product is needed and cannot be assigned to a niche player, keystone or dominator class.

Notation: The notation of the consumer is a human-appealing symbol. The icon is in a blue circle, which provides a colour differentiation to the other actors. It ensures the emphasis on its visual expressiveness even more. All that is explained by Figure 40.

Figure 40: Notation of class consumer

6.2.2.4 Level of Detail

In modelling, especially the Google case study, it became apparent that a deep level of detail is possible. The information shown in the case study of Google can be presented in a depth that the metamodeling has not provided so far. Therefore a new type of relationship was created, called "consists_of".

Syntax: The relation "consists of" can connect every class, but may start from an element only once and enter only once.

Semantic: The relationship "consists_of" can be used in the model to display details of a class or to create subgroups. If an actor can be represented well in general, but wants to be shown in more detail, this class can be used.

Notation: The relation class's notation is a dotted line, and in Figure 41. In addition to the standard attributes, no further attributes are needed for that relation class.

Figure 41: Notation of relations consists_of

In the Airbnb model, the case study's information allowed specifying the cleaning services in more detail. Airbnb is supplied by several cleaning services in London, shown in Figure 42 by the notation "consists of".

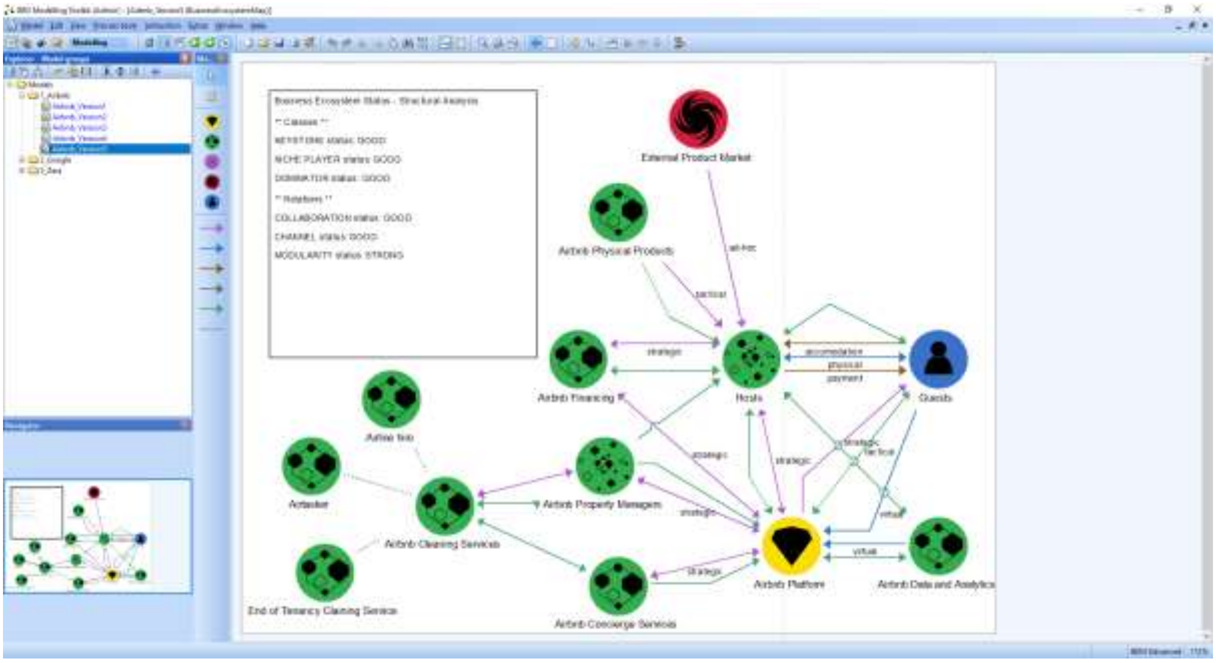


Figure 42: Version 5 Airbnb business ecosystem model

6.2.3 Modelling Procedure

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
    a. Notebook entry
2. Choose stakeholders
    a. Model: keystones, niche players, dominator
3. Know stakeholders' interests
    a. Notebook entry actors
4. Define roles
    a. Select in notebook of actors
5. Define relations
    a. draw relations between actors
6. Conduct analysis
    a. Structural analysis

Figure 43: Modelling procedure

The procedure presented serves as a guideline and is not enforced by the conceptual view or by the implementation. The proposed procedure can be called during modelling. The following has been implemented in the library attributes under the add-ons for external couplings:

ITEM "Instruction"
acquisition:"Instruction" modeling:"Instruction"
analysis:"Instruction" modeling:"Instruction"
evaluation:"Instruction" modeling:"Instruction"
#---
EXECUTE file: ("db:\\Instruction.asc")

The file for the instruction was uploaded directly into the database filemanagement. When executing in the tool, the window as shown in Figure 44 appears.

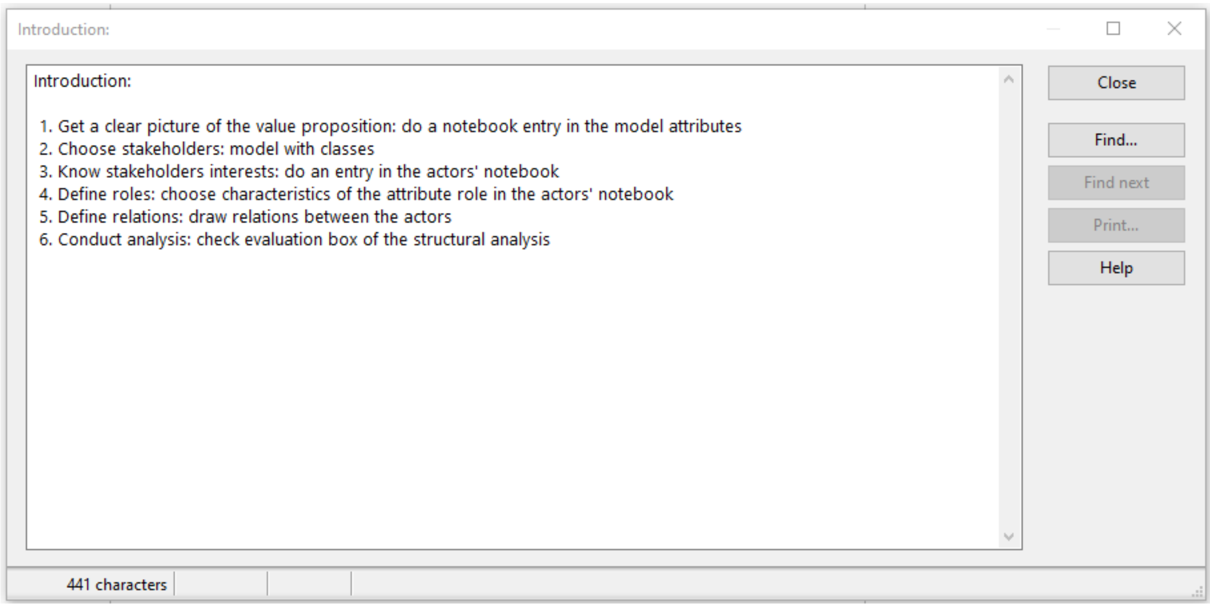


Figure 44: Instruction window

6.2.4 Mechanisms – Structural Analysis

The published literature on business ecosystems has partly shown approaches for analysis. These were presented in this work and described, which elements are part of the artefact. In doing so, the assumptions made were pointed out. The assumed values are especially relevant if no specific figures exist. Since they are essential for the analysis, the assumptions were based on the analysis of the literature. These figures are kept open for future developments to implement the latest scientific findings in the artefact at any time.

The model type metadata includes the attributes for the analysis of keystones, dominators, niche players, collaboration, channel and modularity relations. Figure 45 shows where exactly in ADOxx, the necessary attributes were created.

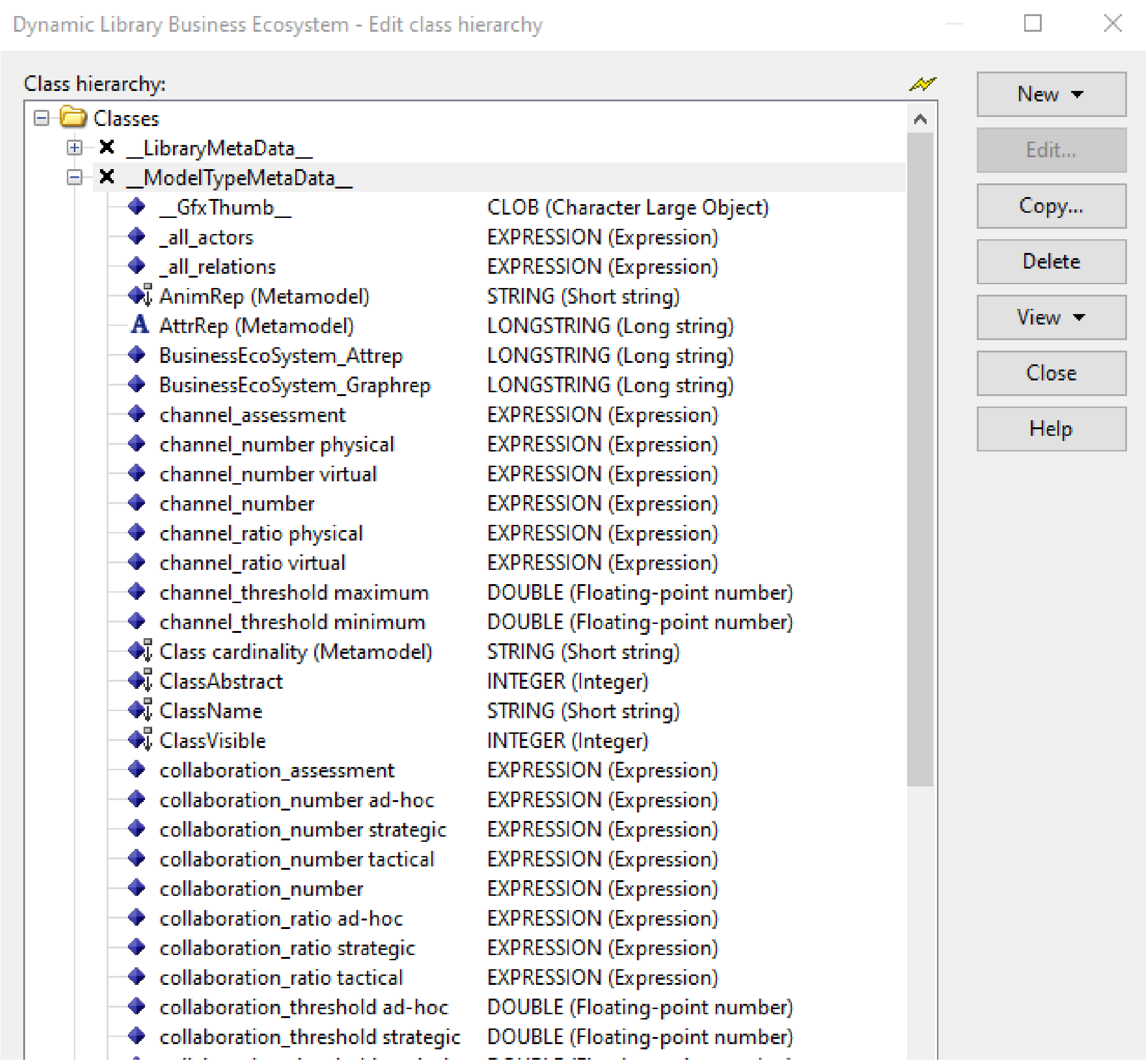


Figure 45: Model type meta data

In the following, the structural analysis is described with pseudocode. The implementation of this in ADOxx is then described in detail. The interpretation of the status is in chapter 6.2.4.10.

```
--------------------------------
start modelling
start analysis

input
    number_of_keystones = (“how many keystones are in the model?”)
    max_number_of_keystones = (“what is the maximum number of keystones allowed
in one model?”)
    min_number_of_keystones = (“what is the minimum number of keystones allowed
in one model?”)
output
    if max_number_of_keystones > number_of_keystones > min_number_of_keystones
    then display “keystone status is ‘GOOD’”
    else display “keystone status is ‘BAD’”
endif

input
    ratio_niche_players = (“what is the ratio of niche players to all players?”)
    min_percentage_niche_players = (“what is the minimum percentage of niche
players needed in one model?”)
output
    if ratio_niche_players >= min_percentage_niche_players
    then display “niche player status is ‘GOOD’”
    else display “niche player status is ‘BAD’”
endif

input
    number_of_dominators = (“how many dominators are in the model”)
    max_number_of_dominators = (“what is the maximum number of dominators al-
lowed in the model?”)
output
    if number_of_dominators <= max_number_of_dominators
    then display “dominator status is ‘GOOD’”
    else display “dominator status is ‘BAD’”
endif

input
    ratio_relation_collaboration_strategic = (“what is the ratio of collabora-
tion-strategic relations to all collaboration relations?”)
    ratio_relation_collaboration_tactical = (“what is the ratio of collabora-
tion-tactical relations to all collaboration relations?”)
    ratio_relation_collaboration_ad-hoc = (“what is the ratio of collaboration-
ad-hoc relations to all collaboration relations?”)
    min_ratio_relations_collaboration_strategic = (“what is the minimum ratio
of collaboration-strategic relations allowed in the model?”)
    min_ratio_relations_collaboration_tactical = (“what is the minimum ratio of
collaboration-tactical relations allowed in the model?”)
    min_ratio_relations_collaboration_ad-hoc = (“what is the minimum ratio of
collaboration-ad-hoc relations allowed in the model?”)
output
    if ratio_relation_collaboration_strategic >= min_ratio_relations_collabora-
tion_strategic
        and min_ratio_relations_collaboration_tactical < ratio_relation_collab-
oration_tactical
```

```
        and min_ratio_relations_collaboration_ad-hoc < ratio_relation_collabo-
ration_ad-hoc
    then display “collaboration status is ‘GOOD’”
    else display “collaboration status is ‘BAD’”
endif

input
    ratio_relation_channel_virutal = (“what is the ratio of channel-virtual re-
lations to all channel relations?”)
    max_ratio_relations_channel_virutal = (“what is the maximum ratio of chan-
nel-virtual relations allowed in the model?”)
    min_ratio_relations_channel_virutal = (“what is the minimum ratio of chan-
nel-virtual relations allowed in the model?”)
output
    if min_ratio_relations_channel_virutal <= ratio_relation_channel_virtual <=
max_ratio_relations_channel_virutal
    then display “channel status is ‘GOOD’”
    else display “channel status is ‘BAD’”
endif

input
    ratio_modularity = (“what is the ratio of modular relations to all rela-
tions?”)
    weak_ratio_relations_modularity = (“what is the ratio up to which the system
is weak in terms of modularity?”)
    moderate_ratio_relations_modularity = (“what is the ratio up to which the
system is moderate in terms of modularity?”)
output
    if ratio_modularity < weak_ratio_relations_modularity
    then display “modularity status is “WEAK”
        if ratio_modularity >= moderate_ratio_relations_modularity
        then display “modularity status is ‘STRONG’”
        else display “modularity status is ‘MODERATE’”
    endif
endif
--------------------------------
```

6.2.4.1 Keystone Status

I assume that at least one keystone must be allowed to exist in a business ecosystem, but no more than two. The parameters’ creation is in two different attributes: keystone threshold maximum (*keystone_threshold maximum*) and minimum (*keystone_threshold minimum*). It is necessary to know the overall number of keystones to perform a comparison. To know the overall number of keystones, the attribute *keystone_number* calculates it. Finally, these attributes are related and evaluated. The attribute *keystone_assessment* determines whether the keystones are in a good or bad state. If there is at least one and at most two keystones in the system, the health status is good, otherwise it is bad. The attributes, their type and characteristics can be seen in Table 12.

Table 12: Keystone attributes for analysis

Attribute	*Type*	*Characteristic*
keystone_threshold minimum	integer	1
keystone_threshold maximum	integer	2
keystone_number	expression	EXPR type:integer expr:fixed:(tokcnt (allobjs (modelid,"keystone")))
keystone_assessment	expression	EXPR type:string expr:fixed:(set (number_keystones, aval ("key-stone_number")), set (thresholdA, aval ("keystone_threshold maximum")), set (thresholdB, aval ("keystone_threshold minimum")), cond (thresholdB <= number_keystones AND number_keystones <= thresholdA, "GOOD", "BAD"))

6.2.4.2 Niche Player Status

For a positive status of niche players, at least half of the entire model's actors must be of this type. Therefore the attribute *niche_player_threshold* was created, which sets the value of 0.5. Another attribute is the total actors, which counts all keystones, niche players, and dominators in the attribute *_all_actors* and an additional attribute that counts all niche players (*niche_player_number*). These two attributes are put into a ratio in the attribute *niche_player_ratio*. This ratio is the basis for the assessment (*niche_player_assessment*) and compared with the threshold. If the ratio of niche players is greater than the required minimum number of niche players of 50 percent, the state of health is good; otherwise, it is bad. All the attributes, types and their characteristics are in Table 13.

Table 13: Niche player attributes for analysis

Attribute	*Type*	*Characteristic*
niche_player_threshold	double	0.5
_all_actors	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”keystone\”>) OR (<\”niche_player\”>) OR (<\”domina- tor\”>)”)))
niche_player_number	expression	EXPR type:integer expr:fixed:(tokcnt (allobjs (modelid,”niche_player”)))
niche_player_ratio	expression	EXPR type:integer expr:fixed: (set (nicheplayers, aval(“niche_player_num- ber”)), set (allactors, aval(“_all_actors”)), ((nicheplayers) / (allactors)))
niche_player_assessment	expression	EXPR type:string expr:fixed:(set (ratio_nicheplayer, aval (“niche_player_ratio”)), set (thresholdN, aval (“niche_player_thresh- old”)), cond ((ratio_nicheplayer >= thresholdN), “GOOD”, “BAD”))

6.2.4.3 Dominator Status

Dominators may only appear in a very small number and are limited here by an attribute with a maximum of one (*dominator_threshold maximum*). In the attribute *dominator_number*, the number of dominators is determined and then compared with the threshold in the attribute *dominator_assessment*. It gives a good result if there is only one dominator in the model and a bad one if there are more dominators than one. The description of the attributes is in Table 14.

Table 14: Dominator attributes for analysis

Attribute	*Type*	*Characteristic*
dominator_threshold maximum	integer	1
dominator_number	expression	EXPR type:integer expr:fixed:(tokcnt (allobjs (modelid,”dominator”)))
dominator_assessment	expression	EXPR type:string expr:fixed:(set (number_dominators, aval (“domina- tor_number”)), set (threshold, aval (“dominator_threshold maximum”)), cond (number_dominators <= threshold, “GOOD”, “BAD”))

6.2.4.4 Collaboration Status

As described in the literature analysis, strategic relationships are essential for ecosystems, but tactical and ad-hoc relationships are also tolerable in a smaller number. These limits are in the attributes *collaboration_threshold strategic* as well as *collaboration_threshold tactical* and *collaboration_threshold ad-hoc*. For further calculations, the total number of collaborations (*collaboration_number*) and those of the individual types (*collaboration_number strategic, collaboration_number tactical, collaboration_number ad-hoc*) are important. The next step is to determine the ratios of the different collaboration types in the attributes *collaboration_ratio strategic, collaboration_ratio tactical, and collaboration_ratio ad-hoc*. After ascertain the total numbers, the assessment is performed in the *collaboration_assessment* attribute by comparing the thresholds with the relations' actual occurrence. Suppose the ratio of strategic collaborations is greater than or equal to the strategic threshold, and the ratio of tactical collaborations is less than the tactical threshold. Also, ad-hoc collaborations are less than the ratio of ad-hoc relations. In that case, the status of collaborations is good. If one of the conditions does not apply, the status is bad. The attributes, types and characteristics are implemented in ADOxx, and described in Table 15.

Table 15: Collaboration attributes for analysis

Attribute	*Type*	*Characteristic*
collaboration_threshold tactical	double	0.15
collaboration _threshold strategic	double	0.75
collaboration _threshold ad-hoc	double	0.1
collaboration _ratio tactical	expression	EXPR type:integer expr:fixed: ((tokcnt(aql("(<\"collaboration\">[?\"type\" = \"tactical\"])"))) / (tokcnt (allobjs (modelid,"collaboration"))))
collaboration _ratio strategic	expression	EXPR type:integer expr:fixed: ((tokcnt(aql("(<\"collaboration\">[?\"type\" = \"strategic\"])"))) / (tokcnt (allobjs (modelid,"collaboration"))))
collaboration_ratio tactical	expression	EXPR type:integer expr:fixed: ((tokcnt(aql("(<\"collaboration\">[?\"type\" = \"tactical\"])"))) / (tokcnt (allobjs (modelid,"collaboration"))))
collaboration _ratio ad-hoc	expression	EXPR type:integer expr:fixed: ((tokcnt(aql("(<\"collaboration\">[?\"type\" = \"ad-hoc\"])"))) / (tokcnt (allobjs (modelid,"collaboration"))))
collaboration _number	expression	EXPR type:integer expr:fixed: (tokcnt (allobjs (modelid,"collaboration")))
collaboration _number tactical	expression	EXPR type:integer expr:fixed: (tokcnt(aql("(<\"collaboration\">[?\"type\" = \"tactical\"])")))

collaboration _number strategic	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”collaboration\”>[?\”type\” = \”strategic\”])”)))
collaboration _number ad-hoc	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”collaboration\”>[?\”type\” = \”ad-hoc\”])”)))
collaboration_assessment	expression	EXPR type:string expr:fixed:(set (ratio_strategic, aval (“collaboration_ratio strategic”)), set (ratio_tactical, aval (“collaboration_ratio tactical”)), set (ratio_adhoc, aval (“collaboration_ratio ad-hoc”)), set (thresholdS, aval (“collaboration_threshold strategic”)), set (thresholdT, aval (“collaboration_threshold tactical”)), set (thresholdA, aval (“collaboration_threshold ad-hoc”)), cond ((ratio_strategic >= thresholdS) AND (ratio_tactical < thresholdT) AND (ratio_adhoc < thresholdA), “GOOD”, “BAD”))

6.2.4.5 Channel Status

Before evaluating the relation channel’s status, the threshold in the attributes *channel_threshold minimum* and *channel_threshold maximum* is defined. The relations should occur balanced with a tolerance of 0.1 points up and down. The overall number of channel relations is determined (*channel_number*) and their number according to type *(channel_number virtual, channel_number physical*). With these parameters, the ratio (*channel_ratio virtual, channel_ratio physical*) determines whether the status is positive or negative for the business ecosystem. The attribute *channel_assessment* compares whether virtual and physical relationships are within the range of 0.4 to 0.6. If this is the case, the status of channel is good; otherwise, it is bad. The details of the attributes are in Table 16.

Table 16: Channel attributes for analysis

Attribute	*Type*	*Characteristic*
channel_threshold minimum	double	0.4
channel_threshold maximum	double	0.6
channel_ratio virtual	expression	EXPR type:integer expr:fixed: ((tokcnt(aql(“(<\”channel\”>[?\”type\” = \”virtual\”])”))) / (tokcnt (allobjs (modelid,”channel”))))
channel_ratio physical	expression	EXPR type:integer expr:fixed: ((tokcnt(aql(“(<\”channel\”>[?\”type\” =

		\”physical\”])”))) / (tokcnt (allobjs (modelid,”channel”))))
channel_number	expression	EXPR type:integer expr:fixed: (tokcnt (allobjs (modelid,”channel”)))
channel_number virtual	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”channel\”>[?\”type\” = \”virtual\”])”)))
channel_number physical	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”channel\”>[?\”type\” = \”physical\”])”)))
channel_assessment	expression	EXPR type:string expr:fixed:(set (ratio_virtual, aval (“channel_ratio virtual”)), set (thresholdVMin, aval (“channel_threshold minimum”)), set (thresholdVMax, aval (“channel_threshold maximum”)), cond (thresholdVMin <= ratio_virtual AND ratio_virtual <= thresholdVMax, “GOOD”, “BAD”))

6.2.4.6 Modularity Status

As already explained in theory, the assumption is that there must be a certain proportion of complementary relations to all relations in the model. The attributes *modularity_threshold weak*, *modularity_threshold moderate* and *modularity_threshold strong* are defined. The total relations in the model (*_all_relations*) are necessary, and the number of all modular relations (*modularity_number*) from which a ratio in the attribute *modularity_ratio* is calculated. The attribute *modularity_assessment* bases on all these numbers. If the ratio of complementary relationships in the model compared to the total number of relationships (*modularity_ratio*) is greater than or equal to the threshold of 0.5, the modularity status is strong. If the ratio is below 0.1, few complementary relationships are present in the business ecosystem and is considered weak. Between 0.1 and 0.5, the modularity relations status is moderate. The individual attributes, their type and the characteristics are in detail in Table 17.

Table 17: Modularity attributes for analysis

Attribute	*Type*	*Characteristic*
modularity_threshold weak	double	0.1
modularity_threshold moderate	double	0.5
modularity_threshold strong	string	everything above modularity_threshold moderate
_all_relations	expression	EXPR type:integer expr:fixed: (tokcnt(aql(“(<\”collaboration\”>) OR (<\”channel\”>) OR (<\”modularity\”>)”)))
modularity_ratio	expression	EXPR type:integer expr:fixed: (set (modul, aval(“modularity_number”)), set (allrelations, aval(“_all_relations”)), ((modul) / (allrelations)))
modularity_number	expression	EXPR type:integer expr:fixed: (tokcnt (allobjs (modelid,”modularity”)))
modularity_assessment	expression	EXPR type:string expr:fixed:(set (ratio_modul, aval (“modularity_ratio”)), set (thresholdMW, aval (“modular-ity_threshold weak”)), set (thresholdMM, aval (“modular-ity_threshold moderate”)), cond (ratio_modul < thresholdMW, “WEAK”, ratio_modul >= thresholdMM, “STRONG”, “MODERATE”))

6.2.4.7 Visualization

In this chapter, different status messages for classes and relations were determined. These are only determined so far and cannot be seen by the user during modelling. For this purpose, the attribute BusinessEcoSysem_Graphrep is created under the model type meta data, which makes the desired status visible on the modelling interface in real time. The implementation of the attribute is in Figure 46.

BusinessEcoSystem_Graphrep - Edit facets - Standard value

```
GRAPHREP
RECTANGLE x:1cm y:1cm w:10cm h:10cm
TEXT "Business Ecosystem Status - Structural Analysis" x:1.2cm y:1.2cm

TEXT "** Classes **" x:1.2cm y:2cm

TEXT "KEYSTONE status:" x:1.2cm y:2.7cm
ATTR "keystone_assessment" x:4.3cm y:2.7cm

TEXT "NICHE PLAYER status:" x:1.2cm y:3.4cm
ATTR "niche_player_assessment" x:4.9cm y:3.4cm

TEXT "DOMINATOR status:" x:1.2cm y:4.1cm
ATTR "dominator_assessment" x:4.5cm y:4.1cm


TEXT "** Relations **" x:1.2cm y:4.9cm

TEXT "COLLABORATION status:" x:1.2cm y:5.6cm
ATTR "collaboration_assessment" x:5.3cm y:5.6cm

TEXT "CHANNEL status:" x:1.2cm y:6.3cm
ATTR "channel_assessment" x:4cm y:6.3cm

TEXT "MODULARITY status:" x:1.2cm y:7cm
ATTR "modularity_assessment" x:4.6cm y:7cm
```

Figure 46: Business ecosystem graphrep

The attributes can be seen directly on the modelling interface for the user, as shown in Figure 47. It allows the user to see the assessment attributes directly on a sort of dashboard. If the user models her or his business ecosystem and changes a class or attribute that directly impacts a relation or class status, the interface displays the status in real-time. It ensures to see at any time whether a change has a positive or negative effect on the system or the affected class.

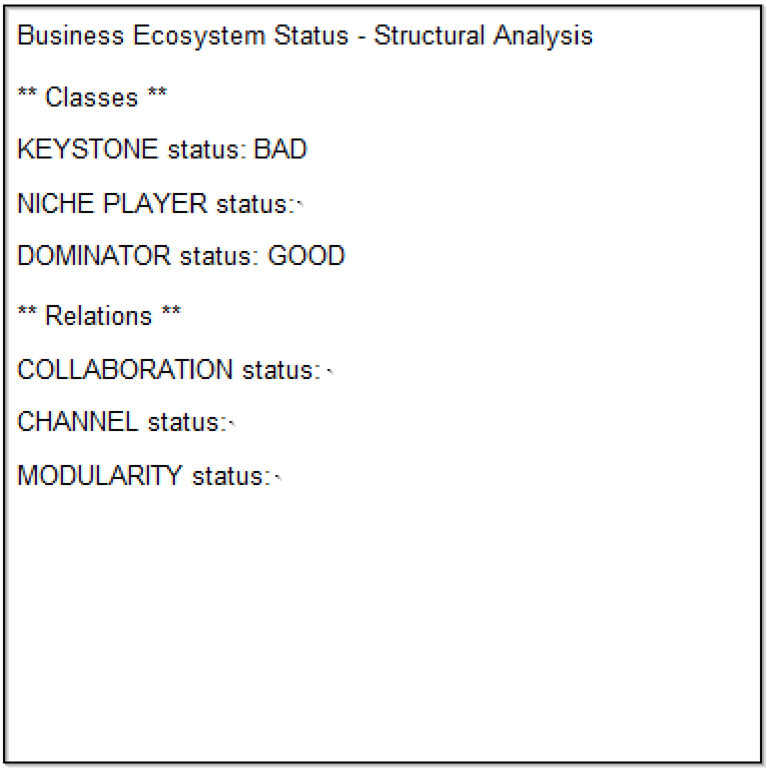


Figure 47: Interface structural analysis

Figure 48 shows the structural analysis interface for Airbnb. It is identifiable that it is a healthy business ecosystem since all parameters appear to be good and modularity is strong.

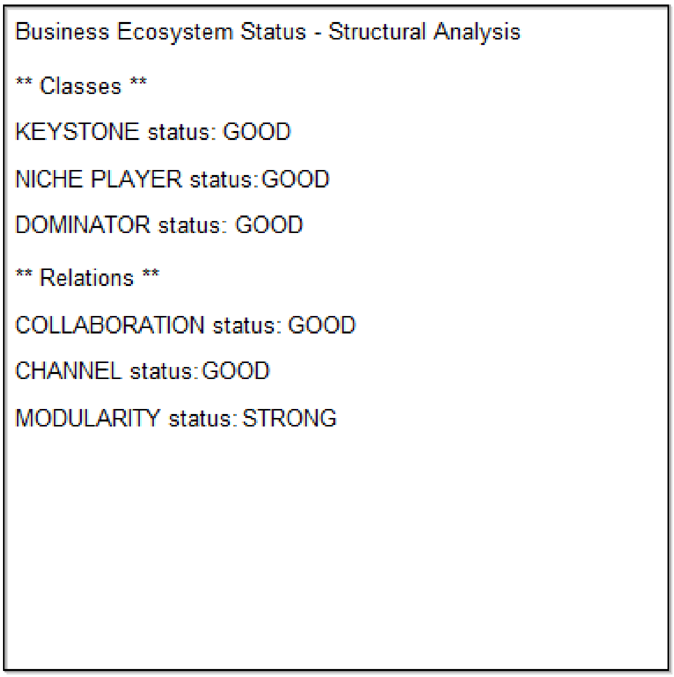


Figure 48: Interface structural analysis Airbnb

6.2.4.8 Model Attributes

The user can also view the individual, previously defined, attributes and their values. The attribute BusinessEcoSystem_Attrep is created in the model type metadata, as in Figure 49.

BusinessEcoSystem_Attrep - Edit facets - Standard value

```
GROUP "Keystone assessment"
ATTR "keystone_number"
ATTR "keystone_threshold minimum"
ATTR "keystone_threshold maximum"
ATTR "keystone_assessment"
ENDGROUP

GROUP "Niche player assessment"
ATTR "niche_player_number"
ATTR "niche_player_threshold"
ATTR "niche_player_assessment"
ENDGROUP

GROUP "Dominator assessment"
ATTR "dominator_number"
ATTR "dominator_threshold maximum"
ATTR "dominator_assessment"
ENDGROUP


CHAPTER "Relations"
GROUP "collaboration"
ATTR "collaboration_number"
ATTR "collaboration_number strategic"
ATTR "collaboration_number tactical"
ATTR "collaboration_number ad-hoc"
ATTR "collaboration_threshold strategic"
ATTR "collaboration_threshold tactical"
ATTR "collaboration_threshold ad-hoc"
ATTR "collaboration_assessment"
ENDGROUP

GROUP "channel"
ATTR "channel_number"
ATTR "channel_number physical"
ATTR "channel_number virtual"
ATTR "channel_threshold minimum"
ATTR "channel_threshold maximum"
ATTR "channel_assessment"
ENDGROUP

GROUP "modularity"
ATTR "modularity_number"
ATTR "modularity_number physical"
ATTR "modularity_number virtual"
ATTR "modularity_threshold weak"
ATTR "modularity_threshold moderate"
ATTR "modularity_threshold strong"
ATTR "modularity_assessment"
ENDGROUP
```

Figure 49: Attribute representation

The user of the tool navigates into the notebook of the model in the modelling interface. There are several, before specified, tabs: the value proposition, classes and relations. In the value proposition, simple text is required. In the tab classes, one can see the relevant attributes of the classes for the structural analysis. It is in Figure 50. Also, the attributes can be seen and changed for the relations if needed and are in Figure 51.

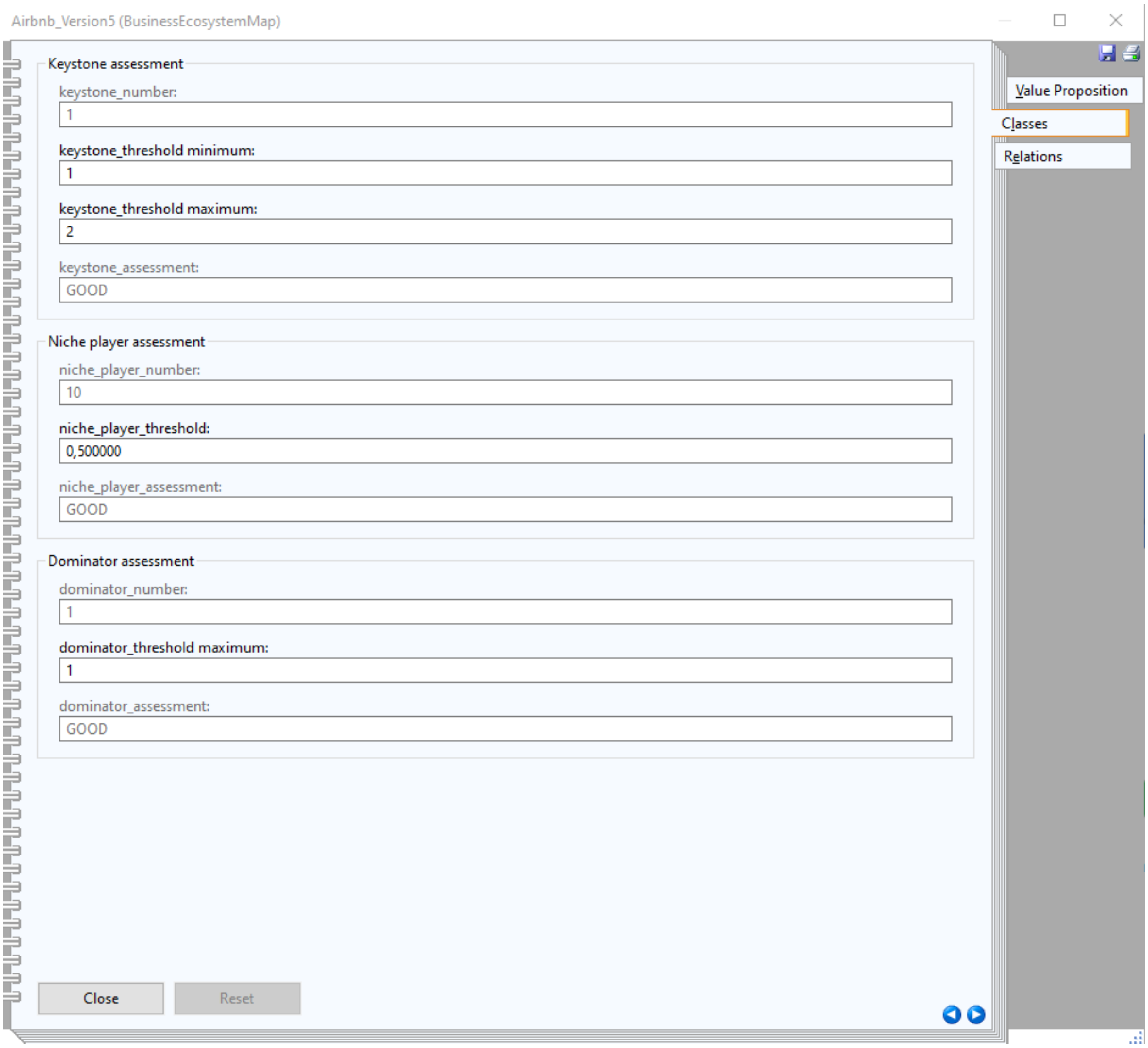


Figure 50: Model notebook classes

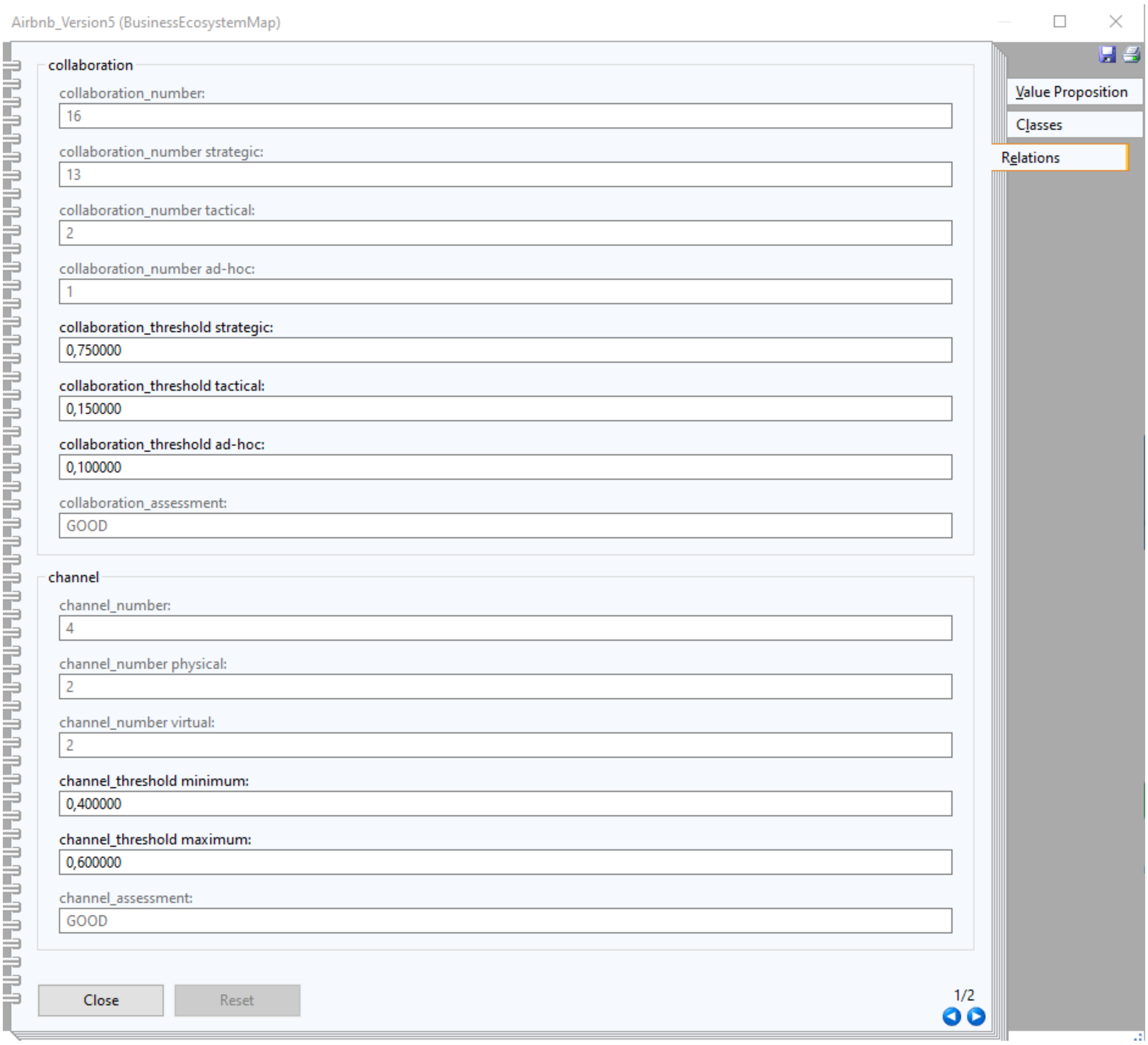


Figure 51: Model notebook relations

6.2.4.9 Reciprocity

Further analysis is on the reciprocity described above. It is not displayed directly in the model interface compared to the analyses mentioned before and not created in the model type metadata. Instead, the attributes for calculating reciprocity are created under each class, as shown in Figure 52, and is in the classes' notebook.

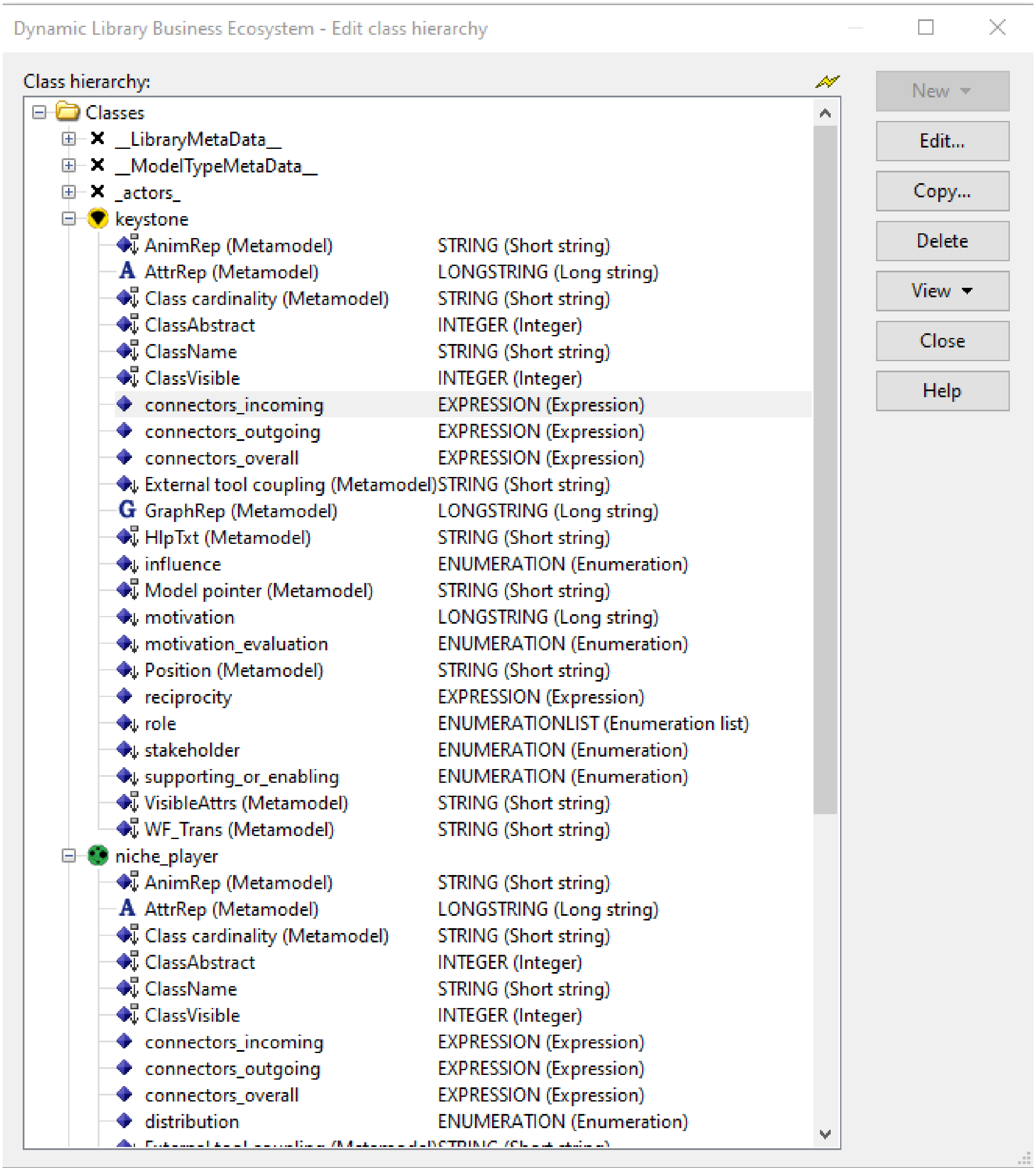


Figure 52: Attributes for reciprocity in ADOxx

The attributes *connectors_inocming* and *connectors_outgoing* calculate the number of edges going towards and away from the class to determine reciprocity. The connectors_overall attribute summarizes for a specific class how many edges go in and out in total. The attribute *reciprocity* then determines how many relations originate compared to the total number. Thus it can be evaluated if there is a balance between incoming and outgoing relations. All the attributes are shown in Table 18. However, one has to treat this key figure with caution. As explained in theory, reciprocity cannot be evaluated purely mathematically and has a large part of intangible value. Therefore, reciprocity is determined and provided in the artefact, but is only a first step towards a precise analysis of this ratio.

Table 18: Reciprocity attributes for analysis

Attribute	*Type*	*Characteristic*
connectors_incoming	expression	EXPR type:integer expr:fixed: ((tokcnt(cfobjs(“collaboration”))) + (tokcnt(cfobjs(“channel”))) + (tokcnt(cfobjs(“modularity”))) + (tokcnt(cfobjs(“flow”))) + (tokcnt(cfobjs(“empty”))))
connectors_outgoing	expression	EXPR type:integer expr:fixed: ((tokcnt(ctobjs(“collaboration”))) + (tokcnt(ctobjs(“channel”))) + (tokcnt(ctobjs(“modularity”))) + (tokcnt(ctobjs(“flow”))) + (tokcnt(ctobjs(“empty”))))
connectors_overall	expression	EXPR type:integer expr:fixed: ((tokcnt(ctobjs(“collaboration”))) + (tokcnt(ctobjs(“channel”))) + (tokcnt(ctobjs(“modularity”))) + (tokcnt(ctobjs(“flow”))) + (tokcnt(ctobjs(“empty”))) + (tokcnt(cfobjs(“collaboration”))) + (tokcnt(cfobjs(“channel”))) + (tokcnt(cfobjs(“modularity”))) + (tokcnt(cfobjs(“flow”))) + (tokcnt(cfobjs(“empty”))))
reciprocity	expression	EXPR type:double expr:fixed: (set (in, aval(“connectors_incoming”)), set (out, aval(“connectors_outgoing”)), set (sum, aval(“connectors_overall”)), ((out) / (sum)))

6.2.4.10 Interpretation Structural Analysis

The structural analysis is either “good” or “bad” for the criteria keystone, niche player, dominator, collaboration and channel. For the relation “modularity” the values are “strong”, “moderate” or “weak”. The calculation of these is described in the previous section. What has not yet been dealt with is the interpretation of the structural analysis. The value “good” describes that according to the concept the criterion is positively fulfilled and thus corresponds to what is relevant for business ecosystems. Conversely, the value “bad” describes that the criterion is negatively fulfilled and thus does not correspond to what is important for business ecosystems. The value “strong” only occurs for the attribute modularity and shows that the emergence of business ecosystems is strongly supported. The value “weak” indicates that the criterion is not sufficiently fulfilled to be supportive for business ecosystems. The value “moderate” lies between these two and can either be seen as a positive indication in the direction of “strong” or as a negative indication in the direction of “weak”. It is the task of the modeller to examine this more closely.

6.2.5 Model type

There is one model type in the business ecosystem metamodel. It is the BusinessEcosystemMap that includes all the classes and relation classes discussed in that work. It is defined in the Add-ons of the ADOxx library attributes: *MODELTYPE “BusinessEcosystemMap” from:all attrrep:”BusinessEcoSystem_Attrep” graphrep:”BusinessEcoSystem_Graphrep”*.

To either have a clear focus on the discussed characteristics of business ecosystems or have all elements discussed for modelling, I created two modes.

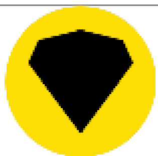
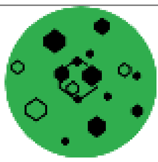
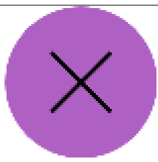
MODE “BEM Standard”
INCL “keystone”
INCL “niche_player”
INCL “dominator”
INCL “consumer”
INCL “collaboration”
INCL “channel”
INCL “modularity”
INCL “flow”

MODE “BEM Advanced” from:all
INCL “keystone”
INCL “niche_player”
INCL “dominator”
INCL “consumer”
INCL “undefined”
INCL “collaboration”
INCL “channel”
INCL “modularity”
INCL “flow”
INCL “empty”
INCL “consists_of”

6.2.6 Summary

To get an overview of all classes and relation classes, this part of the thesis gives a summary. All classes are summarized under the actors and include keystone, niche_player, dominator, undefined and consumer. Their notation and their role are described briefly in Table 19.

Table 19: Summary classes

CLASSES _D-construct_ _actors_ (superclass = _D-construct_)		
class	*notation*	*role*
keystone		guiding actor
niche_player	 	expert
dominator		destructive actor
undefined		undefined/empty
consumer		customer

The summary of relation classes is in Table 20, namely collaboration, channel modularity, flow, empty and consists_of. The notation is given and the available characteristics of the individual relations.

Table 20: Summary relation classes

RELATION CLASSES _relations_ (_D-construct_ to _D-construct_)		
relation class	*notation*	*characteristics*
collaboration	→	strategic, tactical, ad-hoc
channel	→	physical, virtual
modularity	→	unique, supermodular
flow	→	good or service, money or credit, information, intangible value
empty	→	undefined/empty
consists_of	- - - - - - - -	-

To outline the previous analysis and implementation of the business ecosystem metamodel, the business ecosystem concept diagram in Figure 53 is shown below. It illustrates the classes, relation classes, procedures and mechanisms. For the individual elements, the previous chapters in which the scientific theories were elaborated and those in which the modelling was developed, are given.

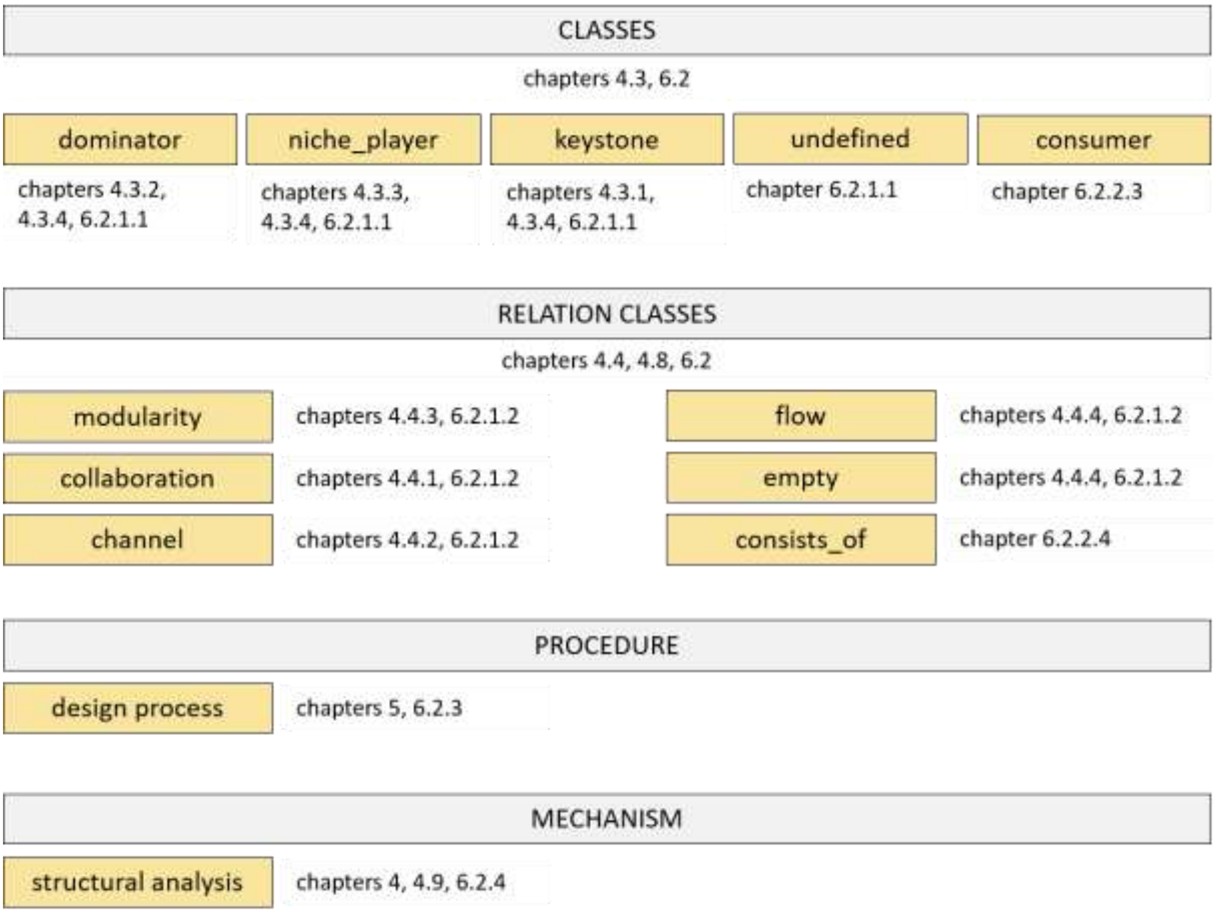


Figure 53: Business ecosystem concept diagram

7 Evaluation of the Artefact

After implementing the modelling method using ADOxx, a demonstration of its application is conducted. This way, it can be shown that the artefact contributes to the third research objective. A demonstration is possible through explorative experiments, simulations, proofs or case studies. It is essential to know how to correctly use the artefact, which describes the modelling procedure (Hevner and Chatterjee, 2010, p. 30).

Once demonstrating the artefact's application, one has to observe and measure how well the artefact supports the problem's solution. An assessment shows the suitability by comparing the goal with the observations from the actual results. The evaluation can take different forms depending on the problem and may include a comparison of the functionality of the artefact, quantitative performance measures, feedback, or simulations and observations such as case studies (Hevner and Chatterjee, 2010, pp. 26–30). In this case, the problem is the lack of design capabilities for business ecosystems. The solution is to apply the theory to create the artefact and to implement it.

A crucial component in the course of a design process is to evaluate it. An evaluation must be carried out to demonstrate the utility, quality and effectiveness of an artefact. For this purpose, appropriate metrics are defined within the design of information technology artefacts. It is possible to check functionality, completeness, consistency, accuracy, performance, reliability, usability or other relevant attributes. If analytical metrics are suitable for evaluating the artefact, it may be possible to evaluate it mathematically (Hevner and Chatterjee, 2010, p. 279).

The design process is iterative and incremental, whereby the evaluation process provides essential feedback to the design. Thus, the design is a non-linear process; it is complete and adequate when it solves the problem's requirements and constraints. Consequently, assumptions and requirements for the technology or organization may be outdated and change iteratively (Hevner and Chatterjee, 2010, p. 279).

Different methodologies exist on how to evaluate design methods: observational, analytical, experimental, testing and descriptive ones. For this artefact, qualitative methods are best suited, observational and comprise case studies or field studies. They allow an in-depth investigation of whether or not the artefact is suitable for the solution. The examination uses a case study to analyse it in depth in different business environments. Field studies monitor the artefact's usefulness for several projects (Hevner and Chatterjee, 2010, p. 280).

7.1 Case Study Evaluation

In the context of this work, the evaluation is done by employing a case studies. Different business environments are chosen to explore whether the modelling approach is suitable or not. In the following, there is a description of two cases of real-world organisations. Based on that description, the cases' modelling according to the design process takes place with the artefact's help. To have an evaluation of the artefact, the discussion of strengths and weaknesses follows.

7.1.1 Google's Android

Since the beginning of Google in 1998, it has continuously been looking for other great success besides its internet search's core business. Google has set itself the mobile internet market as its next goal to remain competitive in the long term. To achieve this, the company has correctly predicted that computers will no longer be the primary online communication medium. As people increasingly want to use the Internet and contact other people via mobile devices, mobile phones gained power. Some disadvantages cannot be ignored: Mobile phones have less memory, run on different software and have limited bandwidth (Bhattacharya et al., 2009, p. 1).

With the launch of Android, the estimates were that Google had triggered a revolution in the mobile market. Android is a global open operating system (OS) that is set to launch the wireless future. Google's idea was to create a new computing environment that would bring mass acceptance of mobile internet technology. Android-based mobile phones should be offered at a lower price than high-priced smartphones, but provide more functionality than them by offering a better web browsing experience (Bhattacharya et al., 2009, p. 1).

The release of the first version of the Stanford website by Google took place in 1996. In the following years, they registered the domain google.com. The company Google Inc. was founded in 1998 and soon became the most efficient search engine on the market. With this core competence, Google was listed as the world's largest search engine in 2000 with 1 billion URLs. A secret of success is that Google attracted new users and could also keep existing ones by offering simple page design and a straightforward logo. Step by step, the company entered the online advertising market and started marketing based on searches. Google offered many online services too, including email, instant messenger, online mapping, social networking, video sharing and blogging. It enabled the company to generate revenues from other business areas, in addition to its core business. With a market share of 81%, Google covered most of the search engine searches worldwide in 2008 (Bhattacharya et al., 2009, p. 2).

At this point, it seems that the company is successfully exploiting the potential offered by the internet and has a long-term strategy underlying it. The diversification of the organization into various fields, is intended to protect the cash cow. Through these actions, it was also possible to attract the maximum number of users and advertisers. Google predicted that cell phones would be the appropriate future platform for the internet. In 2005, an SMS-based search was launched. Google bought the wireless start-up Android Inc. and reported the marketing of Android-based cell phones in 2007. Android will provide the operating backbone for all cell phones. So an Android platform, available for thousands of different cell phone models, was announced. The Linux-based operating system of Android is to be made available as open-source and thus conquer the mobile web (Bhattacharya et al., 2009, pp. 2–3).

The company's goal was to create a standard open mobile platform. It should establish an open ecosystem for the mobile world. A broad alliance was formed with 30 organizations with technological or wireless expertise and came from various fields related to cell phones and the internet. Among the device manufacturers, LG, Motorola and HTC and the service providers Sprint Nextel, NTT DoCoMo and T-Mobile took part. For semiconductor companies Intel and Qualcomm were involved, eBay was part of the merger in online auctions, engineering companies such as Noser Engineering and many others.

With the help of Android, the system created an operating system, user-interface and applications as foundation for the standard platform. It offers a developer-friendly open-source environment, which should provide mobile operators and manufacturers with a maximum of freedom and design possibilities. It allows for personalized solutions. Android can be tailored, developed, and marketed according to mobile operators and manufacturers' needs and allows for cost-effective, innovative products to be created in the shortest time possible. Developers will be involved and receive practical tools to enable mobile-compatible work, resulting in user-friendly services. The customer experience is enhanced and made more comprehensive through rich applications, user-friendly interfaces and innovative features (Bhattacharya et al., 2009, p. 3).

In 2008, T-Mobile launched the first Android-based phone produced by the manufacturer HTC and included some smartphone features. It was also possible to install several third-party applications in addition to those from Google. The cell phone carriers and Google have ensured every application's offering, even if it has a conflict of interest with applications from Google itself (Bhattacharya et al., 2009, p. 3).

In 2013 Android will have the most smartphone installations, but the surrounding ecosystem and especially software development will become more active. From the beginning to 2013, 900 million Android devices have been activated, with Android accounting for 79 percent of total smartphone shipments and Apple's iOS 13 percent. Google Play has become the largest digital content store and Android's largest and most profitable app store. It is available in over 200 countries with more than one million applications and over 50 billion downloads by 2013. In Google's developer console, developers can publish new applications, products and updates to hundreds of millions of users within minutes. The question for Google was how to make the business ecosystem around Android even more profitable for all players, OEMs (original equipment manufacturers), carriers, retailers, developers content partners and Google itself (Elbouchikhi et al., 2013, pp. 1–2).

Operating Systems

In 2013, Android had the largest market share of shipped smartphones, with 75 percent of total shipments when comparing competing operating systems. At that time, the second-largest market player was iOS, followed by Blackberry (Elbouchikhi et al., 2013, p. 3).

OEMs

OEMs that manufacture the original equipment play a critical role in Google's ecosystem, and Android, in particular, ranging from cell phone manufacturers to tablet producers, to other companies using Android as an embedded operating system. Among the manufacturers of smartphones, Samsung, HTC, LG, Motorola, and Sony are particularly noteworthy, although there were others. These organizations' involvement in the ecosystem has attracted OEMs, but they have brought with them knowledge about component supply, channel distribution, scale manufacturing, and marketing power. It has not only satisfied the demand for their products but expanded the whole ecosystem to include capabilities that Google alone would not have been able to provide (Elbouchikhi et al., 2013, p. 3).

Android is the operating system for other devices, such as Amazon's Kindle Fire and Barnes & Noble's Nook. Nevertheless, this is double-edged because these companies benefit from the fact that Google has invested in Android. It is difficult for Google to profit from these organisations' products or user base (Elbouchikhi et al., 2013, pp. 3–4).

Carriers

Telephone companies are also an essential part of the Google business ecosystem. Examples are AT&T and Verizon in the United States, DoCoMo in Japan or, as mentioned above, T-

Mobile. The phone companies were initially attracted to Android because it is an alternative to Apple's iOS, allowing differentiation in their product range. Variation was better possible with Android than iOS because it does not control the end-user experience as much as Apple does. Sales of Android devices took place worldwide, mainly in the telephone companies' stores (Elbouchikhi et al., 2013, p. 4).

Application Developers

Because Android is offered to OEMs for free, Google cannot generate revenue from the OS license. It created an interesting dynamic, which forced Google to look for other ways to make profit. The digital application marketplace Google Play was created, in which music, books and magazines are marketed. Soon the application developers became central to the life of Android, responsible for over a million applications. The end-users widely accepted these. It was also due to the diversity and the availability of the latest applications on Android devices. Besides the success, challenges occurred as well. One example is Facebook Home, an application developed by third-party application developers that designs the entire user experience around Facebook. For developers in the Android ecosystem, the combination of strong growth in device activation and noticeable monetisation improvements was attractive. Because Android is open source, there were many ways to customize the user experience (Elbouchikhi et al., 2013, pp. 4–5).

In conclusion, Google's Android strategy has been built around two potentially competing areas: the desire to make Android open for all organizations, with the restriction that some of Google's most popular applications are available for free so that the core business remains. The purpose of the ecosystem is to organise the world's information and to create universal access and usage to it (Elbouchikhi et al., 2013, pp. 6–7).

To model Google's Android business ecosystem, I followed the design approach discussed in Chapter 5.2.

1. Get a clear picture of the value proposition

First, I analysed the value proposition of Google. The definition is entered into the notebook as in the modelling process. A screenshot from the modelling environment is in Figure 1.

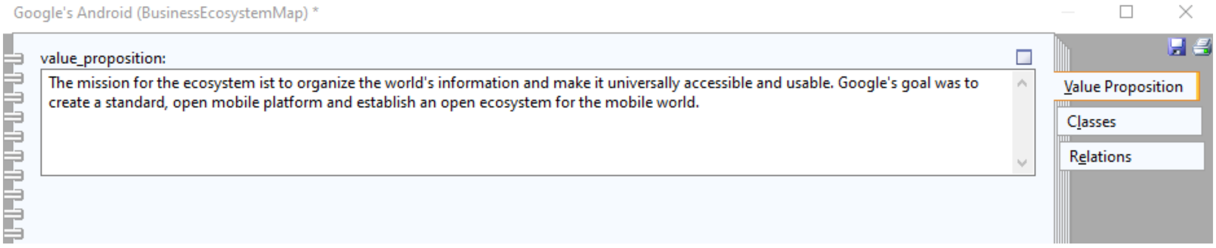


Figure 54: The value proposition of Google's Android

2. Choose stakeholders

The second step is to select the stakeholders. For this purpose, the classes are used, and the case study's interpretation defines whether a stakeholder is a keystone, niche player or dominator. The participants of the ecosystem under examination are in Figure 55.

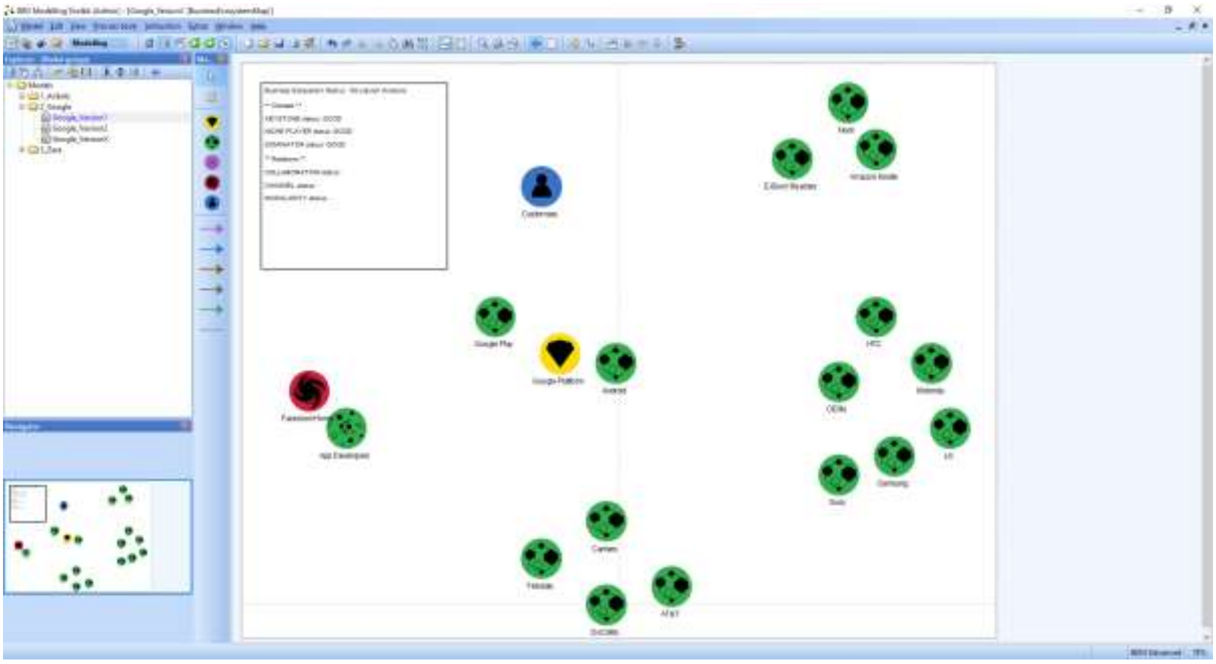


Figure 55: Stakeholders of Google's Android

3. Know stakeholders' interest

In designing business ecosystems, it is essential to know the interests of the various stakeholders. The case study identifies and filters these. The interests are then entered in the notebook of the respective stakeholder. Typically, it is also possible to determine the stakeholder's motivations concerning the value proposition. Figure 56 shows an example of how this looks like for Android.

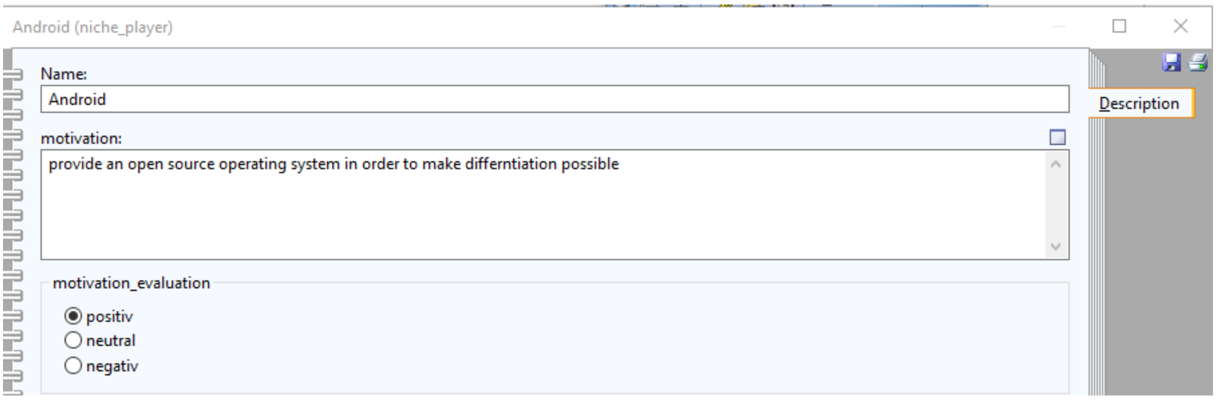


Figure 56: Android's interests

4. Define roles

Step four defines the roles of the actors in the system. There are various ways of describing them in more detail in the class notebook. The system's role can be described, the influence on the whole system and whether it is a primary or secondary stakeholder and if it enables or supports. A screenshot of the Android ecosystem of Motorola is in Figure 57.

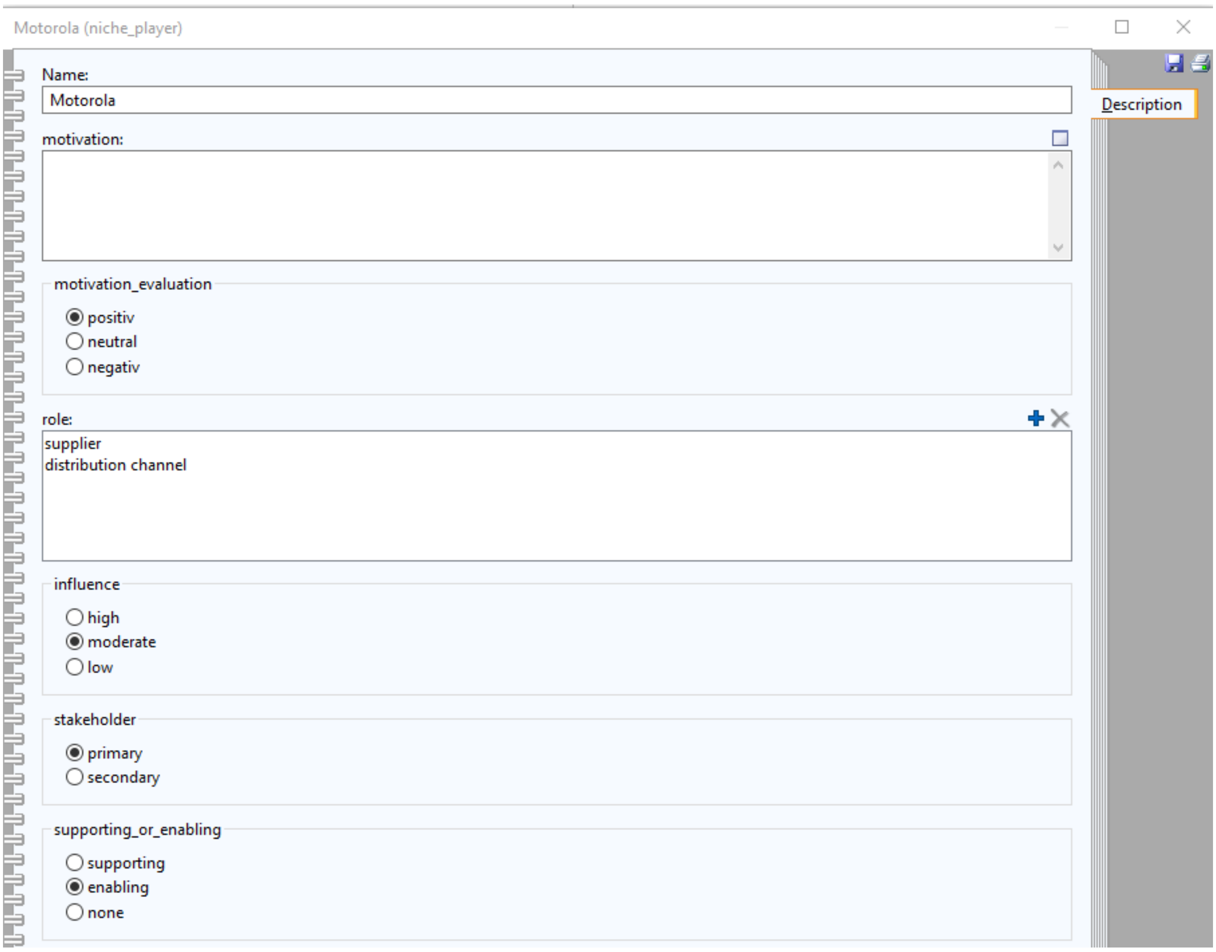


Figure 57: Role of Motorola in Google's Android business ecosystem

5. Define relations

Next, the relationships between the actors are defined. One has to decide which type of relationship with which characteristics exists between which stakeholders. According to the case study, how these relationships look like in the ecosystem of Google's Android is shown in Figure 58.

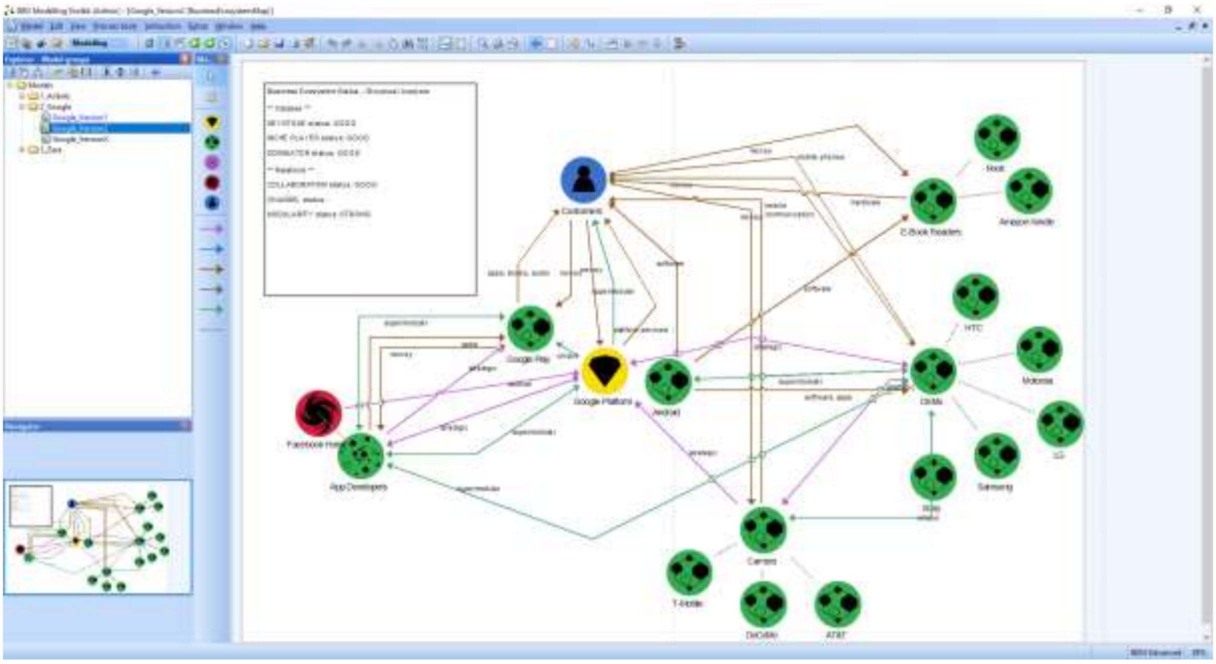


Figure 58: Relations in Google's Android business ecosystem

6. Conduct analysis

Once designing the system, real-time analysis monitors the system continuously. It shows whether the system can function as an ecosystem with its characteristics. The business ecosystem of Google and Android is healthy and works. Thus, an implementation of the system can function according to the characteristics of ecosystems. The individual parameters in Figure 31 show this. It corresponds to the reality that Google's Android's business ecosystem is healthy and functioning.

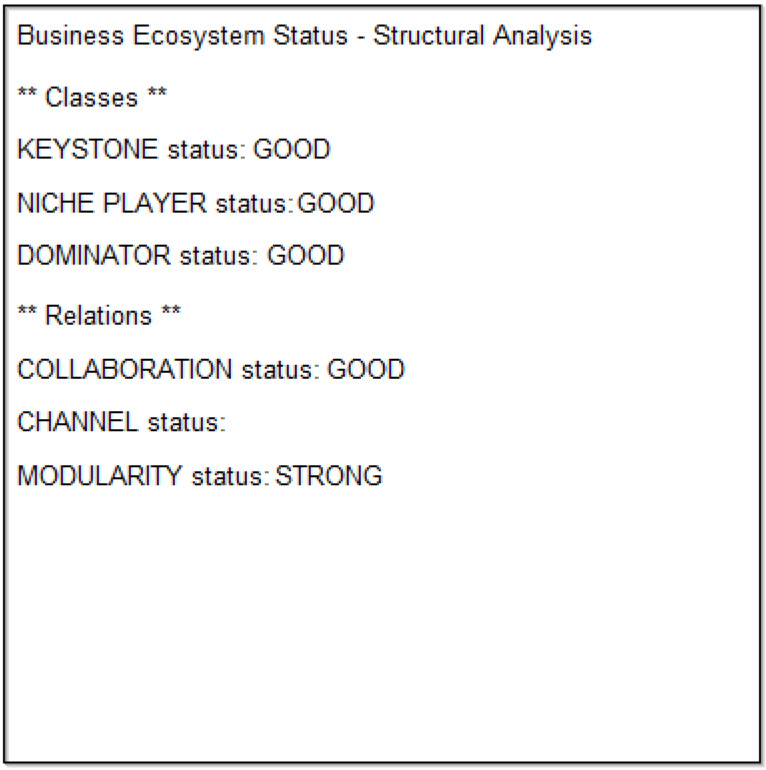


Figure 59: Structural analysis of Google's Android business ecosystem

7.1.2 Inditex's Zara

In 1975 the first Zara store was opened and became a success. Zara is a subsidiary of Inditex, which is a retailer of designs, manufactures and sells apparel, footwear and accessories for men, women and children. Their core competency is to deliver fashion fast. Their customers need to understand that if they like something, they have to buy it immediately; otherwise, it won't be in the shops after some weeks. Nearly 3000 stores spread across Europe, America, Asia-Pacific, Central and East Africa. Zara accounts for 80 percent of Inditex's total sales. Zara's business model bases on vertical integration. The company purchases its products from around 200 external suppliers, handled by a purchasing office and include fabrics and other raw materials. Both internal and external manufacturers do the dyeing, structuring and finishing of the fabrics. The process enables very short production cycles (Carugati et al., 2008, pp. 1495–1496).

Zara outsourced 50 percent of its production. Two-thirds of this are produced in Europe and North Africa, the rest in Asia. Zara has formal contracts with these manufacturers, some of these are long-term relationships. In that case, the manufacturers predominantly produce solely for Zara. 50 percent of production is made in-house in Spain. Once production is complete, the finished garments are returned to Zara, inspected, packaged, and distributed to the distribution centres. These centres stock the stores which are mostly owned by Zara, and there customers purchase the goods (Carugati et al., 2008, pp. 1495–1496).

In order to model Zara, I again followed the design process.

1. Get a clear picture of the value proposition

First, I analysed Zara's value proposition. It brings about the first challenge when using the business ecosystem artefact, as there is no value proposition suitable for business ecosystems. The value proposition is solely tailored to the company itself, as seen in Figure 60.

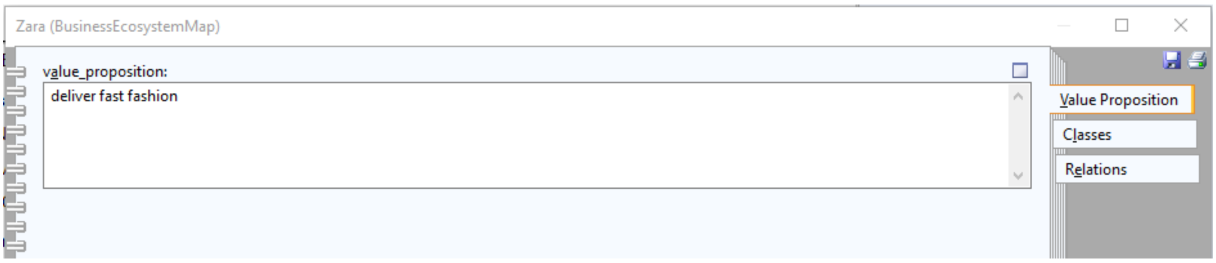


Figure 60: The value proposition of Zara

2. Choose stakeholders

The second step is to select the stakeholders. The classes are used, and the case study defines whether a stakeholder is a keystone, niche player or dominator. In the system under analysis, it is not possible to define the stakeholders according to the classes. Thus the undefined class is used as well as the consumer. The approximation is in Figure 61.

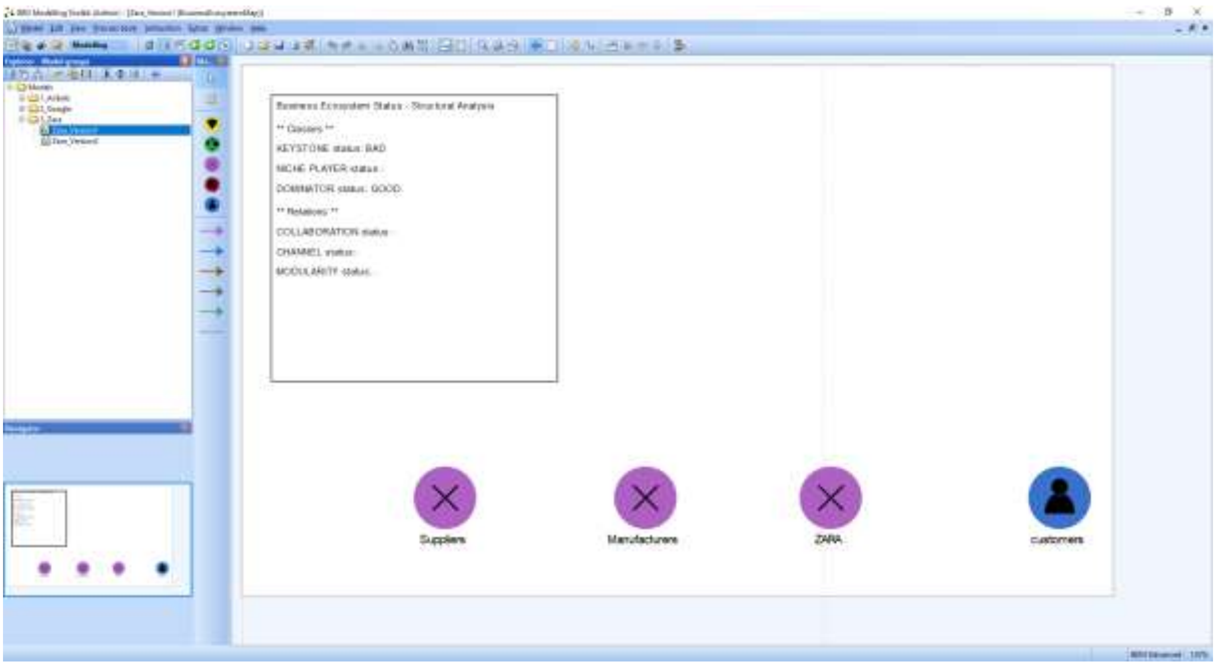


Figure 61: Stakeholders of Zara

3. Know stakeholders' interest

Interests of participants are important for business ecosystems. Here the interests of Zara's manufacturers are shown as an example in Figure 62.

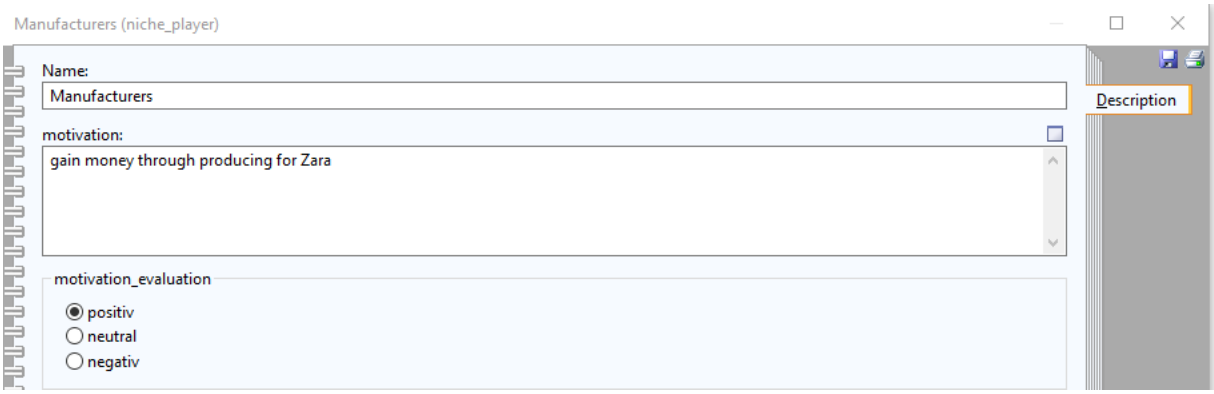


Figure 62: Interests of Zara's manufacturers

4. Define roles

Step four defines the actors' roles in the system. As an example, the suppliers of Zara are chosen and are in Figure 63.

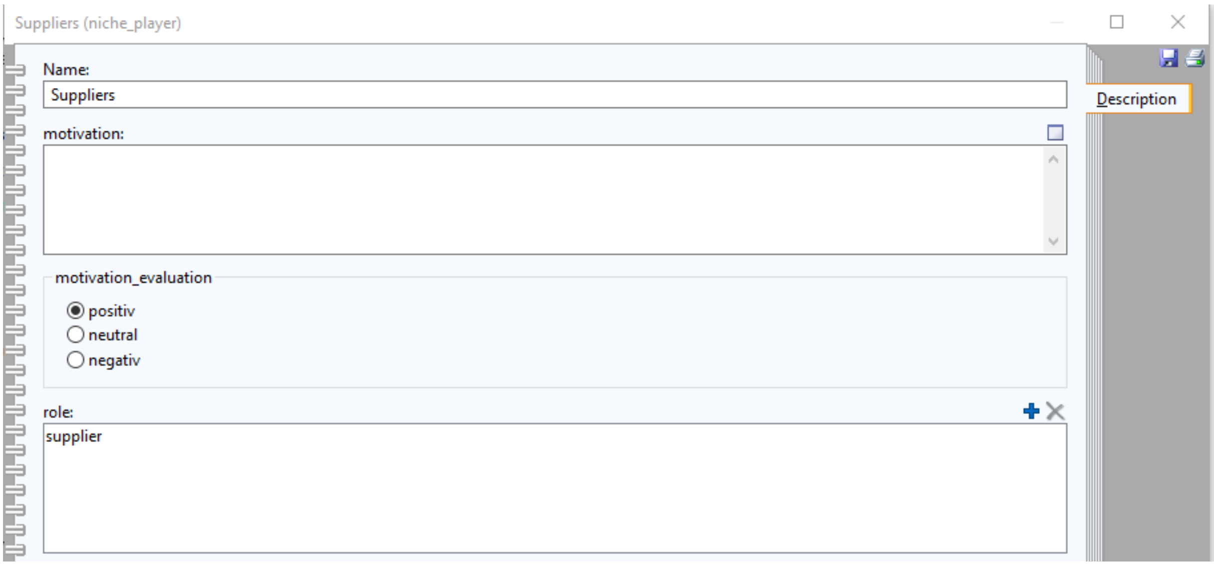


Figure 63: Role of suppliers

5. Define relations

Next, the relationships between the actors are defined. What they look like for Zara can be observed in Figure 64.

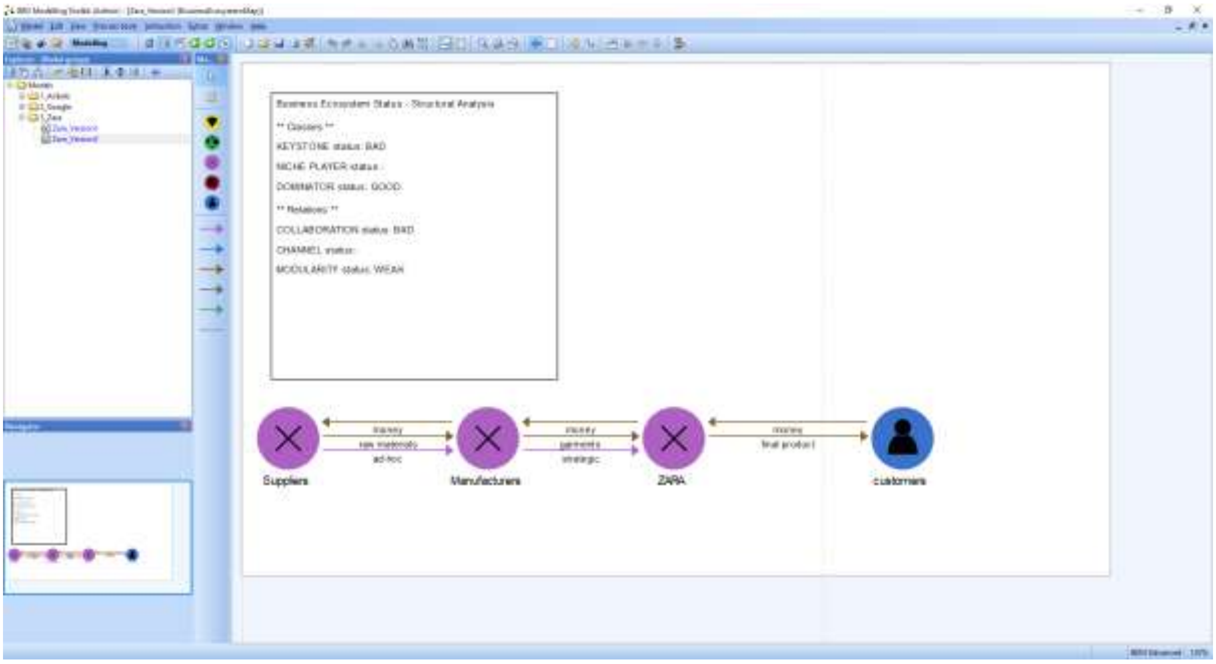


Figure 64: Relations in Zara's supply chain

6. Conduct analysis

Once designing the system, real-time analysis monitors the system continuously. It shows whether the system can function as an ecosystem with its characteristics. Zara does not function as a business ecosystem, as seen in Figure 65. It does not have the necessary characteristics. Thus it can be said that the artefact is not suitable for supply chains.

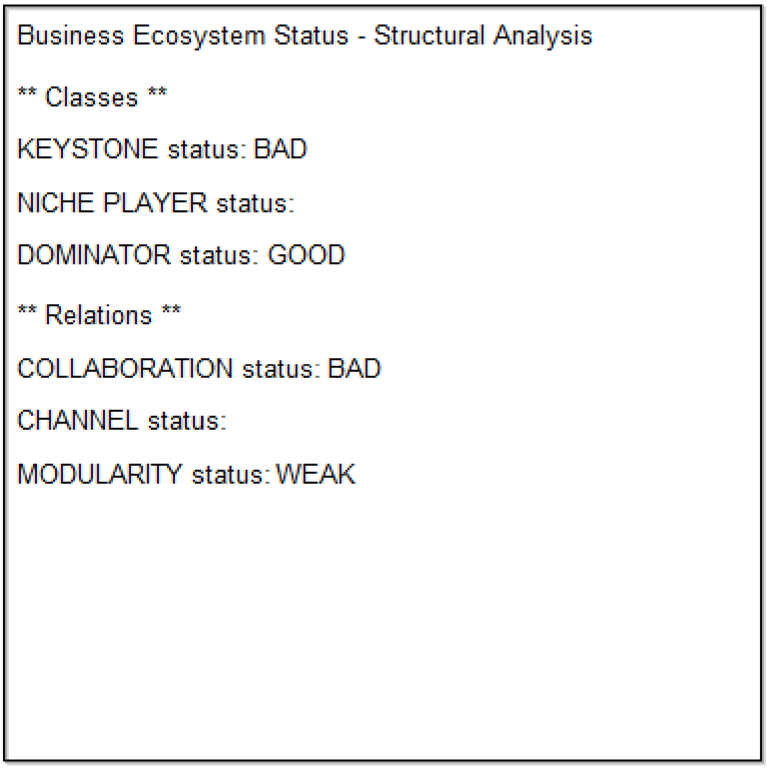


Figure 65: Structural analysis Zara

What does Zara have to do to become a business ecosystem?

As tailoring of Zara's' goal is to its business needs, the value proposition has to change. A business ecosystem value proposition for Zara should focus on solutions that meet consumers' needs and the well-being of the whole system. Obviously, in the modelled picture of Zara, there is no single actor typical for business ecosystems. These actors cannot simply be used but must correspond to their semantics. The position and function of Zara would have to change fundamentally, assuming here that Zara should become the keystone. Zara would have to position itself as a regulating, directional actor that initiates change in the form of solutions – with a value proposition above it that all actors support. The supply chain would dissolve, and the suppliers and manufacturers shown at the moment would have to develop into specialized niche players. It is possible that they are more distributed and no longer divided into two large groups. For example, it is conceivable that designers will have a modular, cooperative relationship with independent production facilities. At the moment, all clothing distribution is handled by Zara, which a business ecosystem could solve via cooperative relations. The system under observation would need the characteristics of business ecosystems, namely a cooperative, complex system that allows modularity. The complementary relations are entirely missing in the status quo and should to be established by exchanging complementary activities.

7.2 Strengths and Weaknesses

With the help of the artefact, it is possible to present the concept of business ecosystems as shown with Android and Zara. By the method of metamodeling, all aspects of the artefact can be integrated. The described procedure shows the advantages of metamodeling with ADOxx, which enables personalized, domain-specific modelling too. Due to the actors' different representation, the model gains in strength, since there is an emphasis on the characteristics specific to business ecosystems. It is achieved by focusing on the classes keystones, niche players and dominators in contrast to Moore (1996), who emphasizes the classic participants like suppliers, customers, government, and more. So the artefact can be applied domain-specifically. The characteristics of business ecosystems show that there are many different ways to view relationships. It is possible to use and evaluate all the typical relationships known to the current state of knowledge for business ecosystems through the artefact. It is an advantage of the tool: real-time evaluation while an ecosystem is being modelled. The determination of whether the designed system can function in this way or not is possible during the modelling process.

Users can customize the artefact to their needs by limiting it to one relational form and drawing different models focusing on specific relation types. Alternatively, one can extend the artefact by defining the undefiled class and empty relation. A clear advantage of the artefact is that it is changeable and flexible. It does not matter which definition the modeller starts from, as they can adapt the tool accordingly. It is especially relevant if there are new scientific findings. It gets particularly interesting when there are first empirical data that can be used for the structural analysis. The defined thresholds or limits can be linked to the empirical knowledge of business ecosystems.

The evaluation of reciprocity must be critically questioned. It cannot be tested purely mathematically and is therefore not very expressive since gut feeling, and intangible value does not flow into the figure. In general, the artefact's weakness is that the structural analysis basis lacks in business ecosystems' empirical results. These are not available now and therefore approximations considering findings from other domains help. In this context, an advantage of the artefact is the open design. New empirical results can be incorporated at any time and changed in the model's notebook.

What the artefact does not consider is the different influence of different actors on the whole system. The representation of actors with substantial influence is larger than those with little. However, this does not affect the structural analysis, but only a difference in the representation.

Although the tool fulfils its primary use, i.e. the graphical model representation, and analysis of business ecosystems, there is still a great potential for further development. One possibility is using heuristics, such as a more exact determination of an actor type. It is conceivable asking specific questions before inserting a class. The user should not decide whether it is a keystone, niche player or dominator, but is determined by rules. These questions are, in turn, determined by theoretical knowledge and can thus support the modelling of business ecosystems.

In general, the artefact provides a good basic structure for modelling business ecosystems based on a solid foundation of scientific knowledge. All theoretical findings have been incorporated into the artefact. The case studies as well as the strengths and weaknesses show that the business ecosystem concept is meaningful and the artefact allows designing business ecosystems. Nevertheless, there is still a great potential for further development: through scientific findings on business ecosystems or, in the meantime, with the help of findings from other disciplines.

O3: How can the business ecosystem design be evaluated?

The third research objective is about the business ecosystem designs' evaluation. Chapter 6 deals with the development of the metamodel and chapter 7 with the testing of models. The case studies show that the artefact and the design approach are adequate for its evaluation. It means that the artefact delivers the needed results in the right context, as shown for Android and Zara. Thus, the artefact is a suitable method for evaluating a business ecosystem design.

8 Discussion and Conclusion

This work aimed to close the gap in the theory of business ecosystems concerning a generally valid conception on the one hand and to approach an answer to the question of the design of business ecosystems on the other hand. The scientific findings were presented, analysed and linked to reaching the first research objective. Thereby it became apparent that several theoretical findings see a central actor in the business ecosystem and niche players that enable modularity. Also, such a system can have a value-sucking population, the dominators. Although the different organizations, individuals, or general members in the system are not (or do not have to be) organizationally tied to each other by classical contracts, they are connected by the keystone. They are strongly linked to each other by cooperative and complementary relations. The fundamental difference to a classical network is that business ecosystems focus on their value proposition, which shows the design process in detail. Additionally, the consumer can choose from a set of independent products. It manifests itself in the relationships typical for business ecosystems, which can take various forms of cooperation, modularity, virtuality or reality, and flows. With the help of these activities and the actors themselves, convergence towards the system's boundaries can happen, although these cannot be drawn clearly in most cases.

The visualization of business ecosystems is possible in various ways. This thesis shows two different possibilities of static visualization. It gives an idea of the potential theoretical forms that can be considered options for the metamodeling set up later. In the modelling, an early stage of the system's evolution is assumed but not limited to it. The theory describes the entire stages, which lead from birth to expansion via leadership to renewal or death. A central actor is assumed in the described theoretical evolution, whereas a similar behaviour could also be possible for niche players or dominators. If a dominator evolves in a leader's direction, there is a great danger for the business ecosystem and will occur under different circumstances. It certainly includes the behaviour in terms of hierarchy, since in business ecosystems, no classical hierarchy is necessary. Control or hierarchy in these systems happens via trust, supervision of others, motivation and distributed decision processes. There are initial approaches in literature to evaluate the effectiveness of these and the entire ecosystem. It include robustness, which measures the continuity of members throughout the system. Very characteristic for business ecosystems is the evaluation of niche creation. The diversity and variety can be shown, and the reciprocity measures the balance of the values or the exchange. The actors in a business ecosystem share values, which should coincide so that a positive influence is possible and to avoid potential conflicts.

All these aspects are presented conceptually and necessary as knowledge to consider business ecosystems design. The presented design procedure must not be seen as strictly sequential but is an iterative, interactive process. It starts with an idea, which elaborates in this phase to an initial value proposal. The central point is understanding the system's perception inside and outside of the customers and ideally bringing them together. The next step is the specification of this value proposition. The parties for its realization are selected, which, do not have to be the business ecosystem's actual actors yet. These are selected in the following phase, whereby their interests must agree with the value proposition. Subsequently, the first central connection to the conception arises: the actors are assigned to their role keystone, niche player or dominator. As the findings on design have shown, different alternatives are possible when assigning roles, which are complementary rather than mutually exclusive. It also applies to the relations' determination. The relationships are taken directly from the scientific findings and used in the most diverse forms. In the design process, the final phase is implementing the plan, whereas modelling creates the essential added value by performing structural analysis. It allows testing whether the business ecosystem can function in a specific way before implementation.

The artefact makes use of all the knowledge available on business ecosystems up to this point. For the artefact's implementation, the method of metamodeling is used, which has some clear advantages. Models are an abstraction of reality and therefore well suited as building plans for the design and realization of businesses. Complex systems like business ecosystems can be described, and their structure, elements and relations can be studied as well as their response in the real world. It was accomplished in the business ecosystems artefact by implementing the elements, relations, structure, and structural analysis as described in theory with ADOxx. As shown in this thesis, with the artefact and the application on case studies, it is possible to build and verify the system through modelling before implementing it. In relation to modelling, it can be mentioned that behind each node of a model there are Business Process Modelling Notation (BPMN) processes. Since the business ecosystem modelling method is designed as a flexible and extensible tool, an integration of BPMN into the presented method can be realised.

This work summarises the relevant knowledge into a concept of business ecosystems, a proposition of a design process, and implementation of an artefact via metamodeling. In the process, potentials for further research on the topic of business ecosystems are identified. These include the evolutionary stages for niche players and dominators, transition of actor types, real world studies and application, metrics for relations and specifically reciprocity. Also, there are open issues concerning the model, namely the implementation of BPMN behind each node of the model and heuristics and dynamic behaviour in the model. These potentials are discussed in detail in the following.

The actors are theoretically well defined, and their integration into the modelling could be improved with heuristics. In terms of evolution, literature only considered the keystone so far. It is conceivable for future work to think about the evolutionary stages by actor type. Also, an analysis of transitions is useful, such as: when does a keystone become a niche player and why? This is then applied to the different cases by addressing the transitions between keystone, niche player and dominator. It does not only add to the theoretical basis but is applicable in practice through the artefact. The analysis of such changes concerning the whole system expands the modelling with a dynamic view. It triggers the great potential that the basis created with this thesis brings about, namely dynamic behaviour in the model. A use case is the evaluation of robustness, which measures system members' survival rate. If one adds dynamic behaviour, measuring the number of actors remaining in the system in the long run, is possible and shows their strategic importance. It can be interesting for establishing long-term cooperation relations.

For the extension of the artefact by a dynamic component, I think of system dynamics (see Forrester, 1994). It is a method for the holistic analysis and simulation of complex and dynamic models. A simulation in addition to the structural analysis extends the metamodel. In the course of evaluating business ecosystems, I believe there are many opportunities to explore domain-specific metrics. Since there is a lack of studies on real-world business ecosystems at this point, deriving metrics prove to be complicated. It leads to the next, which is the enormous potential for insights and knowledge that real-world studies can bring. These, in turn, can provide data for the creation of key figures. The modelling method can further be developed in such a way that existing images or visualisations are used and harmonised. By doing so, a wide variety of interpretations of business ecosystems can be compared, thus creating a universal basis for comparison.

I see reciprocity as a central key indicator. Interdisciplinary collaboration with sociology could help to develop a metric for evaluating business ecosystems. So far, it is not yet evaluable to the point of being meaningful in the artefact. Metrics can also make a positive contribution to relationships between actors. One example of this is collaborative relations. At the moment, the artefact uses the time horizon. What seems to make sense here is an assessment of the strength of the relationship and collaborative exchange. Another example is modularity, which is part of the artefact and positive as soon as there are modular relations. However, so far, theory has not explicitly worked out how unique modular and supermodular relationships affect the entire business ecosystem differently.

The chosen framework of this research work is to expand the scientific base on the one hand and to add value to a specific environment in the real world on the other hand. Through rigorous scientific work, a decisive contribution to the knowledge base can be provided using the business ecosystems' elaborated concept. Its added value is that by looking at relevant knowledge, a conceptual, theoretical literature work has shown a holistic view of business ecosystems. The different business ecosystem design areas have been discussed and processed into a theoretically and practically applicable design process. The contribution of this work to the knowledge base is complemented by an outlook so that further contributions to the theoretical and practical basis can expand the concept. However, this theory does not stand alone but can fulfil a business need through the implemented and evaluated artefact. The changes that happen in the environment have a direct impact on the business need. If one applies the artefact in the appropriate environment, namely to design a business ecosystem, the evaluation has clearly shown that it is suitable for modelling it. A specific business ecosystem design can be represented as a model – a form of abstraction of reality – and tested for suitability before implementation. It can be of particular value to designers, managers, visionaries or leaders so that their ideas and values can be tested and evaluated before implementation. The artefact helps change the perspective from a classical value system to a cooperative and modular business ecosystem.

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Figure 10 created with Lattice Miner: https://lattice-miner.soft112.com/

All ADOxx models created with ADOxx

Appendix

Case Study Airbnb

Airbnb offers a platform and software artefacts, whose service is centred around the accommodation. Airbnb has established itself in a highly competitive market as a platform for short-term lodging. The cooperation and ecosystem structure enabled the organization to leave competitors far behind and become one of the most highly evaluated start-ups. By opening up to external developers in 2017, the ecosystem has become even more established (Hein et al., 2018, pp. 2–5).

Airbnb offers the platform in the system, which is more precisely the software behind it. It is primarily about property management and offers a range of tools to support reporting, planning, channel management and payment processes. As mentioned above, Airbnb has opened up and made the API publicly available. Another cornerstone of the system is the guests. They are part of a two-part marketplace that brings together supply and demand via the platform. The aim is to bring together the most suitable guests and hosts. The hosts, who mainly rent out vacation homes as a secondary occupation, offer their living space. They are continually aiming at improving their service, listing and overall booking rate. Airbnb's property managers also offer a complete service and take over the property management tasks. It includes meeting guests, organizing and planning cleaning staff, providing pricing strategies and many other tasks. The cleaning services are an essential part of the service, which directly impacts guest satisfaction. In London, for example, several options and providers supplying Airbnb cleaning services exist, such as Airline hire, the Airtasker platform or End of Tenancy Cleaning Service. After the guests have left, they help the house owners clean up and prepare for the next visitors. Airbnb Concierge Services are a complimentary service that provides special attention to residences. A complete service can be offered or used to welcome guests. This part of the ecosystem is very flexible and can be adapted endlessly to meet a wide range of needs. Airbnb offers its physical products, which vary from toiletries to remote locks and noise signals. Of course, there is much competition from external markets, which can also sell to hosts. Airbnb's financing provides hosts with financial resources if they wish to expand their operations, for example. There are over 150 million users, and around 640,000 hosts using the Airbnb platform. It generates many data bringing the right guests and hosts together. This data is measured and monitored by Airbnb (Hein et al., 2018, p. 5; Higher Bookings, 2020).

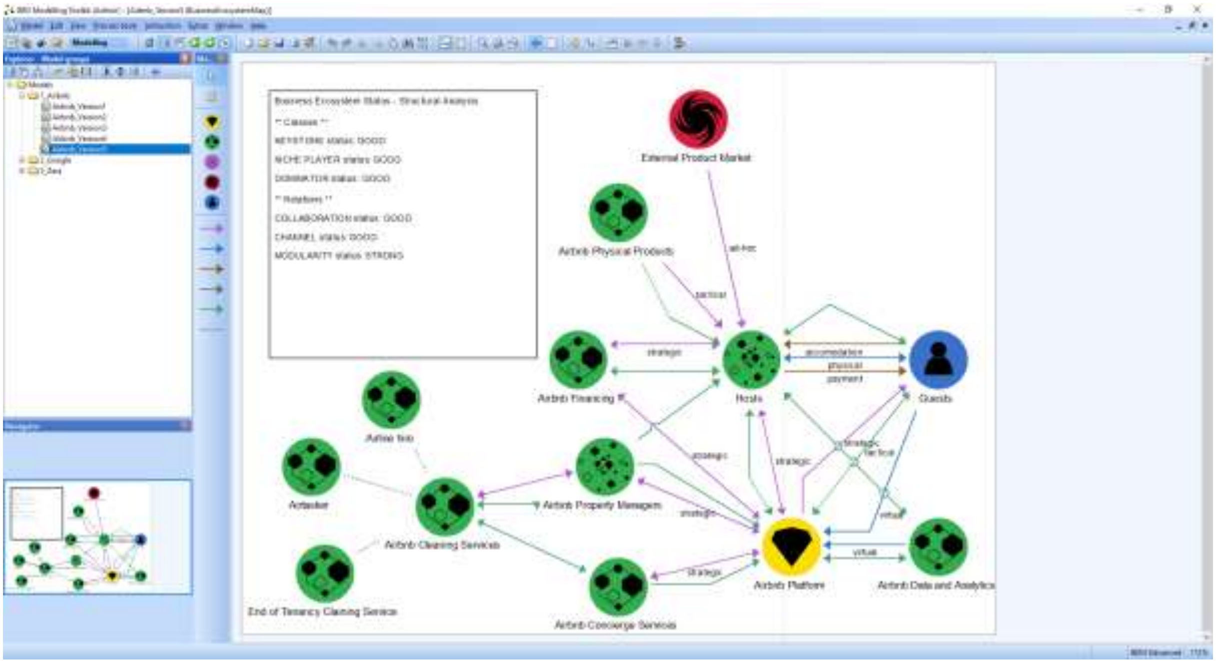

Figure 66: Airbnb business ecosystem model

Abstract

Due to an increasingly volatile and rapidly changing environment, interactive, flexible, and complex solutions are in demand. Classical systems can no longer cope with these challenges; one possibility to master them is the idea of business ecosystems. Until now, there has been a lack of a concept for them and knowledge about their design. In the theoretical, scientific part, this work combines the previous findings in the form of a concept by identifying and presenting the typical elements of business ecosystems, such as actors and relationships. During its implementation, a controlling actor in business ecosystems, many specialised niche players, and possibly a value-draining dominator are found in literature. The collaborative and modular relationships between the system actors are characteristic. After the concept is established, a design method for business ecosystems based on these insights is shown and completed. The iterative process starts with the creation of a value proposition, moves on to the selection of suitable stakeholders, whereby their interests are particularly relevant for the long-term existence, into the role definition of the stakeholders, and leads to the linking of the individual actors through relations and ends in the implementation. This method is evaluated using a prototype by implementing a metamodeling concept with the help of ADOxx. The artefact incorporates the fundamental knowledge of the theoretical conceptualization and design of business ecosystems. It creates the basis for an evaluation of a specific system, which takes place utilising structural analysis. This analysis of a domain-specific model shows whether a business ecosystem can survive or not. Based on two case studies of Google’s Android and Inditex’s Zara, it becomes clear that the artefact is a suitable method for representing and designing business ecosystems. Thus, this thesis contributes to the knowledge base by presenting an extensive framework and an applicable design process. The artefact provides a proven way to model and analyse business ecosystem design before implementing it. The artefact enables a change of perspective for scientists, designers, visionaries, managers, and leaders from a classical value system to a modular business ecosystem.

Kurzfassung

Durch eine steigend volatile und sich schnell ändernde Umwelt sind interaktive, flexible und komplexe Lösungen gefragt. Bisher bewährte Systeme schaffen diese Herausforderungen nicht mehr; eine Möglichkeit diese zu meistern ist die Idee von Business Ecosystems. Jedoch fehlt es bisher an einer Konzeptionierung des Wissen und Designs ebensolcher. Diese Arbeit verbindet in einem theoretisch-wissenschaftlichen Teil die bisherigen Erkenntnisse in Form eines Konzepts, indem die für Business Ecosystems typischen Elemente wie Akteure und Beziehungen dargestellt und bewertet werden. Dabei wird festgestellt, dass es in Business Ecosystems einen zentralen, steuernden Akteur gibt, viele spezialisierte Niche Players und möglicherweise einen wertentziehenden Dominator. Charakteristisch sind die kollaborativen und modularen Beziehungen zwischen den Systemakteuren. Nachdem das Konzept aufgestellt ist, wird basierend auf diesen Erkenntnissen eine Designmethode im Sinne einer Modellierungsmethode für Business Ecosystems vorgeschlagen. Diese startet beim Aufstellen eines Wertversprechens, geht über zur Auswahl der geeigneten Stakeholder, wobei deren Interessen für das langfristige Bestehen besonders relevant sind, in die Rollendefinition der Stakeholder, und führt zur Verknüpfung der einzelnen Akteure durch Relationen und mündet in der Umsetzung. Diese Methode wird mittels Prototyp evaluiert, indem eine Metamodellierung mithilfe von ADOxx implementiert wird. In das Artefakt fließen die gesammelten Erkenntnisse vom Konzept und Design von Business Ecosystems ein und schaffen die Basis für eine Evaluierung eines spezifischen Systems, die mittels struktureller Analyse passiert. Die Analyse von einem domänenspezifischen Modell zeigt, ob ein Business Ecosystem entstehen kann oder nicht. Anhand von zwei Case Studies zu Google’s Android und Inditex’s Zara wird erkenntlich, dass das Artefakt eine geeignete Methode zur Darstellung und zum Design von Business Ecosystems ist und einen Mehrwert im Gegensatz zu diagrammtischen Ansätzen bringt. Damit liefert diese Arbeit einen Beitrag zur Wissensbasis indem ein umfassendes Konzept dargelegt, sowie ein anwendbarer Designprozess vorgestellt und evaluiert wird. Das Artefakt bietet eine geprüfte Möglichkeit, das Business Ecosystem Design zu modellieren und analysieren bevor dieses implementiert werden. Durch das Artefakt ist ein Perspektivenwechsel für WissenschaftlerInnen, DesignerInnen, VisionärInnen, ManagerInnen und Führungskräfte von einem klassischen Wertesystem zu einem modularen Business Ecosystem möglich.