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Modeling a Business Ecosystem from the Point of View of a Particular Participant

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Abstract. The scientific literature related to business ecosystems is growing. However, the majority of this literature is devoted to so-called Digital Business Ecosystems (DBE), which are largely related to the networking aspect of business ecosystems, i.e., the exchange of values among their participants. Other parts related to the work of a participating enterprise, as well as its suppliers and regulators, are often excluded. In this work, we take a different approach, namely, to model an ecosystem that exists around a specific enterprise. The work is based on concepts transferred from biological cybernetics to business, such as structural coupling and autopoiesis. In this work, the Fractal Enterprise Model (FEM) is used for modeling business ecosystems. The research follows the Design Science methodology. The goal is to suggest some patterns expressed in the modeling language that can help an enterprise build a model of the ecosystem of which the enterprise is in focus. The patterns can help identify activities that are missing in the enterprise itself, thereby providing a basis for improving its functioning.
Keywords: Business Ecosystems, Modeling, Structural Coupling, Autopoiesis, Fractal Enterprise Model, FEM.

1 Introduction

The concept of business ecosystems was introduced by Moore; see, for instance, [1]. This was achieved, at least in part, by transferring the concept of an ecosystem from biology to business. The general diagram showing what a business ecosystem consists of is presented in Figure 1, which is adapted from [1]. As shown in Figure 1, the ecosystem is built around a company's core business by adding elements that constitute the full environment in which the company operates. Although the concept of a business ecosystem was introduced approximately 30 years ago, it has gained significance in research within the Information Systems (IS) discipline relatively recently, when IT platforms started to be regarded as the backbone of so-called Digital Business Ecosystems (DBE) [2], [3], [4].

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Most works related to business ecosystems, and DBE in particular, attempt to analyze and present ecosystems from an outside perspective by introducing different roles and investigating how companies with these roles cooperate, e.g., through the use of digital technology [3]. However, this view may or may not correspond to the view of the company that participates in a DBE. The company may consider the DBE as one of the channels for getting orders (and possibly customers), which may not be the most important channel. For such a company or organization, it makes sense to consider the ecosystem in which it operates, as it may or may not coincide with the ecosystems of other DBE participants. This highlights the need to understand the ecosystem as perceived by the focal enterprise, as this perspective may diverge significantly from that of other DBE participants.

This difference in perspective means that a DBE in many research papers may capture only part of a company's broader business environment, as different actors define its boundaries based on their roles and objectives. For instance, a company may engage in multiple ecosystems for procurement, innovation, or other purposes [5], [6]. As a result, what is labeled as a DBE in academic studies or strategic models often represents just a subset of the company's actual business landscape.

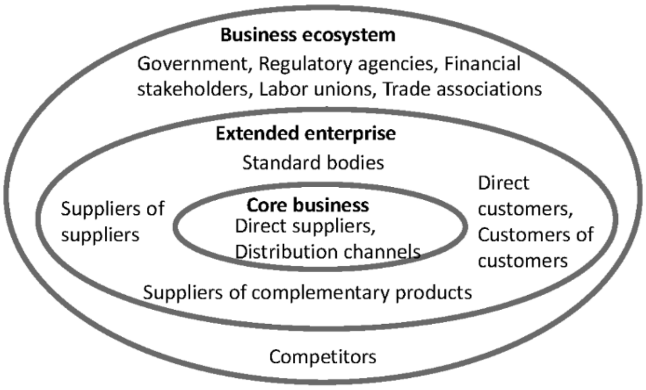

Figure 1. The structure of an ecosystem, adapted from [1]

This article has a practical goal of providing an organization with guidelines on how to develop a model of the ecosystem of **which it is a part**. Building such a model has practical implications, as it may show that some **essential components for the business are missing**. The latter can lead to actions for creating the missing components, thereby improving the business.

We achieve this goal by adopting a systems-theoretical perspective, viewing an organization as a system that operates within and constantly interacts with its environment. We will also use some essential concepts besides the concept of ecosystems, some of which were transferred from biology and biological cybernetics, such as structural coupling or autopoiesis.

The concept of *structural coupling*, which is related to ecosystems, was transferred from biological cybernetics [3] to social systems; see the works of Luhmann [7], [8]. The concept of structural coupling is relatively straightforward; it suggests that a complex system adjusts its structure to the structure of the environment in which it operates, i.e., its ecosystem. The adjustment comes from the constant interaction between the system and its environment. Moreover, during the system evolution in the environment, some elements of the environment and their interactions become more critical than others. The latter leads to the system adjusting to a limited number of environmental elements with which it becomes structurally coupled. According to Luhmann [8], a system deliberately limits its couplings to a few elements as a strategy for dealing with complexity.

Structural coupling has its counterpart in the already-existing business concept of *commodities*. Commodities are standardized goods that are interchangeable, meaning one unit is essentially the same as another, regardless of the producer. Examples include crude oil, gold, wheat, coffee, and natural gas. The commodities vendors are on the opposite side of structural coupling, as an organization can easily change a commodity vendor. Nevertheless, commodity vendors are part of the ecosystem surrounding a given organization; therefore, they should find their place inside the model of the organization's ecosystem. At the same time, the difference between a commodity vendor and a structurally coupled organization is not always clear-cut. In a dynamic business environment, a commodity vendor that was once easily replaceable can become a critical, tightly integrated part of the organization's operations. This can happen, for instance, if the vendor starts providing specialized products, establishes long-term contracts, or becomes difficult to replace due to supply chain dependencies.

An additional concept from biological cybernetics is *autopoiesis* [9]**.** Autopoiesis refers to a process within a system that continuously rebuilds and maintains itself by incorporating elements from its environment to ensure its ongoing function and stability. In biological systems, this means that living organisms constantly regenerate their components, such as cells and tissues, to sustain life. In organizational systems, this translates to processes that maintain the workforce, infrastructure, and resources necessary for operations. For instance, an organization should substitute workers who leave, whether due to retirement or relocation. It should also substitute its equipment when it no longer satisfies production requirements.

An organization's ecosystem includes various external actors that help replace its elements when they are lost or become unusable. Some of these replacements come from closely connected organizations with strong ties to the company, while others come from commodity vendors that provide easily replaceable supplies.

If the supply of materials to rebuild itself is limited, there can be competition for the resources. In such a case, competitors are part of the organization's ecosystem and must be represented in its model. Competition can be, for instance, for customers or workers.

Lastly, any business operates under a system of laws, such as bookkeeping regulations. Unlike in nature, where rules are dictated by biological and physical laws, business laws are created by regulators, making them an integral part of the business ecosystem. Another key difference is that organizations, especially large ones, can influence these laws through lobbying, whereas living organisms in the natural world cannot alter the fundamental laws of biology or physics.

As a result, the model of a business ecosystem around a given organization should represent markets, customers, vendors, and regulators, as well as relations between them, including relations to the organization itself. These relations should include the organization scanning the relevant part of the environment, which constitutes part of the so-called System 4 of the Viable System Model [10].

To build a model of the ecosystem in which a given organization operates, we need to use a modeling language [11], [12]. This language should possess sufficient expressive power to represent ecosystem elements and their relationships. In this article, we will use the Fractal Enterprise Model (FEM) [13], [14], [15] for this purpose. There are two reasons for this. Firstly, FEM is our invention, and we have extensive experience in using it for various purposes. Secondly, FEM has already been successfully used for finding structurally coupled elements within an organization. The results are published in [16], and they show that FEM can represent an essential part of an ecosystem that exists around a given organization.

FEM has a form of a directed graph with two types of nodes, *Processes,* and *Assets*, where the arrows (edges) from assets to processes show which assets are utilized by which processes and arrows from processes to assets show which processes help to have specific assets in "healthy" and working order. The arrows are labeled with meta-tags that show in what way a given asset is utilized, e.g., as *workforce*, *reputation*, *infrastructure*, etc., or in what way a given process helps to have the given assets "in order", i.e., *acquire* new elements to fill an asset, *maintain* existing elements, or *retire* elements that can no longer be used in the process.

A FEM is built recursively by using a so-called unfolding procedure and two types of archetypes: process-assets archetypes that show which kind of assets might be needed for running a process, and an asset-processes archetype that shows which processes are required to maintain an asset in order. Unfolding starts with a primary process – a process that delivers value to a customer/beneficiary – by applying process-assets archetypes and alternating them with the asset-processes archetype.

The aim of this research is to create a set of patterns expressed in FEM that could be used for building a model of the ecosystem in which a given organization operates. The patterns are sufficiently abstract, so they can be used for various organizations across different industries. Each pattern concerns a specific part of the business ecosystem, e.g., customers or suppliers. To connect the pattern to an enterprise, we need to represent not only the "external" elements – environment – but also some internal elements of the enterprise to which they are connected. Therefore, each pattern encompasses both external and related internal elements of an organization.

The work follows the Design Science (DS) approach [17], [18], which aims to create an artifact, in our case, a set of abstract patterns, that can be used to build a model of the ecosystem around the given company. As mentioned before, the model can identify essential parts that are missing, thereby facilitating organizational change. In this article, we present and discuss only the most important part of the patterns needed for building an ecosystem model.

The rest of the article is structured according to the following plan. In Section 2, we present our knowledge base, which is used to create a set of patterns. To this belong a set of concepts, such as structural coupling, that were used in our research, an introduction to FEM, and a short description of the methodological approach. We consider this part essential, as we do not anticipate that all readers are familiar with FEM. In Section 3, we discuss in more detail how FEM can be used for representing ecosystems. Section 4 presents examples of patterns from which one can create a model of an ecosystem in which a given organization operates. Section 5 provides a short overview of the relevant literature on business ecosystems. In Section 6, we discuss the results of our investigation and present plans for the future. This article is an extension of a conference paper presented at BIR 2025 [19].

2 Knowledge Base

2.1 Structural Coupling

The concept of structural coupling comes from biological cybernetics, more specifically, from the works of Maturana and Varela, see, for instance, [9], [20]. The idea of structural coupling is relatively simple; it suggests that a complex system adjusts its structure to the structure of the environment in which it operates. The adjustment comes from the constant interaction between the system and its environment. Moreover, during the system evolution in the given environment, some elements of the environment and their interactions become more important than others. The latter leads to the system choosing to adjust to a limited number of environmental elements with which it becomes structurally coupled. According to Luhmann [8], a system deliberately chooses to limit its couplings to a few elements as a strategy of dealing with complexity. These elements, in turn, function as information channels to other parts of the environment.

An element of the environment to which a system becomes coupled, being a system on its own, may, in turn, adjust its structures to accommodate the given system, creating interdependency between the two structurally coupled systems. The process of structural coupling emergence during the co-evolution of two interacting systems is represented in Figure 2. As a result of mutual interdependency, the structurally coupled systems change together, with each system changing in response to changes in the other. The coupling might not be symmetrical, i.e., one system may dominate the other, making it more likely that the latter would change as a reaction to changes in the former than vice versa.

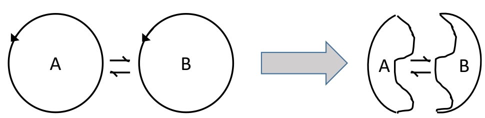

Figure 2. Rise of structural coupling. Adapted from [21]

The concept of structural coupling has been adopted by other fields that employ the system-theoretical approach. A typical example is Social Science, to which Luhmann [8] brought this term. However, in the domain of organizational systems, which are socio-technical systems, the concept of structural coupling is not widely used; see, however, [22]. In this work, we will consider the structural coupling between an *enterprise*, System A in Figure 2, and its *environment*, which includes a number of systems of type B in Figure 2.

2.2 Autopoiesis

According to Zeleny [23], there are three general types of processes in an autopoietic system: (1) Degradation, (2) Production, and (3) Bonding, see Figure 3. Production is a process of creating new components. Bonding is a process of introducing new components into the system structure. Degradation is a natural process of component aging and falling out of the system structure, which requires the production of new components to be bound into the structure. The specific meaning of these generic processes depends on the system in question. In a post-review by Zeleny [24], there are several examples of the instantiation of the generic process.

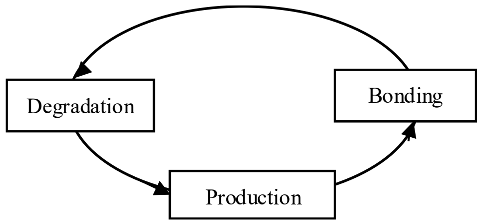

Figure 3. Generic processes in an autopoietic system, adapted from [23]

2.3 Scanning the Environment – the Viable System Model

The Viable System Model (VSM) was developed by Stafford Beer [10] and his colleagues and followers [25], [26]. It represents an organization as a system functioning within its environment and consisting of two parts: *Operation* and *Management*. In turn, Operation is split into several semi-autonomous operational units, denoted as System 1, which have a communication mechanism to ensure their coordination – System 2. Management, in turn, is divided into three parts, denoted as Systems 3, 4, and 5. For the current article, the most interesting aspect of VSM is System 4, which is responsible for scanning the environment to identify current trends and adjust the organization's offerings accordingly. The activities of System 4 are human actions, and the ways of adjusting to changes in the environment in the business differ from those that exist in the biological world.

2.4 Introduction to FEM

A simple example of an FEM diagram is shown in Figure 4. This example represents a simplified model of IbisSoft, a company co-founded by the first author in 1989. The model represents the company in its early years, when it served as a distributor of the high-level software development tool JAM, developed by the US-based company JYACC. The main business was selling JAM licenses and helping customers with software development projects that used JAM. The model in Figure 4 represents only the selling part of the business. A more complex diagram that represents both parts will be presented later[†].

[†] All FEM diagrams presented in this article have been built using the FEM toolkit, which is freely available from our website related to FEM: https://fractalmodel.blogs.dsv.su.se/fem-toolkit/. The toolkit is available for Windows, Unix, and macOS. The site provides information on FEM, including examples of models and recordings of presentations related to FEM. It also has links to the articles related to FEM and the FEM toolkit. The FEM toolkit is used in one of the courses at Stockholm University, and students find the toolkit easy to operate.

FEM has four concepts represented by shapes, two of which are used to present internal elements of the enterprise, and two are used to represent the environment. The shapes used to represent internal elements are process and asset, and there can be two types of relations between them: *used in* and *managed by*.

In Figure 4, a process, depicted as an oval, represents a repetitive behavior. A process can be marked as a primary process – a behavior that produces value for external stakeholders and for which the organization receives compensation in some form. Such a process is visually represented by a double-line border. Note, however, that the primary process is not always the most important process within the enterprise. For instance, in a car manufacturing company, the process of designing new car models is more important than manufacturing. However, manufacturing creates something that people and organizations pay for.

An asset, depicted as a rectangle, represents a set of things that are engaged in the behavior and play a specific role in it, thus ensuring that the behavior continues to be repetitive. An asset can be marked as tacit – something that resides in the heads of people related to the given process. Such an asset is visually represented by a dashed border, as the top asset to the right, shown in Figure 4. A process or asset has a label attached that explains the type of behavior the process represents or the type of elements the asset contains. The labels are not standardized and are set by the modeler. Visually, the label is placed inside the shape that represents a process or asset.

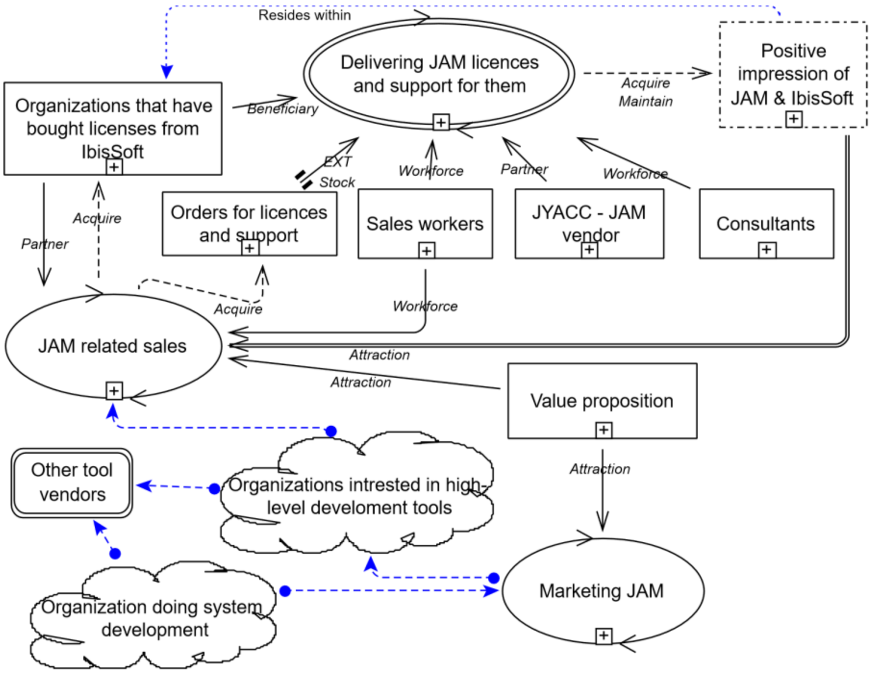

Figure 4. An example of an FEM diagram

In Figure 4, a *used in* relation between a process and an asset means that the asset plays a certain role in the process. The relation is visually represented by an arrow with a solid line that goes from the asset to the process. A *managed by* relation between an asset and a process means that the process changes the asset, i.e., adds or removes elements or changes their properties. The relation is visually represented by an arrow with a dashed line that goes from the process to the asset. To identify which role the asset plays in the process or how the process changes the asset, a label is added to the relation. The set of labels is standardized; more exactly, there are nine labels that can be added to a *used in* relation and three labels that can be added to a *managed by* relation. The latter are *Acquire*, *Maintain*, and *Retire*.

If a *used in* relation has a label *Stock*, the arrow's tail gets two additional vertical lines, see Figure 4. This label means that for each process run, the run consumes one or several elements of the asset. Thus, this asset requires continuous replenishment. The label "EXT" (Executable

Template) indicates that the asset serves as a control element for the process, i.e., it contains instructions for completing process runs. Other labels are self-explanatory.

To give the reader a better understanding of the elements of FEM, Figure 5 presents a legend that can be attached to any figure that presents a FEM diagram. Some elements of this figure are explained in the next sections.

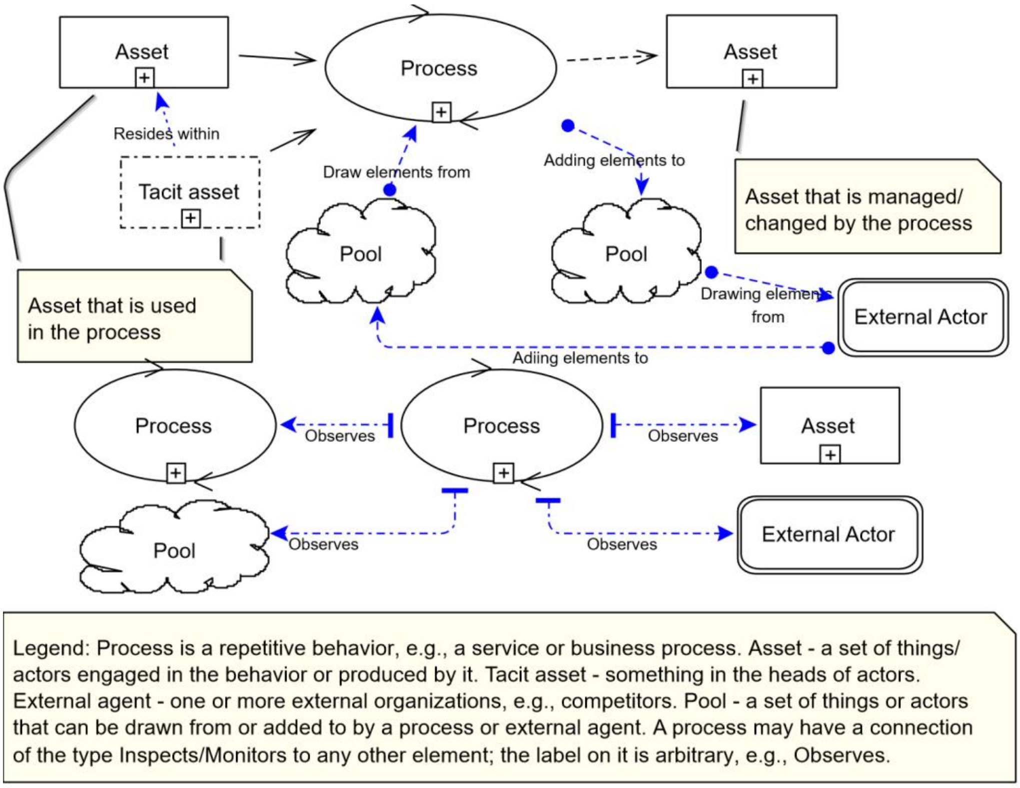

Figure 5. Explanation of the elements of the FEM figures

A straightforward way to build an FEM that represents the internal structure of an organization is to start from a primary process, identify all assets involved in it, determine the processes that manage these assets, and then repeat the search for assets associated with the management processes. Thus, building the model can be viewed as alternatively applying two types of archetypes (or patterns): a process-assets archetype and an asset-processes archetype. There are several archetypes of the type process-assets, two of which are shown in Figure 6, but there is only one archetype of asset-process type shown in Figure 7. The upper part of Figure 6 shows the generic archetype, the lower part shows the archetype for the primary process, which has a beneficiary – a party that gets something from the process.

Ultimately, we will obtain a recursively constructed graph that represents the organization's operational activities. The concept of recursion is represented by the term "fractal" in the name of the modeling technique; see [13], [14]. More precisely, a recursive structure is constructed by repeating the same type of component across multiple levels. The model, therefore, expands ("unfolds") according to the same logic each time. A process requires certain assets, which is captured by the process-assets archetype. Each asset, in turn, requires processes to be maintained, which is captured by the asset-processes archetype. These processes also require assets, and the cycle continues. This recursive unfolding can be viewed as a fractal concept because each new level reproduces the same structural pattern as the level above. Just like a fractal, the model exhibits self-similarity: the relationship between processes and assets repeats itself regardless of the scale at which the model is examined.

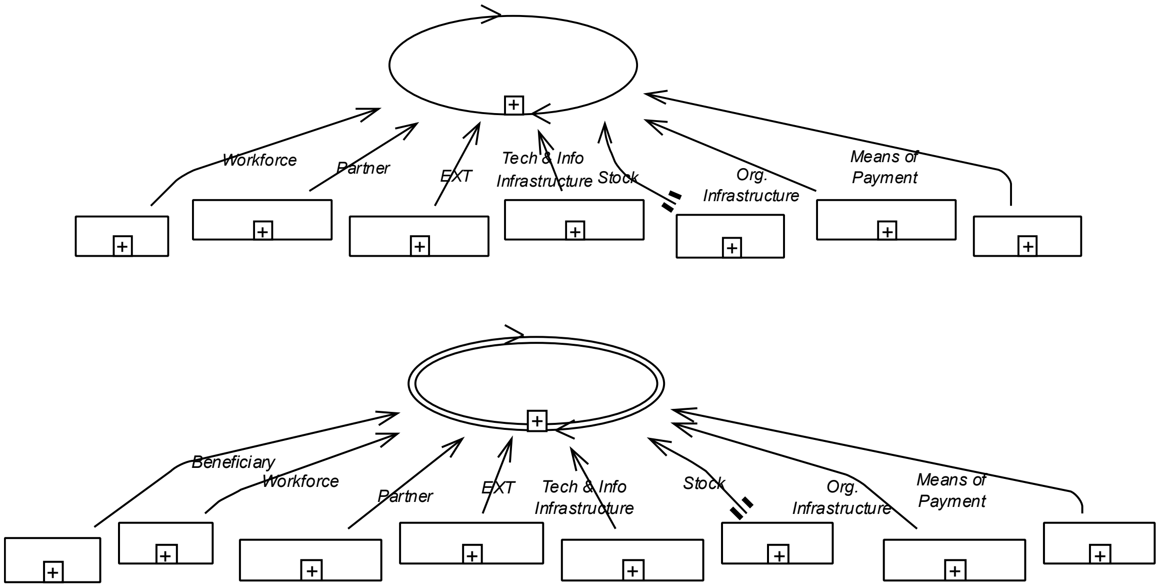

Figure 6. Process-assets archetypes. Upper part – the general archetype. Low part – the archetype for the primary process.

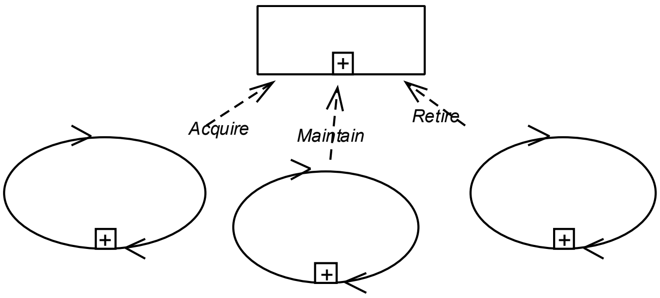

Figure 7. The asset-process archetype

The upper part of Figure 4 is built based on the archetype presented in Figure 6, the lower part. The process "JAM related sales" is shown together with the *Acquire* arrow from it to "Organizations that have bought licenses from IbisSoft"; this represents the application of the archetype presented in Figure 7. Note that not all parts of an archetype must appear in a particular model.

A primary process is determined based on the business under investigation. Normally, it is not difficult to find out which processes are primary. They have customers who pay money for products or services delivered. However, there are cases where the payment is made by a third party; for instance, students at Swedish universities do not pay any fees, as the government finances the universities.

The two concepts that are introduced to represent the organizational environments are:

- External pool – a set of the same type of elements as in assets, which is represented by a cloud shape, see Figure 4. The label inside the external pool describes its content.
- External actor, which is represented by a rectangle with rounded corners. An external actor is an agent, such as a company or person, acting outside the boundaries of the organization in question. It can be a competitor or collaborator. The label inside the external actor describes its nature. If the shape represents a set of external actors, the box has a double line (see Figure 4).

To connect environmental concepts to other elements of a model, a relation *drawing/adding* has been introduced in FEM. It can connect a process to a pool, an external actor to a pool, or connect two pools. The visual representation is an arrow with a dashed blue line and a rounded tail; see Figure 4. If the arrow points to a pool, the arrow tail shows who adds elements to the pool. In the opposite direction, it shows who draws elements from the pool to convert them to their assets. This type of relationship can also connect two pools to show the movement of elements from one pool to another. The labels on these relations are not standardized; a modeler can set any text to explain what it represents.

The arrow between "Positive impression of JAM & IbisSoft" and "JAM related sales" has a double line, which indicates a transitive relation. A transitive relation means that an indirect connection exists through one or more intermediate steps. For instance, if process A influences process B, and process B influences process C, then A has a transitive influence on C. When making the model more detailed, the double-line arrow should be replaced with the actual elements that connect the two shapes in the source model.

With this, we conclude our brief introduction to FEM; new elements will be introduced in subsequent sections as needed. Readers interested in learning more about FEM are referred to [13], [14], and [15].

2.5 Methodology

The goal of this research is to develop a set of patterns that can help build an FEM model of the ecosystem that exists around a given organization. Therefore, choosing the Design Science (DS) paradigm [17], [18] as a research approach is a natural choice. DS focuses on finding generic solutions for both known and unknown problems. The result of a DS research project can be a "solution" to a problem in the terminology of [18] or an "artifact" in the terminology of [17]. Alternatively, the result can be in the form of "negative knowledge", stating that a particular approach is not appropriate for solving certain kinds of problems.

The artifact/solution we aim to develop is a set of patterns that assist a modeler using the FEM technique in building a model of the ecosystem that exists around the company in question. If some elements of the patterns are not present, it provides the company with an incentive for improvements. Thus, our goal is not only to build a model of the ecosystem around a company, but also to point out how the company ecosystem can be improved.

Besides the theories described in this section, the knowledge base used in this article includes practical experience of the first author in co-running a small consulting business, IbisSoft, for 20 years. This experience was used to build patterns described in Section 4. Thus, the research can also be considered a form of reflective theory building [27], where one of the authors functions also as a practitioner.

Based on our understanding of DS [28], a typical DS project can be represented as an iterative two-phase process, where each iteration involves the design phase followed by the testing phase of the design in practice. The testing phase provides the basis for the design phase in the next iteration. The work presented in this article covers the design phase of the first iteration, plus testing on a real-world example.

3 Using FEM to Represent an Ecosystem

3.1 Extended Version of the Example

We will use the extended version of Figure 4 to illustrate how FEM can be used to represent an ecosystem of an enterprise. Figure 8 extends the model in Figure 4 to illustrate the consulting services provided by IbisSoft during its first years of operation. Actually, the consulting services were a larger business than selling JAM licenses, as most companies that purchased JAM required assistance in integrating it into their system development processes.

Besides the relations introduced in Section 2.5, there are two other relations: *inspects/monitors* and *association* in Figure 8. The first relation connects a process with any other elements of the model, i.e., process, asset, pool, or external actor. In this case, the process exhibits an observing (*scanning*) behavior, i.e., gathering information from the observed entity with minimal or no intervention. Visually, this relation is represented by an arrow with a dash-dotted blue line and a small rectangular tail. The tail points to the observing process, and the arrow points to what it observes. A label in the form of free text can be added to specify the nature of the relation. There are two such relations in Figure 8, both going from the process “Creating value proposition”. One goes to the external actor “Other tool vendors,” and it has the label “Investigating offerings”. The other goes to the pool labeled “External sources on needs and solutions,” which is marked as “Investigating.” The pool represents the periodical literature on the industry’s needs and solutions provided by various vendors.

The second relation, *association*, has no definite meaning; it is used whenever there is a need to express something that is impossible to express with other relations. Visually, it is represented by an arrow with a blue dotted line. This relation can be symmetrical – an arrowhead on both ends, or asymmetrical – an arrowhead only on one end. The meaning of the relation is explained using a free-text label. There is one symmetrical relation in Figure 8 between “Organization that have bought licenses from IbisSoft” and “Organizations that needs help to use JAM for system development”. The label on it, “Intersect,” explains the meaning of this relation. There is also one asymmetric relation between “Positive impression of JAM & IbisSoft” and “Organizations that have bought licenses from IbisSoft”, which has the label “Resides within”. It shows that the positive impression resides in the heads of IbisSoft’s customers.

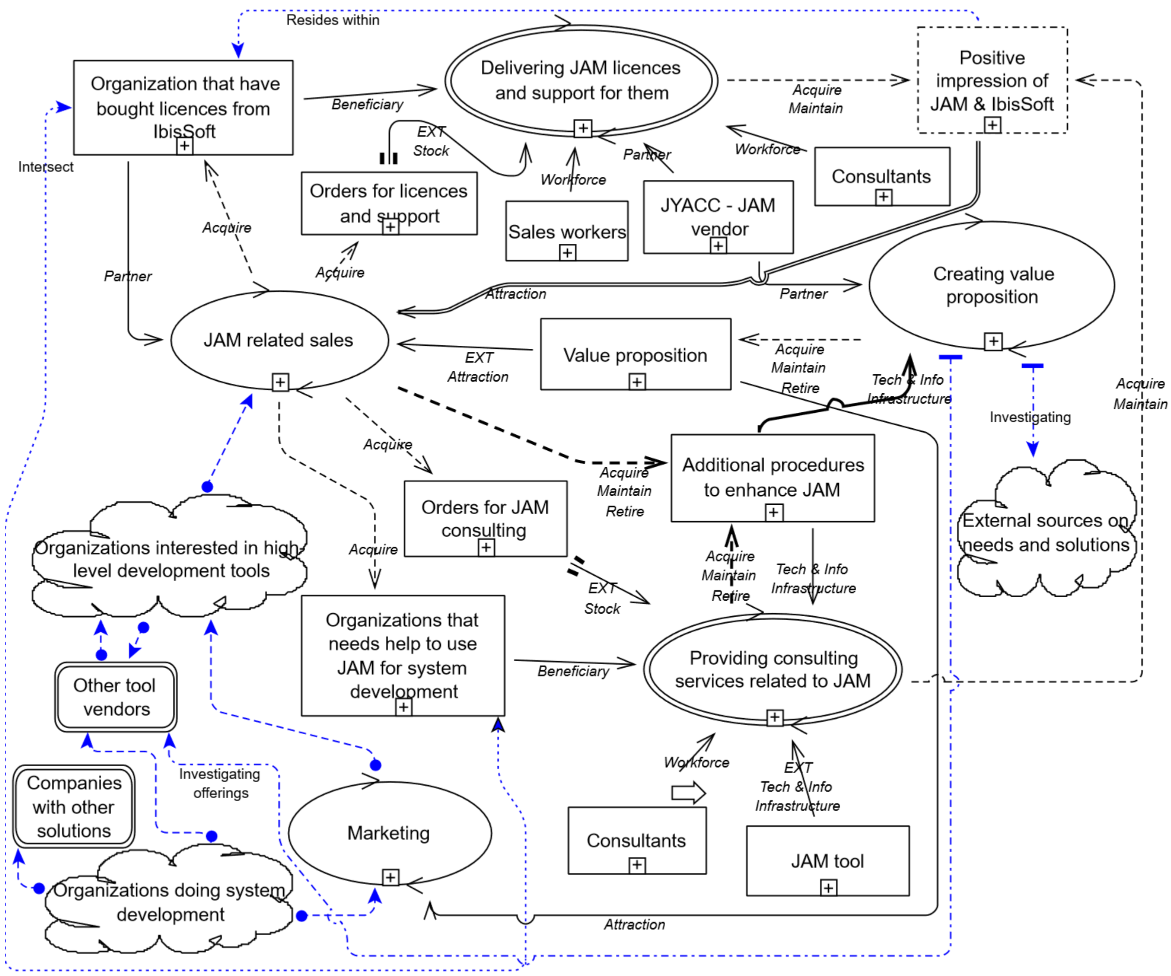

Figure 8. An extended version of a FEM diagram from Figure 4

The example presented in Figure 8 may be considered static, but this is due to the simplification made when presenting the example. Actually, any asset has supporting processes that acquire, maintain, and retire its elements, and new elements do not need to be similar to those that have been retired. Let us take an example that exists in Figure 8, namely, a relation between *Providing consulting services related to JAM* and *Additional procedures to enhance JAM*, which is marked by *Acquire*, *Maintain,* and *Retire* labels. The meaning of this relation is that consultants working on customer projects create generic routines that can be reused in other projects and are included in offerings to new customers. This shows that the *Value proposition* is not static, but is constantly changing; part of these changes is produced by the tool's owner, who continually delivers new versions of the tool.

Note also that Figure 8 gives only a basic idea of how IbisSoft worked at that time. It shows only processes and their results. It does not show that the processes can evolve to become more effective with time. Process change is discussed in [29], see Figure 5 in [29].

3.2 Connections to Concepts Introduced Earlier

For a modeling technique to be adequate for our task, it should be able to represent the main concepts related to ecosystems, as briefly discussed in the previous subsections: structural coupling (Section 2.1), autopoiesis (Section 2.2), and scanning of the environment (Section 2.3).

Regarding ***structural coupling***, let us consider the model of IbisSoft presented in Figure 8. IbisSoft has a limited influence on how the company JYACC developed the software development tool JAM. However, JAM, being a flexible tool, allowed the IbiSoft consultants to create a library of additional generic routines that could enhance JAM and could be reused in new development projects.

The generic routines are represented in the model of Figure 8 as the asset *Additional procedures to enhance JAM*. This asset is acquired in the processes *JAM related sales* and *Providing consulting services related to JAM*. These reusable routines (procedures) were used directly in the consulting process (*Providing consulting services related to JAM*) and indirectly in the sales process (*Creating value proposition*).

Creating and using additional routines constitutes how IbisSoft adjusts its offering to meet customer needs. This was also a way to *adjust* IbisSoft to the market demands, i.e., to its *environment*. By refining its offering through these routines, IbisSoft also ensured that JAM remained relevant and competitive.

Customers who purchased JAM to accelerate their system development were also required to adjust their system development process to the capabilities offered by JAM. They could no longer devise their user interface arbitrarily, but were constrained to utilize the possibilities that existed in JAM. This means that adopting JAM required customers to rethink some aspects of their development process. It led to structural coupling between IbisSoft and its customers. The coupling implies a mutual dependency: IbisSoft adjusts to customer needs, and customers adjust to the structure and constraints of JAM.

The marketing efforts of IbisSoft and other companies selling high-level development tools influenced how organizations perceived system development. As a result, some organizations stopped developing systems using low-level programming languages and became interested in using high-level development tools. This shift, driven by marketing, is shown in Figure 8, where organizations move from the pool of *Organizations doing system development* to *Organizations interested in high-level development tools.* This represents a shift in the opposite direction to the own adjustment, i.e., activities of IbisSoft and other vendors of high-level tools *changed the environment*. In other words, IbisSoft was not only reacting to the environment but also actively influencing it.

Regarding ***autopoiesis***, IbisSoft needed to constantly increase its customer base, firstly, to expand the business, and secondly, to compensate for the customers who no longer used JAM (this process is not shown in Figure 8). This reflects the natural turnover that any company faces, where some customers stop using a product due to changing needs or technological shifts. The process related to sales in Figure 8 encompasses both production and bonding of customers based on the pool of *Organizations interested in high-level development tools*. This is the only example of autopoiesis presented in Figure 8. It is generalized in Section 4.1. Another example of autopoiesis related to employees is discussed in Section 4.2.

Regarding ***scanning of the environment***, in Figure 8, the process of creating a value proposition is linked by the *inspection/monitor* relation to *Other tool vendors* (external agent) and to *External sources on needs and solutions* (external pool). These relations indicate that IbisSoft conducts environmental scanning to formulate its value proposition. Such scanning is essential for understanding how the competitive landscape evolves and what customers expect from modern development tools. IbisSoft gathers information from both its direct competitors and broader industry trends. The first scanning concerns direct competitors, while the second scanning focuses on the literature on trends in system development. This twofold scanning ensured that IbisSoft not only reacted to competitors but also anticipated shifts in technology and methodology. More examples of environmental scanning are presented in Section 4.

Note that our goal is to develop a model of a company's ecosystem, regardless of the company's business. It should look for new customers, new employees, and adjust itself to changes in regulation, etc. This is because, for many companies, customers may not need the company's products or services, for instance, because they have gone out of business. Employees may find a new job or move to a different location. Regulation can change independently of the company's wishes. Suppliers can change their products, or get out of business, etc. All these examples illustrate how external elements that the company depends on can shift unpredictably.

Even if the company's business remains unchanged, its environment is constantly evolving. Thus, a company needs to have routines in place to adjust to these changes, even when its main business remains unchanged. Changing the business direction is a different matter. Here, FEM can also be used but in a different way, see, for instance, [30]. For those who are interested in how IbisSoft evolved, see [31].

4 Patterns

This section presents examples of patterns for modeling an ecosystem using FEM. To make the patterns clearer, elements belonging to the organization have green borders (or thicker borders in black-and-white prints), and processes that scan the environment have a blue background. The patterns can be used for building a model of an ecosystem that exists around a company. The patterns can also be used for analysis of the ecosystem. If some elements of the pattern are not present in the company, it indicates potential areas for improvement for management.

4.1 Pattern Related to Customers and Competitors

The pattern presented in Figure 9 is related to acquiring and maintaining (keeping) the customer base. It applies to any process or service that offers something people are willing to pay for. In Figure 9, this process or service is the starting point of the graph. The main process for acquiring and maintaining customers is *Sales*.

The main attraction to become a customer is the value proposition. In the pattern, the value proposition functions as the key element that links the enterprise's internal capabilities to the needs and expectations of its customers, thereby shaping how the organization positions itself within its ecosystem. The value proposition is created based on several sources, such as an investigation of competitors' offerings and literature (reports) on demand, both of which are examples of *environment scanning*.

Scanning is not the only source for adjusting the value proposition; other sources include the sales process and the main process that delivers value to the customers. These sources influence the value proposition indirectly and are represented as transitive relations. How these transitive relations are expanded depends on the specific enterprise. These sources help the enterprise adapt to customers' and market (via *scanning*) needs, which are parts of *its structural coupling*. This means that the enterprise and its environment gradually become aligned, as the company adjusts its offerings based on what it learns, while customers adjust their expectations based on what the company provides. As long as the customers see unique value in the company's offerings, they remain connected to the enterprise. However, if they perceive the products or services as commodities, they are more likely to switch to another provider.

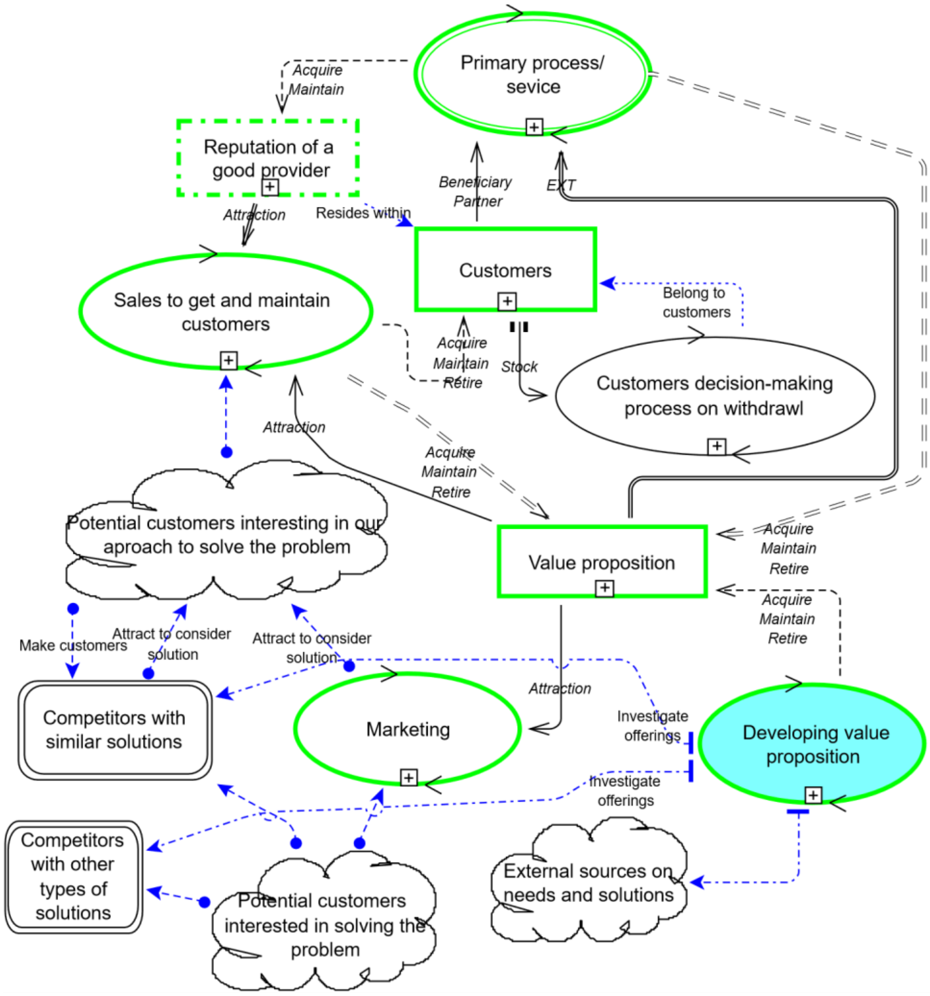

Figure 9. Acquiring and maintaining a customer base

The value proposition serves as an EXT to the primary process, but in a transitive way. When building a complete model, this relation should be substituted by a chain, for instance, creating a product specification, which is used as an *EXT* to the primary process. The process of creating a specification can be connected to external sources of information related to the process, which will expand the connection of the enterprise with its environment via *environmental scanning*.

An enterprise can be structurally coupled to a higher degree to its customers if it serves only a few regular customers (as in [32]). Note that, depending on the business, customers might be considered as a part of the company. Then, the sales process is responsible for *autopoiesis* related to customers.

4.2 An Example of Patterns Application

The model of Figure 8 can be considered an application of the pattern in Figure 9 to the activities of IbisSoft at the beginning of its existence. The model in Figure 8 is a partial model of IbisSoft activities. It contains more components than in the pattern; for instance, it has an asset that represents orders received from the customers. The labels inside the shapes are more concrete as they represent the actual activities of *IbisSoft*. Also, there are two primary processes in the IbisSoft model. Thus, the pattern from Figure 9 applies to each of them. However, the sales process in Figure 8 is common for the two primary processes.

The model in Figure 8 also expands the transitive relations of Figure 9. For instance, the transitive relation that connects *Sales* to *Value proposition* in the pattern is realized by *Sales* being connected to *Additional procedures to enhance JAM,* and the latter is connected to *Create value proposition* by the *Tech & info infrastructure* relation. The relations that are included in the transitive link are highlighted by thicker arrows. In the same way, the transitive relation between the *Primary process* and the *Value proposition* in the pattern is realized by *Providing consultancy services* connected to *Additional procedures to enhance JAM,* and the latter is connected to *Create value proposition* by the *Tech and info infrastructure* relation. Note that we have not expanded the transitive relation between *Positive impression* and *JAM-related sales* in Figure 8, as this expansion is more complicated; see how it can be presented in [33].

Regarding structural couplings, IbisSoft was structurally coupled to the marketplace depicted in the model as *Organizations interested in high-level development tools*. This coupling means that all new customers were obtained from this pool. By the end of 1990, this pool almost disappeared in connection with moving to the Web, which was accompanied by programming using low-level programming languages. The market appeared once more, much later (about 10 years later), when Web applications became more complex, and they were too costly to develop without high-level tools. By the time the market disappeared, IbisSoft had changed its strategy and was uncoupled from this market, as seen in [31]. Another structural coupling of IbisSoft was to the partner – JYACC, as IbisSoft did not use or sell any other high-level development tools. This was explicitly revealed when JYACC encountered a problem moving its tool from a character-based environment to a graphical one. The first graphical version of the tool was of relatively poor quality, which negatively affected IbisSoft's business.

4.3 Pattern Related to Employees

The pattern presented in Figure 10 is related to acquiring employees – a part of autopoiesis. The process of *Recruiting & Training* is responsible for getting new elements from the environment and converting them into elements of the asset *Workers*, which serves as *Workforce* for some processes. The elements are taken from the pool *People looking for the job …*, which consists of two parts. One is people who do not have a job, and the other is people who are unsatisfied with their current position. To attract the right kind of people, the company needs a skill specification and a value proposition, which includes salary, working conditions, etc. In this pattern, the value proposition refers to what the enterprise offers potential employees – salary, working conditions, and development opportunities – in order to attract the right candidates.

To properly create a value proposition, there is a need to investigate the supply (size of the pool) and what the competitors suggest when they recruit new workers. This is done by the process *of Designing skill specification & value proposition, which also creates* the *Training specification* if needed. The process of *Recruiting & Training* may also employ partners, e.g., media companies or recruiting agencies. Current workers' satisfaction can also play the role of attraction, but in an indirect way, e.g., during talks with acquaintances or via posts on social media.

Recruiting and Training is a process responsible for autopoiesis related to workers. It can become a very important process if there is hard competition for certain kinds of specialists. If it exists, the company may need to employ less educated people and increase its training programs. It may also happen that the company becomes structurally coupled with educational institutions that train certain types of specialists.

4.4 Patterns Related to Regulators

Regulators do not often appear in enterprise models. However, some internal processes need to be driven according to the existing regulations. When regulations change, the processes also need to be changed. This happens not only in highly regulated domains, but also in areas in which regulations change often, like the economy. A pattern that allows an enterprise to follow changes in regulations is presented in Figure 11.

When external regulation has changed, the internal procedures for some processes should also be changed. The workers who are engaged in the process should be aware of the fact, and their tacit knowledge related to the process should be updated. In addition, some changes in regulation require updating the systems that are engaged in the process. Thus, in the case of a substantial change, there is a need to update internal procedures, systems, and tacit knowledge of the workers.

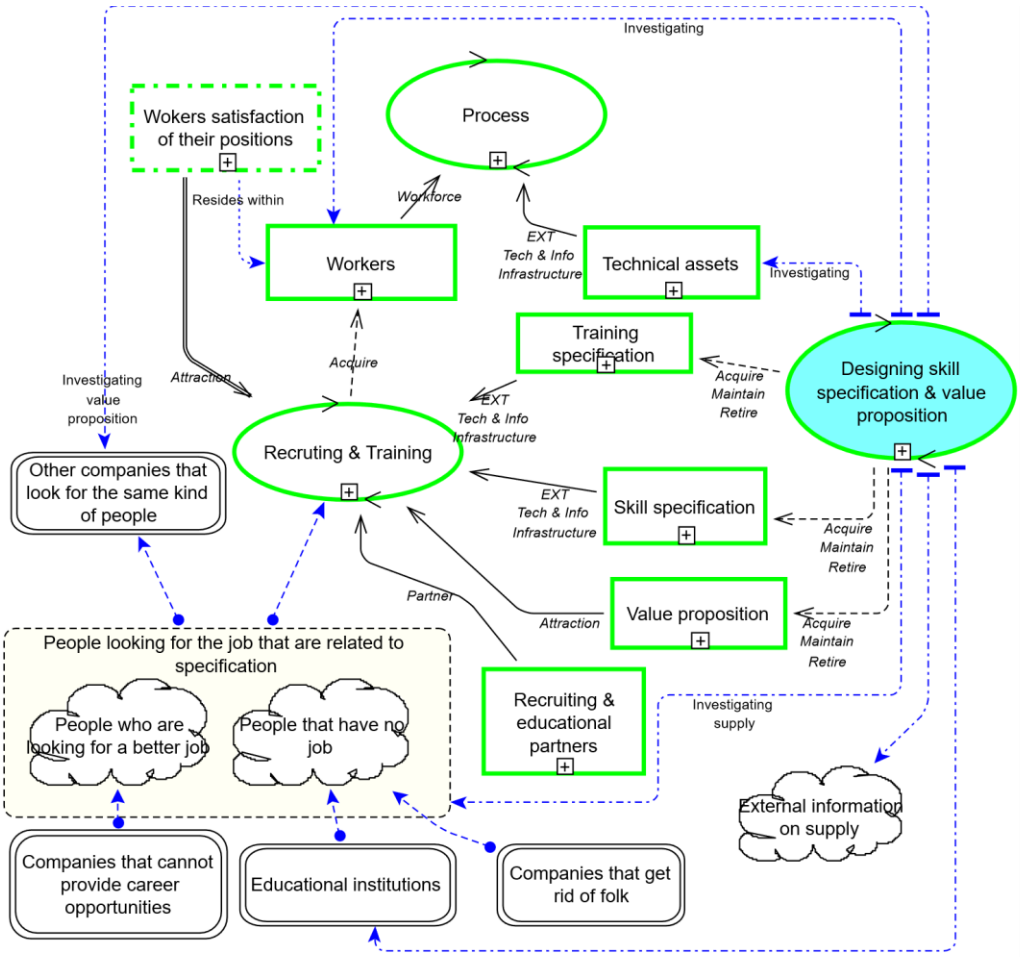

Figure 10. Recruiting/Hiring pattern

Figure 11 shows how the changes can be arranged if the systems can be updated inside the enterprise. If some systems have been purchased, the changes to the systems are provided by partners. Partners can also be used to provide training for the workers.

Figure 11 shows how a company follows regulations. Some companies can influence regulators, as well as follow them. A model of influencing regulators is presented in Figure 12. For simplicity, only the asset internal procedure is shown on the diagram. The company influences the regulator by making suggestions to be introduced into the regulation. It also follows up on what is happening inside the regulatory body.

Standards can also be considered as regulations. Large companies attempt to influence the standards by providing personnel who work on developing these standards. The partial model that reflects this is presented in Figure 13.

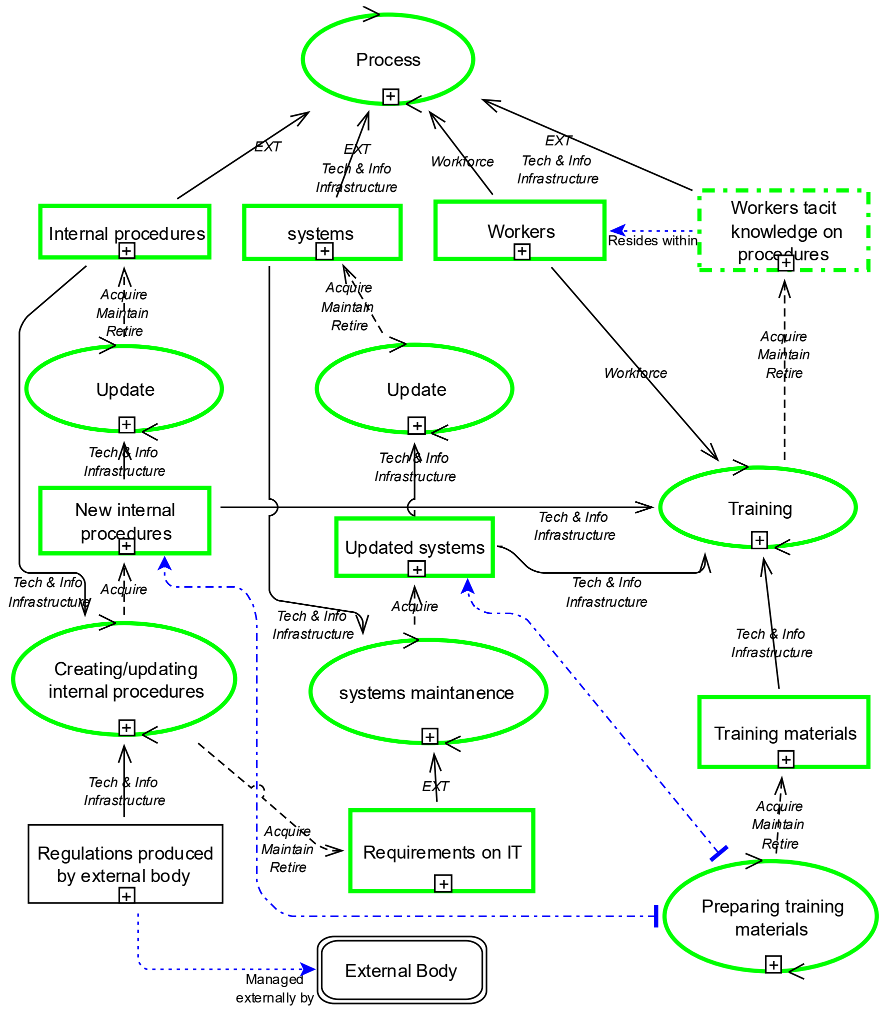

Figure 11. A pattern related to regulation

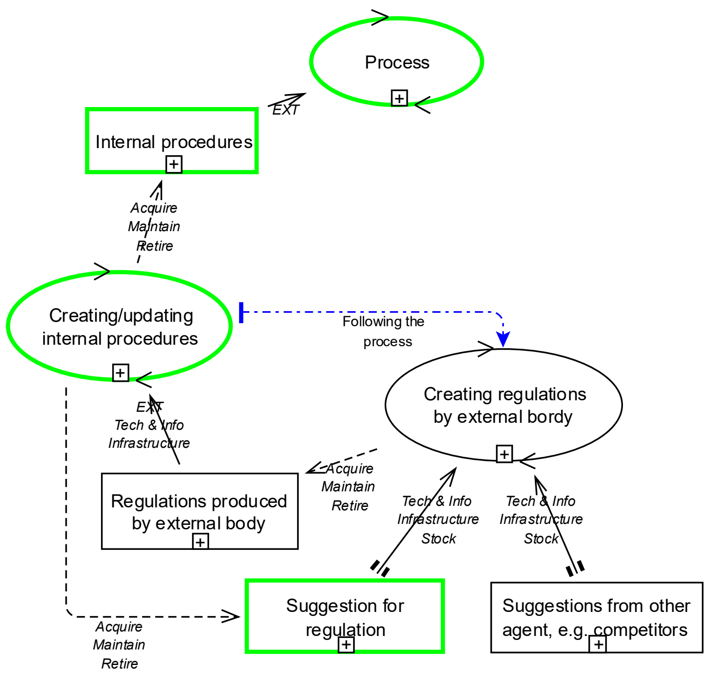

Figure 12. Influencing regulators

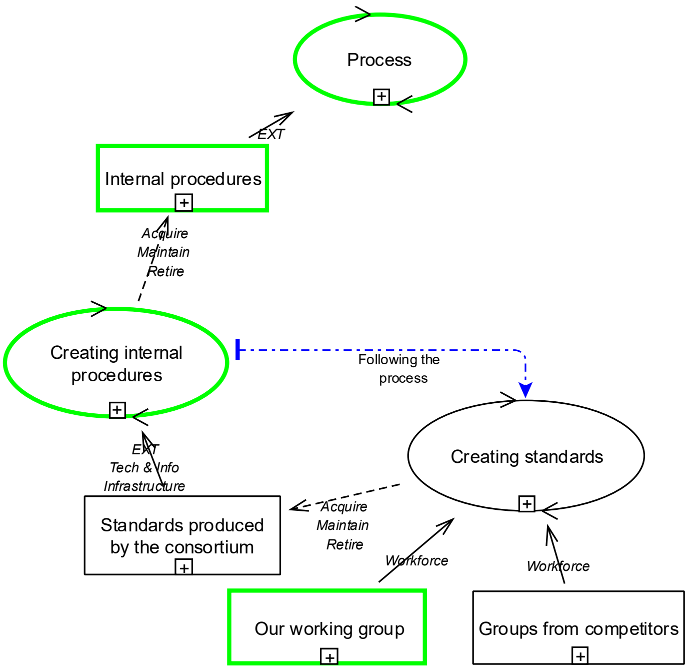

Figure 13. Working on standards

4.5 Pattern Related to Partners

In this subsection, we consider a pattern related to acquiring and maintaining partners. The pattern is presented in Figure 14. Partners are acquired for a specific process, and to understand what kind of partners are needed, the process *Developing value proposition* needs to investigate this process. It also needs to know what competitors are paying for similar services, and what potential partners are advertising themselves. Based on the value proposition, the process *Acquire and Maintain* acquires one or several partners and establishes contracts/agreements with them. Such a contract is used for regulating what the partner does and how the contract can be terminated.

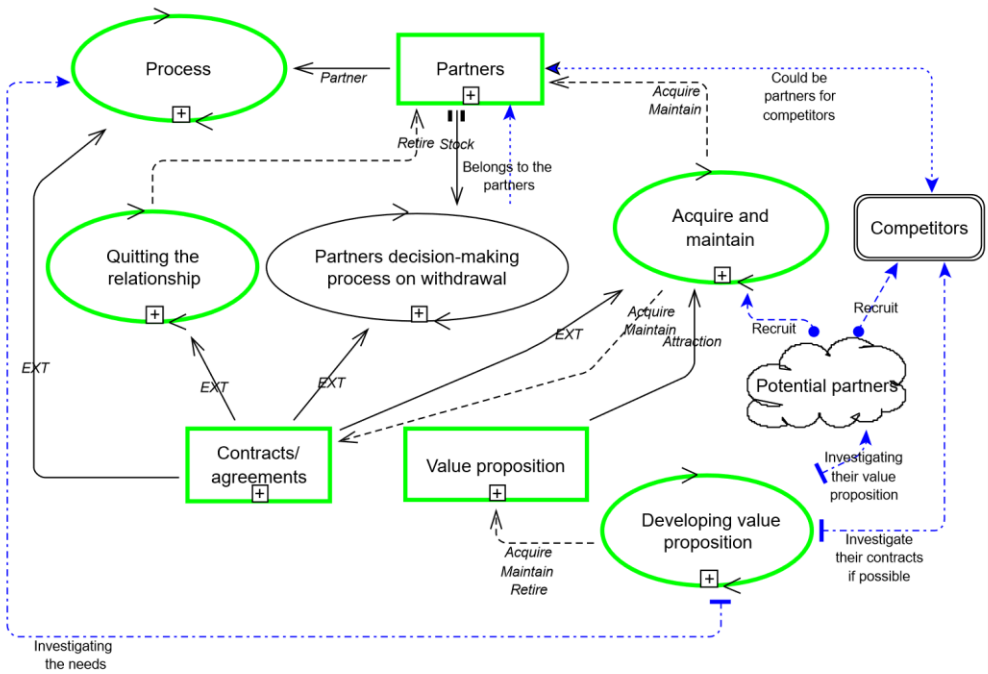

Figure 14. Pattern related to acquiring and maintaining partners

5 Comparing with Related Literature

5.1 Related Literature

There is a substantial body of Information Systems (IS) research addressing business and digital ecosystems, and several systematic literature reviews have synthesized this work, including [11], [34]. Many studies present methods or conceptual models for describing digital business ecosystems (DBEs). However, as [11] shows, most modeling languages and techniques focus primarily on actors, roles, and high-level collaboration structures, whereas essential aspects such as capabilities, dynamics, policies, resource renewal, and resilience are only marginally addressed or not modeled at all.

The review [11] also demonstrates that a wide range of conceptual modeling languages has been applied in DBE research. Commonly used notations include UML and UML-derived extensions, BPMN, e3-value, and ArchiMate, while other approaches are based on ontologies, canvases, or matrix-based representations.

Among the more established modeling languages, e3-value [35], [36], [37] is a prominent example. It was designed to model value exchanges between actors in a business network, focusing on value co-creation scenarios, economic transactions, and actor roles. It has been widely applied in digital business and service ecosystems. Nonetheless, e3-value captures only economic value flows and does not represent the internal processes, resource dependencies, or adaptive mechanisms within an enterprise. As a result, although useful for mapping value networks, it cannot represent the operational and structural aspects required to model an ecosystem from the perspective of a specific company.

We have analyzed the literature and found that our approach to modeling business ecosystems substantially differs from what could be found in the literature. Firstly, instead of describing an ecosystem as consisting of collaborating companies, we take the perspective of an individual company, which may also participate in a DBE, and focus on modeling its ecosystem. Such an ecosystem includes not only collaborative partners but also competitors of different types, as well as markets from which the company gets assets to compensate for its natural loss, as well as regulators. This view is more nuanced, as a collaborative partner with respect to servicing customers might be a competitor in another area, e.g., hiring specialists.

Secondly, we heavily rely on the concepts from the systems theory, such as structural coupling [9], [20] and autopoiesis [23], [38], which is not the case with the mainstream literature. This focus forces us, for instance, to pay attention to where an enterprise gets new assets when its own become depleted and who the competitors are for these assets. These two differences make our work unique, at least in the domain of modeling ecosystems.

Beyond modeling-focused research, several influential works have shaped the conceptual understanding of business and digital ecosystems [39]. Moore in [1] introduced the ecosystem metaphor into strategic management, emphasizing that firms co-evolve within communities of interdependent actors. The authors of [2] extended this idea to digital infrastructures, emphasizing decentralization and self-organization. Recent work by the authors of [40] further extends and refines Moore's foundational ideas by demonstrating that existing ecosystem definitions remain fragmented, often emphasizing only selected components such as actor networks while neglecting others such as shared fate, complementary offerings, or cocreated value propositions. Papers [5] and [6] deepen understanding of platform ecosystems, focusing on interdependencies, complementarity, and architectural leverage. Papers [3] and [4] articulate key challenges related to platform governance, architecture, and ecosystem dynamics.

However, these influential works share a common limitation: they do not support operational, process-level modeling of how a specific enterprise maintains viability within its ecosystem. Our FEM-based approach addresses this gap by integrating systems-theoretical concepts with process-oriented modeling, allowing representation of both internal renewal mechanisms and external ecosystem relations.

5.2 Why Have We Used the Fractal Enterprise Model?

Some arguments for using FEM have been presented in Section 5.1. Here, we present additional arguments for why we have chosen FEM. FEM is our own invention; this means that we are familiar with it and can use it properly. Besides this subjective argument, we also have objective reasons for why FEM is suitable for describing ecosystems.

In this work, we focus on the relationship between an organization and its environment. FEM has special shapes and arrows that represent the environment and the enterprise connections to it. Two of the four FEM's shapes are designated for the environment: the *external pool* and the external agent. They can be connected to internal elements by special arrows, *drawing/adding*, that show how elements from the environment can be converted into internal elements of the enterprise, and what the enterprise can contribute to the environment. One more arrow, *inspects/monitors*, can also be used to observe the environment without introducing any changes in it. To our knowledge, other enterprise languages do not possess such features, which means that the modeler must use general means to represent connections between the enterprise and its environment.

During this research, we found FEM adequate for the purpose. This does not mean that other languages could not be used. However, we have not found any research that attempts to model the ecosystem surrounding an enterprise using a modeling language. Therefore, the question of which language is the most suitable for the task remains open.

6 Conclusion and Plans for the Future

6.1 What Has Been Achieved

The article suggested that it is possible to create patterns that can help an enterprise build a model of its ecosystem. The goal was achieved by developing several patterns related to acquiring customers, employees, and partners, as well as dealing with regulators. These patterns are at the core of the Design Science artifact that we are building.

6.2 Limitations of the Study

As already mentioned, the patterns presented in this study were created based on the 20 years of experience of the first author in running a software development company. As of today, they have not been tested for creating an ecosystem model for companies other than IbisSoft. The authors' immediate plans include such activity. During the application of the patterns to another company, the patterns could be corrected, and new patterns could emerge.

6.3 How the Result Could Be Used

As discussed, our goal is to help build a model of an ecosystem in which a particular enterprise participates. Such a model could be used to identify parts that are present in the patterns but do not exist in a particular company. Discovering such parts could trigger management decisions to create the missing parts, for instance, those related to investigating the environment.

The model could also be used for strategic decision-making. For instance, consider that we have created a model and then analyzed its part related to the workforce according to the pattern in Figure 10. Suppose the analysis shows that the specialists we have employed for a particular process are no longer trained by any educational institution, yet there is high demand for them. The management needs to take some action in this situation. One alternative is to modify the process/service in which such specialists are employed, so that they require specialists who are readily available in the labor market. Another alternative for a large enterprise is to establish an educational department that trains specialists or enter into an agreement with a local educational institution to initiate such a program.

To be more concrete, consider an enterprise with a large legacy system written in COBOL, for which the labor market is scarce. The company can decide to (a) retire this system by buying or developing a new one, or (b) arrange education for people who are open to learning an old language, as long as the salary is good, and they feel safe.

6.4 Plans For the Future

We are continuing our work to create patterns that help build a model of an ecosystem. Also, we have not presented patterns related to a company being part of a DBE. One such pattern that we show without additional explanation is represented in Figure 15. It has three roles: (1) our company, marked by the green borders; (2) coordinator, marked with the rose border color; and (3) other companies, marked with the blue border color. The model includes notes (which have special shapes) that provide additional explanations.

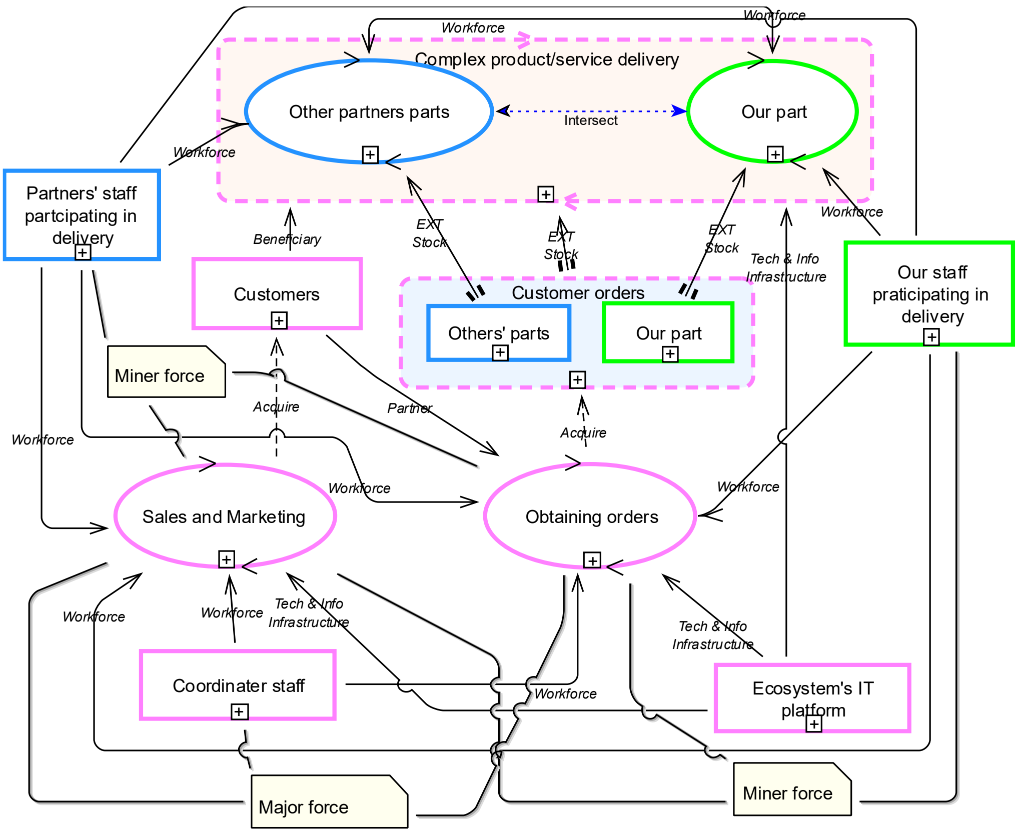

Figure 15. A pattern for DBE with a coordinator

Our future activities include developing additional patterns and applying them to build an ecosystem of one of several enterprises. Another direction concerns the question of how to decide whether a certain element of a model represents a structural coupling rather than a commodity or commodity vendor. This can be formed as a set of questions for the stakeholders and rules for coloring the model according to the answers, e.g., using a red background color to identify structural couplings.

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