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The ghost in the machine: AI in software ecosystems

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Abstract

Although software ecosystems have been around for decades, the emergence of generative AI (GenAI) and Agentic AI is significantly changing the nature of software ecosystems. AI allows for individuals and organizations to replace human actors with AI agents that act on behalf of humans or organizations, but without human involvement. This leads to fundamental shifts in how ecosystems function and evolve. In this paper, we explore the trend of moving towards GenAI and Agentic AI in software ecosystems, the implications this will have in practice and we hypothesize on how this will likely evolve in a context where some agents in the ecosystem are human and others are AI driven. As the basis for our discussion, we provide examples from multiple companies in the software-intensive domain that are all exploring the potential of AI in software ecosystems. The key contribution of the paper is a conceptual model in which we outline the steps we believe companies will move through when evolving towards AI-driven ecosystems.

CCS Concepts

• **Computing methodologies** → **Multi-agent systems**; Data sharing and interoperability; • **Information systems** → *Interorganizational systems*; • **Software and its engineering** → *Software architectures.*

Keywords

Business ecosystems, software ecosystems, AI-driven ecosystems, human-AI collaboration, maturity model

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1 Introduction

Software ecosystems is a well-established concept referring to platforms, applications, and services developed by different stakeholders that interact and collaborate to deliver solutions to customers. A software ecosystem is typically described as an environment that fosters co-innovation, expands functionality beyond what any single entity could provide and enhances value delivery to users [23], [22], [11], [19]. Examples of successful software ecosystems include Apple's iOS and Google's Android platforms. Both these evolve around a common technology platform that enables third-party developers to build and integrate complementary applications.

In the software-intensive systems domain, we see several examples where open platforms are used to bring together actors to facilitate interaction, foster innovation and accelerate value creation. As one example, Siemens MindSphere is an industrial IoT-as-a-service solution with the intent to empower customers and partners, as well as the internal Siemens organization, to quickly build and integrate personalized IoT applications [1]. In the automotive domain, COVESA is an open collaborative alliance that brings together organizations from across the globe with the shared goal of developing open standards and innovative technologies for connected vehicle systems [2]. In May 2025, NVIDIA introduced Lepton which is a centralized AI computing-power marketplace that enables cloud providers, developers, and partners to trade GPU capacity efficiently [3]. While these examples are only a few out of many successful software ecosystems, they reflect the power of bringing different stakeholders together in an environment that enables, supports and automates activities and transactions. As recognized in [13], viewing the software industry and the market it serves as an ecosystem introduces both challenges and opportunities in relation to e.g., new business models, open innovation, collaborative development, issues of ownership, strategic planning and variability management.

However, while challenges and opportunities associated with software ecosystems have been studied for years, the emergence of generative AI (GenAI) and Agentic AI is rapidly changing the nature of software ecosystems. Suddenly, there is the opportunity to have AI agents assist, complement or even replace human actors. Activities and transactions that used to be costly in terms of effort and time can be automated and brought to a minimum with AI agents that act on behalf of humans. In our experience, few (if any) companies know what this will mean, what impact this will have and what the future of software ecosystems will look like.

In this paper, we explore the trend of moving towards GenAI and Agentic AI in software ecosystems, the implications this will have in practice and we hypothesize on how this will likely evolve in a context where some agents in the ecosystem are human and others are AI driven. As the basis for our discussion, we provide examples from multiple companies in the software-intensive domain that are actively exploring the potential of AI in software ecosystems. It should be noted that the companies are in the early stages and that they have limited experience and few concrete use cases of AI in software ecosystems. However, they are exploring use cases, they have ideas on how to adopt AI in their ecosystem tasks and

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[1] https://plm.sw.siemens.com/en-US/insights-hub/
[2] https://covesa.global/
[3] https://www.nvidia.com/en-us/data-center/dgx-cloud-lepton/

activities and they are hypothesizing on what the impact on current and future practices could be. The key contribution of the paper is a conceptual model in which we outline the steps we believe companies will move through when evolving towards AI-driven ecosystems.

The remainder of the paper is organized as follows. In section 2, we review relevant research on software ecosystems and AI technologies. In section 3, we present the research method and the case companies involved in our research. In section 4, we report on our empirical findings and provide examples from the case companies. In section 5, we present a conceptual model in which we outline the steps we believe companies will take when evolving towards AI-driven ecosystems. In section 6, we discuss threats to validity and in section 7 we conclude the paper and outline future research opportunities.

2 Background

2.1 Software ecosystems

The competitive battleground for companies is rapidly shifting from focusing on internal scale, efficiency, quality, and serving customers in a one-to-one relationship, to creating and contributing to an ecosystem of multiple players [25]. To engage with external partners has become critical for any company looking to extend its offerings and increase value delivery to customers. In [23], the authors discuss how software ecosystems are an effective way to construct large software systems on top of a software platform by composing components developed by internal and external actors. While there are several definitions of a software ecosystem, a commonly used one is presented in [3] where a software ecosystem is described as *"...a set of software solutions that enable, support and automate the activities and transactions by the actors in the associated social or business ecosystem and the organizations that provide these solutions."* For years, software ecosystems have been studied from an innovation perspective [11], from a collaboration perspective [9], from a competition perspective [29] and there are numerous papers highlighting the different roles companies take and how to strategically engage and position towards other stakeholders [19], [25], [17], [5]. Viewing the software industry and the market it serves as an ecosystem introduces both challenges and opportunities in relation to e.g., new business models, open innovation, collaborative development, issues of ownership, strategic planning and variability management [13]. In our experience, there is a general trend in the software industry to explore ecosystem engagements for increasing collaborative engagements in the innovation of new products and for decreasing efforts related to maintenance of legacy functionality [4].

2.2 Generative and agentic AI

While there are prominent studies on the role and characteristics of software ecosystems, the emergence of GenAI is rapidly reshaping the ways in which organizations operate and consequently, how ecosystems function and evolve. Driven by advanced algorithms and computational capabilities, GenAI has the potential to improve efficiency and productivity in development, deployment and maintenance of functionality and to accelerate innovation [8].

There are numerous studies exploring the potential, the use, the risks and the challenges associated with AI technologies and tools. So far, most studies take a productivity perspective when exploring how the use of e.g., Cursor and CoPilot can help reduce time and efforts spent on coding, testing and maintenance. For example, [20] study the successes and challenges of AI programming assistants, [30] explore the use of LLMs for software testing, [18] present results on using LLMs in domain-specific languages, and [31] focus on automated program repair using LLMs. In [12], the authors discuss opportunities and challenges when using AI for activities ranging from code generation, code transformation and code optimization to software testing, program analysis and maintenance. Similarly, [1] explore the potential of GenAI and how to optimize the adoption of this technology in business and development workflows. Similarly, [10], reflects on the profound changes that GenAI has on e.g., requirements engineering, software design, software implementation, quality assurance and engineering management.

In our own previous research, we outline the evolution we see companies go through when adopting AI in their business processes, in their R&D processes and in their products [6]. Based on interviews with AI experts from different industry domains, we identify a set of key challenges that companies experience when adopting AI and we derive a three-pronged maturity model that describes how companies transition from traditional towards AI-driven organizations. Our results show that AI is primarily used to improve efficiency and to complement teams in existing tasks. There are many examples of 'AI assistants' and 'AI compensators' and people appreciate using AI to automate tasks and having AI add skills they lack as a team. In products, static, dynamic, multi and continuous ML models are used to improve and to optimize product performance and to help customization of products. Finally, from a business perspective AI is used to automate separate process steps. Only one company in our study had used AI to reinvent entire business processes. The most mature step in our model is where every activity that can be conducted by AI agents has been automated. At the point of our study, no company was at this stage but there are numerous examples of initiatives that aim at accelerating the use of AI agents.

2.3 AI in software ecosystems

In an ecosystem context, GenAI offers the opportunity to facilitate content generation while agentic AI allows for individuals and organizations to replace human actors with agents that act on behalf of humans or organizations, but without human involvement. As the hypothesis in this paper, we believe that the capabilities the AI technology provide will lead to fundamental shifts in how ecosystems function and evolve.

As recognized in [2], AI enables firms to work smarter and faster, doing more with significantly less, in all functions of the organization as well as in interactions with ecosystem stakeholders. In [15], the authors explore how AI can be used to enable and support experimentation practices in ecosystem platforms. In a recent study, [16] present how LLMs can be used fetch the correct and relevant data for presenting data traces of platform ecosystems in graph models and databases. The study is conducted in industry and recognizes the interest and opportunity to use AI in software ecosystems. Similarly, [14] explores how LLMs can be used for monitoring platform ecosystem health and for ecosystem analytics.

However, while there is research covering the areas of software ecosystems and the power of AI technologies, there are few studies that explore how GenAI and Agentic AI will change the nature of software ecosystems. To the best of our knowledge, there is no research that combine the two areas and explore the steps that software-intensive systems companies evolve through when transitioning towards AI-driven ecosystems. In what follows, we present on-going research in which we explore and hypothesize on the use of AI in software ecosystems.

3 Research method

3.1 Case study research

The findings we present in this paper is part of an on-going research initiative in which we explore the use of AI in software ecosystems. For this purpose, we employ a qualitative and exploratory research approach in which we use workshops, informal and formal meetings and interviews to gain insights into how companies think about the use of GenAI and agentic AI in their ecosystems. The qualitative approach was chosen due to its capacity to generate rich, multi-perspective data that represents the perceptions of experts in the field [28], [24], [27]. The company representatives involved in this study are experts in their fields and they have a role and a responsibility involving introducing and advancing AI both internally and in their interactions with external partners. It should be noted however, that this is early-stage, on-going and exploratory work. The notion of AI in software ecosystems is new to the case companies and although they have ideas on what this will mean there are few concrete use cases. Instead, our research is an attempt to help the companies accelerate the use of AI, hypothesize on the impact of AI and transition towards AI-driven ecosystems.

3.2 Case companies

This research is conducted in close collaboration with multiple companies in the software-intensive systems domain as part of Software Center (www.software-center.se). For the purpose of this study, we have so far engaged with eight of the fifteen member companies in workshops, meetings and interviews. Since this is on-going research there are additional activities planned and we are scheduling additional workshops and interviews in several case companies. Below, we list the companies that we engaged with so far and that provide the empirical insights presented in this paper.

- ***Case company A*** is a company manufacturing trucks, buses and construction equipment as well as a supplier of marine systems.
- ***Case company B*** is a is a company developing autonomous drive technology.
- ***Case company C*** is a is a company developing products, services and solutions ranging from military defence to civil security.
- ***Case company D*** is a company developing automation and digitalization solutions for process and manufacturing industries.
- ***Case company E*** is a commercial vehicle manufacturer.
- ***Case company F*** is a company developing technology in the areas of connectivity, security, mobility and AI.
- ***Case company G*** is a company developing software solutions for flight and crew planning and logistics.
- ***Case company H*** is a networking and telecommunications company.

It should be noted that in addition to the recent interactions in the case companies mentioned above, we have had the privilege of working closely with the Software Center member companies for 14 years. Based on longitudinal case study research, we are able to reflect on the introduction, the adoption and the use of new technologies, new ways-of-working and new business models. The insights we acquired during our longitudinal engagements allow us to identify common challenges that the companies experience and we are able to explore what novel ways-of-working could potentially look like. This allows for what we believe is a solid foundation for hypothesizing about what the introduction, the adoption and the use of AI in an ecosystem context will look like even if examples and concrete use cases in industry are few.

3.3 Data collection and analysis

The conceptual model we present in this paper builds on insights we collected during workshops, in informal and formal meetings and in interviews with key stakeholders in the case companies. In addition, and as mentioned above, we benefit from 14 years of close collaboration with these companies. While the data collection methods we employed are the most common ones for empirical research [26], we wish to highlight that the topic we study is an emerging topic and novel to most practitioners. Therefore, the conceptual model we present is partly *empirically derived* (i.e., we have empirical evidence that supports our conceptualizations), partly *empirically inspired* (i.e., we have observations and experiences that influence our conceptualizations but without having validated these in practice) and partly *empirically hypothesized* (i.e., we present an educated guess and proposition about the expected outcome that is grounded in our existing knowledge and experiences). Our data collection activities were initiated in May, 2025 and are ongoing. Since May 2025, we engaged with the companies in the following research activities:

- **May 2025:** Half-day workshop on-site at company D where we met with the team responsible for software ecosystems and marketplaces. We had five people participating and they all shared their view on how their ecosystem strategy is, and will be, changing when introducing and adopting GenAI and Agentic AI in their software and business ecosystem.
- **August 2025:** One-hour online meetings with company A, B, C, E and F in which we met with key roles in each of the companies with responsibility for digital transformation, data and AI strategy, AI adoption, automation and ecosystem engagements. In total, we met with 16 people who all shared how they foresee that AI technologies will change their ecosystems, what new business opportunities they expect and how they are currently using AI in ecosystem-related tasks and activities.
- **September 2025:** One-hour online follow-up workshop with company D where we met with the team responsible for software ecosystems and marketplaces. During this meeting, we continued the discussions that we started when visiting the team on-site in May and we assessed the progress of the team and their activities. Especially, we discussed the

evolution towards AI-driven ecosystems and the team presented their view on the steps the company needs to take to accelerate the adoption and use of AI in an ecosystem context.

- **October 2025:** Three-hour cross-company workshop open for all Software Center companies on the topic of AI in software ecosystems. We had nine participants (four attending on-site and five joining online) representing six different companies. During the workshop, each company shared their current ecosystem infrastructures and strategies and how they are adopting AI technologies in their existing ways-of-working. In some of the companies there are concrete use cases that were presented as examples on how to benefit from AI in engagements with ecosystem partners.
- **October 2025:** One-hour semi-structured interviews with two representatives from case company C. In the interviews, we explored how AI is changing software and business ecosystems and the interviewees also got to validate and/or provide feedback on the maturity model that we developed based on our company interactions (i.e., the activities mentioned above).
- **November 2025:** Full-day on-site workshop planned with company E where the intention is to explore current ecosystem strategies, the on-going adoption of AI and the new business opportunities that the company seeks to realize by utilizing AI.

For analysis of the workshop discussions, the meetings and the interviews, we adopted a thematic analysis approach. Thematic analysis is a common method for identifying and analyzing patterns of meaning in empirical data and it helps illustrate which themes are important in the description of the phenomenon under study [7]. Throughout our analysis, we followed the guidelines provided by [21] to identify patterns and reflect on commonalities across companies. As suggested in [21], the aggregation of empirical data into patterns and themes allow for putting the different pieces of empirical insights into relation with one another. In section 4, we summarize our empirical findings by grouping them in three overall themes; *(1)* Today's human-centric ecosystems, *(2)* Tomorrow's AI-assisted ecosystems and *(3)* The future of AI-driven ecosystems.

4 Empirical findings

In our experience, there are several areas in which AI could play a significant role and where especially AI agents could change existing software and business ecosystems. As a few examples that were mentioned by the case companies, they are trying to understand how to share data and train AI agents to continuously enhance the overall performance of their ecosystems. Also, they are looking into the role of AI agents and what tasks they could do best in an ecosystem. These examples reflect the emergence of the topic of AI in software ecosystems and it should be noted that all case companies we studied are in the very early stages of exploring this. To the best of our knowledge, there are no large-scale software-intensive systems companies in which the use of AI has successfully spread to their ecosystem engagements. Instead, everyone is experimenting to understand what an ecosystem could potentially look like when consisting not only of humans but also of AI agents. Below, we summarize the insights we got in our recent company interactions.

4.1 Today's human-centric ecosystems

The case companies involved in our research are large software-intensive systems companies operating on a global scale. They are keystone players in their ecosystems consisting of a large network of suppliers, partners, customers and institutional collaborators. The case companies operate across multiple industries, maintain diversified portfolios and they leverage both vertical integration and strategic partnerships to stay competitive in their respective markets. During recent years, a common strategy has been to adopt digital platforms to connect customers, suppliers and technology partners with the intention to accelerate innovation and enable new business models. For example, case company D launched an open digital business platform designed to accelerate digital transformation for startups, large enterprises and ecosystem partners in 2022. The platform brings together a portfolio of software, hardware and services to simplify and optimize industrial engineering, manufacturing and operational processes. Similar examples can be found also in the other case companies and especially the automotive companies, e.g., company A, B and E, are actively pushing platform and standardization initiatives to facilitate collaboration and innovation between ecosystem partners.

Common for all case companies is that their current ecosystems are designed and fully driven by humans. The role of humans is to be the collaborators and decision-makers and across all company ecosystems we see humans being the ones enabling, structuring and creating APIs for collaboration in platform-based ecosystems. Human stakeholders initiate actions and transactions, engage in collaborative innovation, monitor ecosystem performance by collecting and analyzing ecosystem health metrics, design and standardize APIs to facilitate the interface between partners etc. Our workshop discussions and interviews reveal that humans play a central and multifaceted role as creators, collaborators, consumers, and stewards of existing ecosystems and that individuals' insights, skills, and experiences drive progress through constant interaction, dialogue, and co-creation. In some companies, experiments are being initiated in which individuals get access to GenAI tools to enhance productivity. However, broader adoption of GenAI, as well as effective use of Agentic AI is still scarce. This is reflected upon by one of the interviewees from company C: *"We are starting to see examples of AI tools being used to locating information in large volumes of documents and in this way helping software developers and engineers to perform their tasks. What we wish for is to leverage AI in internal and external workflows and have agents reduce the cognitive load of humans."* The interviewee goes on by saying that: *"Ideally, we should have agents defining problems at customer sites and people focusing their efforts on delivering value."*

While all case companies are aware of the opportunities of using AI in their ecosystems, they agree on that this is an emerging and novel topic and that there is a lot for them to explore to benefit from this.

4.2 Tomorrow's AI-assisted ecosystems

Although the case companies are still exploring the very first steps of what AI technologies could bring to their ecosystems, they see big opportunities and they realize that this is a disruptive force that will fundamentally change existing ecosystems. For them, the natural next step is an AI-assisted software ecosystem consisting of interlinked AI-powered tools, platforms, developers, cloud services, and end-users that together support and accelerate every stage of software creation and evolution. Such an ecosystem deploys AI for e.g., code generation, testing, documentation, debugging, design, and even requirements analysis. In addition, the use of generative AI tools and intelligent agents will allow teams to prototype quickly, automate repetitive work and maintain quality and efficiency. During our workshop discussions, several company representatives mentioned the opportunity to have humans and AI agents collaborating on code generation, testing, security audits, and user feedback analysis. One idea that was expressed by many people was the notion of AI-assistants that would enhance human stakeholders and accelerate team performance. Some of the examples that were mentioned during workshops and interviews were e.g., pipelines for instant prototyping, automated refactoring, and AI-assisted decision-making during design, coding, and deployment. Also, several company representatives foresee a situation in which AI tools will improve their existing dashboards for monitoring software ecosystem health, predicting potential performance issues and managing software updates using AI-driven insights. One of the representatives in company D touches upon this when saying: *"In the "machine economy", we want to see teams being structured to maximize the value of both human creativity and machine intelligence, and workflows designed for iterative improvement and fast adaptation to user needs and market trends."*

During the workshop discussions, several initiatives were mentioned and the companies shared what they believe are the first steps towards AI-assisted ecosystems. All companies are exploring how to share data and domain knowledge with their ecosystem partners to enhance the overall ecosystem. Several people were talking about service-oriented agents, maintenance-oriented agents and automated customer support as next steps in their intelligent data marketplaces. In one of our interviews in company C, the interviewee shared examples of how the use of GenAI can assist roles in procurement, in marketing and when on-boarding staff. According to this interviewee, there are multiple examples of how simple tasks could be reduced and how humans could benefit from being assisted by AI tools. In company A, there are attempts to use AI assistants in service design and development with the intention to increase speed in prototyping and deployment. As mentioned by one of the company representatives: *"The cost of building a prototype used to be so high that we inserted qualitative assessment steps to decrease the risk of building "the wrong thing". This was expensive and it made development cycles long and slow. Now the cost of creating a prototype is so low so that we can reduce the early steps and go straight into deploying and testing with customers."*

All case companies agree on that AI tools will assist them in building prototypes and suggest improvements in the near future. This will, according to most people, allow humans to focus on creative problem-solving and value delivery. Another main benefit that was brought up in the cross-company workshop is the opportunity to use AI for enabling interaction between ecosystem partners even if there is no defined standard. Typically, the case companies operate in industries where common standards are key but these take years to develop and agree upon. As recognized by the representative from company H, with AI agents it becomes easier, and free, to implement adapters and plug-ins to facilitate communication and collaboration even if there is no shared and common standard. According to the case company representatives from the telecommunication and automotive domains, this would significantly shorten lead-times. Finally, the companies see great opportunities in mass-customization provided by AI. This is reflected upon by one of the representatives from company A when saying: *"As software is becoming increasingly cheap, there is the opportunity to generate unique solutions for every individual customer and use AI to customize and tailor the product for individual customer needs."*

As a common view shared by the companies involved in our study, the adoption of AI in software ecosystems will help reduce repetitive tasks, shorten development cycles, increase code quality and enable collaboration, innovation and prototyping with partners. While this is on-going and yet in its early stages, the company representatives agree on that tomorrow's ecosystems will be heavily AI-assisted.

4.3 The future of AI-driven ecosystems

Although the companies involved in our research are only scratching the surface of what effective use of AI could mean for ecosystem strategies and engagements, we asked them to hypothesize about the future and what it holds. This was an appreciated, while at the same time difficult task, as the company representatives were asked to go beyond current practices and the nearby future. For most people who participated in this discussion, an AI-driven software ecosystem is characterized by the pervasive and orchestrated use of artificial intelligence across interconnected platforms, tools, processes, and stakeholders with the intention to accelerate not only software development, deployment, and evolution but also innovation, collaboration and value creation. People defined it as an ecosystem consisting of seamless integration, automation, adaptability and collaboration between humans and AI agents.

In an AI-driven ecosystem, GenAI and agentic AI form the backbone of data-driven services and solutions and discussions among workshop participants revealed a belief that incumbents will increasingly compete based on their ability to orchestrate multi-agent and multi-party collaborations. While current and next steps involve AI-assisted collaboration and automation of tasks, the future brings agents that will reshape how value is created and shared across entire ecosystems. As expressed by one of the interviewees in company C: *"We become managers of AI."*

When discussing the role of humans, several workshop participants referred to humans having a monitoring role as guides, overseers, and collaborators with machine intelligence. This was reflected also in one of the interviews when the interviewee described how the *"...human role will shift from focusing on operational tasks to creative orchestration, oversight and more strategic decision-making."* Also, several company representatives emphasized the need for effective mechanisms for human oversight, ethical alignment, legal issues and skill development as humans will increasingly supervise or collaborate with autonomous systems.

While the case companies in this study are still in their early stages of adopting AI in their software ecosystems, the opportunity to hypothesize about the future was considered important as it both aligns and challenges existing assumptions. Our workshop discussions yielded valuable food for thought and it helped us in developing a conceptual model for how we believe these companies will evolve when transitioning towards AI-driven ecosystems.

5 Towards AI-driven ecosystems

As we outline in this paper, AI is affecting virtually everything a company is concerned with. The extent to which AI affects a specific company depends on its maturity as well as the maturity of the others in the ecosystem. Based on our interactions with the case companies, we can identify multiple dimensions that are affected as AI enters their ecosystem engagements. Below we discuss these dimensions in more detail.

- **Collaboration**: Traditionally, business ecosystems rely predominantly on human relationships. People have worked together for a long time, built trust with each other and have developed informal agreements and ways of working. When AI enters the scene, the relationships become more protocol oriented. Using these protocols, AI agents can exchange data, negotiate and optimize across the various players in the ecosystem. This leads to a continuous rather than periodic adjustment of the ecosystem and increases the tempo and the heartbeat.
- **Transaction cost**: When humans drive the interactions, the focus is on large transactions and long-term relationships as the cost of negotiating a transaction is high. With AI, companies can apply automated contracting or smart contracts where AI agents source and negotiate. Also, whereas negotiations earlier consisted of large subsystems or entire products, AI agents allow for fragmentation and negotiation for components from different partners. Although business ecosystems are typically organized around a dominant design, with AI agents, the design fragments into smaller parts that can be more dynamically sourced from different players.
- **Acceleration**: The consequence of the above is acceleration in multiple dimensions. Using AI agents, it becomes feasible to benchmark offers, compare these and instantly change providers as the information asymmetry is reduced, allowing purchasing organizations to rapidly reduce cost. Also, companies that relied on customer intimacy as a differentiator will lose that edge as AI agents will not experience that as a benefit, but only as one variable in a broader equation when evaluating partners. Also, functionality that was differentiation will more rapidly commoditize due to AI agents more rapidly identifying and replicating novel functionality.
- **Role of data**: With AI agents having similar capabilities for all parties in an ecosystem, the most promising way for companies to stand out is to collect and have access to proprietary data that can be used for finetuning AI agents or as context for AI agents to outperform others that do not have access to that data. In our experience, data sharing between players in a business ecosystem will become increasingly critical for companies.
- **Power structures**: Whereas power in business ecosystems was traditionally derived from the position of the company, with AI agents the power is increasingly shifting towards "AI intermediaries" that provide an integration layer that the AI agents of other ecosystem participants can integrate with. As an AI intermediary, your role is to provide accelerated collaboration, lower transaction cost and effective access to relevant data. This becomes more important in AI-driven ecosystems due to interaction moving towards algorithmic rather than human collaboration.
- **Strategy**: As we know from game theory research, a set of AI agents left to their own devices may easily construct a business ecosystem where agents act in ways that are adversarial, result in cartels or in brittle collaborations. Consequently, companies need to find effective mechanisms to keep humans in the loop. Not in the continuous transaction flow, but as actors to which ambiguous situations are escalated and as supervisors.
- **Leadership**: As leaders in companies that engage in business ecosystems that are becoming AI-driven, the main focus has to be on four factors. First, seek to own interfaces such as APIs and data contracts. These are critical to operate competitively in the ecosystem. Second, develop governance of your AI agents that ensures that they are competitive and yet good collaborators. Third, develop data partnerships that ensure that your company and AI agents have access to relevant data. Finally, identify proper human-in-the-loop mechanisms to ensure that high-risk situations reach a human instead of being taken forward by an AI agent.

Whereas the above section presents seven dimensions that companies need to be aware of when moving towards an AI-driven ecosystem, the transition is not binary. Instead, we foresee several steps that companies evolve through when transitioning from a human-centric to an AI-driven ecosystem. Below, we present a conceptual model in which we outline the steps we believe software-intensive systems companies will take to evolve towards AI-driven ecosystems. While the first two steps are empirically derived, the more mature steps were either mentioned when asking the workshop participants and interviewees to hypothesize about the future or grounded in our own existing knowledge and experience from working with the companies for 14 years.

1. **Human-centric**: The first step in the maturity model is the human-centric ecosystem that is the status quo in many companies. Here, the relationships within the ecosystem are based on personal networks between people that have built trust with each other over long periods of time. Contracts are negotiated manually and the amount of data that is exchanged between parties is limited. In this context, brand, reputation and quality are important differentiators.
2. **Assisted collaboration**: At the second step, AI agents enter the scene as assistants to humans. The AI agent can support with discovery, analytics and other tasks such as pricing. The advantage of using an AI agent as an assistant is that the speed of decision-making increases, among others through visualization of relevant data. This data may be collected through the first API integrations between partners in the ecosystem.
3. **Agent-mediated transactions**: The third step is concerned with off-loading routine and repetitive transactions to AI agents. In this case, the agent quotes, orders and schedules

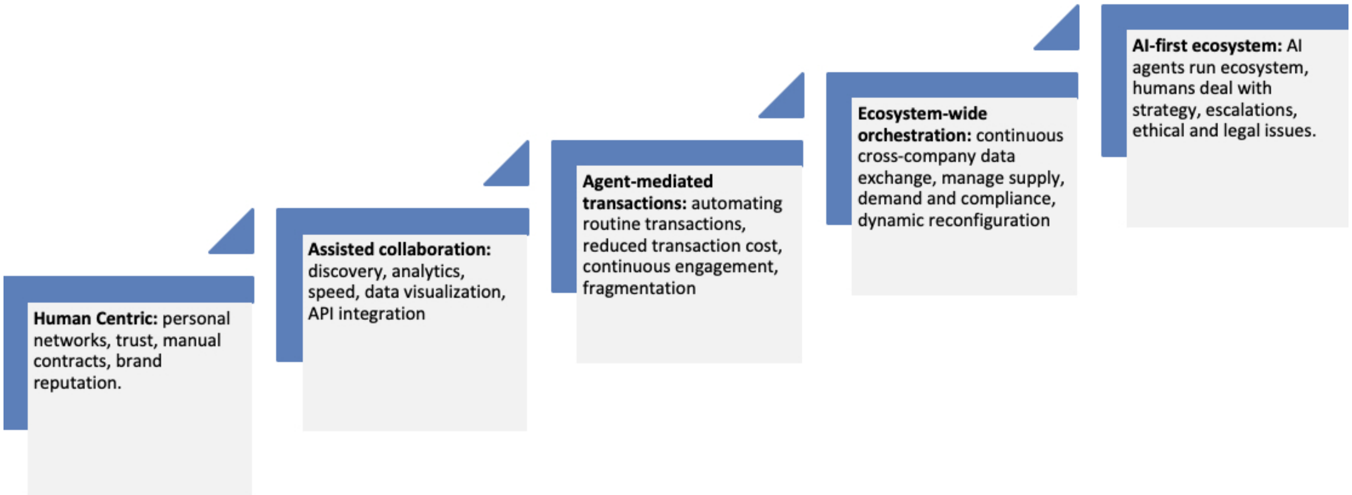

Figure 1: Towards AI-driven ecosystems.

across one of more organizational boundaries. At this step, some of the key benefits of AI-driven ecosystems start to surface, including reduced transaction cost, continuous ecosystem engagement and the first fragmentation of ordering into smaller parts and transactions.

(4) **Ecosystem-wide orchestration**: At the fourth step, we enter an ecosystem-wide, real-time and data-driven coordination that is virtually impossible to achieve by humans. Here, AI agents exchange data across firms continuously and manage supply, demand and compliance to regulations on a continuous basis. Network effects because of access to data as well continuous, dynamic reconfiguration of partners based on their value to other agents become key differentiators.

(5) **AI-first ecosystem**: The final step is where the ecosystem is entirely run by AI agents. Humans are predominantly concerned with strategic questions, escalations and legal and ethical issues. The role of proprietary data and models as well as governance become increasingly important as differentiators. Also, any opportunity to own or control relevant interfaces becomes critical for long-term success as control points are the only way to avoid being deselected by other AI agents when not offering favorable terms to the ecosystem.

In Figure 1, we present the maturity model and we summarize the key characteristics of each step. As a first and initial attempt to validate our model, we showed it to the two interviewees from company C. In the end of the interviews, they had the chance to review the model, learn about the steps and provide feedback. Both interviewees appreciated the model and agreed on the evolution we outline. When being asked about the maturity of the company they represent, they placed their current ecosystem practices in between the first and second step in the model. This is in line with the other case companies involved in this study as our research shows that most companies are in a human-centric ecosystem and have only started to explore how to use and benefit from AI in their ecosystems.

6 Threats to validity

Throughout our study, we carefully considered the validity and trustworthiness of our results [26]. To address *construct* validity, we made sure to define key concepts and terminology in the introduction of each workshop, meeting or interview to ensure a common understanding of key concepts and to avoid misinterpretations. However, it should be noted that the notion of AI in software ecosystems is still an emerging concept for which clear definitions are not fully there. To address *internal* validity, we engaged with industry representatives who were able to provide a deep understanding of the complexity of the phenomenon, e.g., people responsible for, and involved in, software platforms, software ecosystem strategy, digital transformation, automation and AI adoption. To address *external* validity, we used our empirical findings as the basis for the conceptual maturity model we present. It should be noted that while we could empirically derive the first two steps in the model there is not empirical evidence for the more mature steps. Instead, we used empirical data to hypothesize and propose what the evolution will look like. We present the model with the intention to provide value for organizations with similar characteristics and challenges as the ones we studied. Finally, to address *reliability*, we applied established practices for data collection and analysis.

7 Conclusions and future work

There are few technologies that have the potential to change the software-intensive industry to the extent that Artificial Intelligence (AI) is currently doing. With the emergence of Generative AI (GenAI) and Agentic AI, organizations can complement, and also replace, human actors with AI agents that act on behalf of humans or organizations, but without human involvement.

In this paper, we we explore the trend of moving towards AI in software ecosystems, the implications this will have in practice and we hypothesize on how this will likely evolve in a context where some agents in the ecosystem are human and others are AI driven. Our empirical findings show that although concrete use cases are few, companies are actively exploring how to adopt AI in their ecosystem engagements, what the impact of this will be and how the use of GenAI and Agentic AI has the potential to disrupt and fundamentally change their existing ways-of-working. Our key contribution is a conceptual model in which we present five maturity steps that we believe software-intensive systems companies will take when transitioning towards AI-driven ecosystems. To conclude, we believe that what might at the moment be perceived as "the ghost in the machine" will be reality before we know it. In our future research, we aim to further validate our maturity model and engage in experiments with the case companies to help them transition from the first two steps towards the more mature and advanced steps in the model.

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