Investigating the similarity between collaboration systems and digital ecosystems

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***Abstract*—Digital ecosystem is a concept emerged from the natural existence of business ecosystem, which in turn is taken from the concept of biological ecological systems. In this paper we aim to review the literature in the field of digital ecosystem and investigate models that support the claim that collaboration systems and social media networks, to certain extent, could be considered as digital ecosystem. For this investigation we undertake a systematic mapping study to present a wide review of primary studies on digital ecosystems, collaboration systems, and social media networks. The systematic mapping is a research methodology that gives a visual summary of the results obtained from a systematic research process. This paper mapped what is currently known about digital ecosystem. The work presented in this paper aims at investigating the similarity between collaboration systems and digital ecosystems and guide efforts for future research intended to model collaboration system as a digital ecosystem. Finally, we present our own model of a collaboration system working as a digital ecosystem based on the knowledge obtained from our investigation.**

I. Introduction

Digital ecosystem is defined by Digital Ecosystem and Business Intelligence Institute (DEBII) from the perspective of specialization, which sees it as *"an open, loosely coupled, domain clustered, demand-driven, self-organizing, and agent based environment which each species is proactive and responsive for its own benefit and profit"* [1].

The concept of digital ecosystem itself was adopted from the concept of business ecosystem. [2] defines business ecosystem and the idea behind the adoption of the term *"ecosystem"* as follows: *"The term [ecosystem] circumscribes the microeconomics of intense coevolution coalescing around innovative ideas. Business ecosystems span a variety of industries. The companies within them coevolve capabilities around innovation and work cooperatively and competitively to support new products, satisfy customers needs and incorporate the next round of innovation."* For [3] a business ecosystem is a loos network of suppliers, distributers, outsourcing firms, market of related products or services, technology providers, and a host of other organization. All of them affect and are affected by the creation and delivery of companys own offerings. According to [3] also, these entities share the fate of the network as a whole, regardless of the members apparent strength.

On the other hand, we have the concept of collaboration systems. A collaboration system is an IT based set of tools that create a workflow of information to specific teams and members. This allows individuals to share ideas and their talents with other members so that the task can be finished both efficiently and effectively [4].

As a research area, such as digital ecosystem and collaboration systems, matures and starts to receive attention, it becomes important to summarize and provide overview to the increasing amount of studies and results produced by the scientific community. Many research fields have their own methodology for such practice. However, this is not the case with the field of digital ecosystem, similarly with the field of software engineering [5]. There is now a trend towards a more structured literature review by using systematic literature review and systematic mapping [6], [7], [8], [9], [10], and [5], and we plan to deploy those systematic research methods to the field of digital ecosystems.

The purpose of this paper is to investigate studies in the field of digital ecosystem and collaboration systems to find evidence on the similarity between these two concepts. The goal is to find guidance in the literature on how to model a collaboration system as a digital ecosystem. This study is also interested in social media networks as they are viewed as large digital ecosystems. These goals and interests will have direct effect on forming the research questions later in this study, along with constructing criteria to select papers for the systematic mapping. We believe this investigation to be the first step in our journey to develop and deploy a model for collaborative digital ecosystem.

This paper is organized as follows: After this introduction, section 2 describes the methodology of systematic mapping that we are going to follow. Then, the results of the systematic mapping are shown in section 3. In section 4 we discuss the proposed research questions in the light of the found results and propose a model for collaboration system as digital ecosystem. Finally, we conclude with section 5.

II. Systematic Mapping of Digital Ecosystems

This section discusses the methodology of systematic mapping which was followed to obtain material for this research. The discussion will cover the search strategy, databases used, and the selection criteria. The methodology is based on the software engineering systematic mapping guidelines by [5].

A. Research Questions

The research questions investigated in this study are as follows:
RQ1: What part do collaboration systems take in the field of digital ecosystems?
RQ2: What part do social media studies take in the field of digital ecosystems?

B. Search Strategy

In this study we reviewed research material obtained from different databases. As this is an early stage of what we hope to become a full research, other material might be added in later studies. The sources of research material are presented in (Table. I). The search terms used are presented in (Table. II). Note that terms a, b, c, d and e were not used individually but in combination with other terms. This was done in order to limit the search results to the field of digital ecosystem.

TABLE I. DATABASES SEARCHED FOR THIS STUDY

Database Name
ACM
Elsevier
IEEE Xplore
Science Direct
Springer

TABLE II. SEARCH TERMS

No.	**Search Terms**
a	Digital Ecosystems
b	Social Media
c	Collaboration Systems
d	Business Ecosystems
e	System of Systems
1	{a, b, c, d, e} AND {modeling, semantic modeling}
2	{a} AND {b} AND {interaction}
3	{b} AND {Tagging}

C. Inclusion and Exclusion Criteria

The refinement of search results was done in two phases. In the first phase, only the title and abstract were searched. The goal was to find studies that mainly describe models of digital ecosystems, and social media and collaboration systems as part of digital ecosystem.

In the second phase, the inclusion and exclusion criteria shown in (Table. III) were used to refine the studies selected after the first step. These criteria were selected based on the needs of this study presented previously within the problem statement and the research questions. A study was selected if it met at least one inclusion criteria. Exclusion was made when a study did not meet any inclusion criteria or it met one or more exclusion criteria. Exclusion criteria had a higher priority than inclusion criteria.

III. SEARCH RESULTS

The results of the selection process are presented as follows: In the first step, five databases were searched individually using the keywords established in the previous section. A total of 26,763 studies were found. In the second step, 186 of the 26,763 studies were selected based on a search on the title and abstract. The first step set the search domain to the area of interest, and the second step filtered the studies based on the title and abstract. If we were to perform the search on each title and abstract directly, the results would be different and some of the results might not be targeting our area of interest. A search for title and abstract in a database that holds more than million studies is not as specific as a search of a few thousands studies. In the third step, eleven duplicate studies were excluded resulting in 175 studies. In the fourth step, the detailed inclusion and exclusion criteria were applied and resulted in 31 studies.

TABLE III. DETAILED INCLUSION AND EXCLUSION CRITERIA

Detailed Inclusion Criteria	
1	The study provides an overview of digital ecosystems.
2	The study focuses on interaction between different digital ecosystems.
3	The study investigates the characteristics of digital ecosystems.
4	The study presents a model of digital ecosystem.
5	The study presents case studies on digital ecosystems
6	The study discusses social media networks and/or collaboration platforms as digital ecosystem
Detailed Exclusion Criteria	
1	The study does not provide sufficient detail (e.g., full text not available online).
2	The study discusses ecosystems other than digital ecosystems, unless it represents a model that we can benefit from in our work. (e.g., natural ecosystems)
3	If several studies discuss the same issue, only the most complete, newest or most cited study is selected; the rest are excluded.

A. Classification Scheme

The 31 studies selected for systematic mapping were classified based on the six different topics (i.e., Business Ecosystem, Collaboration Systems, Digital Business Ecosystem, Digital Ecosystem, Semantic Web, Social Ecosystem, Social Media Network, and System of Systems), and mapped with respect research goals, and the results of this mapping are presented in (Fig. 1).

A map was developed in the form of bubble charts. The mapping shown in (Fig. 1), maps the number of studies addressing each topic with respect to the goal of the research conducted in these studies. Some studies are mapped to multiple categories, which is the reason for the unequal number of studies represented in the map.

IV. DISCUSSION OF RESULTS

In this section we are going to elaborate on the acquired studies in the field of digital ecosystem. The main goal is to review and shed the light on studies that can answer our previously defined research questions, and then deploy the knowledge acquired to construct our own model of a collabortion system as digital ecosystem.

The organization of the following sub-sections will be as follows; first, we are going to review studies mentioning models of digital ecosystems. Then, we will present the research questions and review the papers that can help answering these questions, and present a model for collaboration system as digital ecosystem.

A. Digital Ecosystems Modeling

In order to understand the extent to which collaboration systems are related to digital ecosystems, we first need to see how digital ecosystems models are present in current literature.

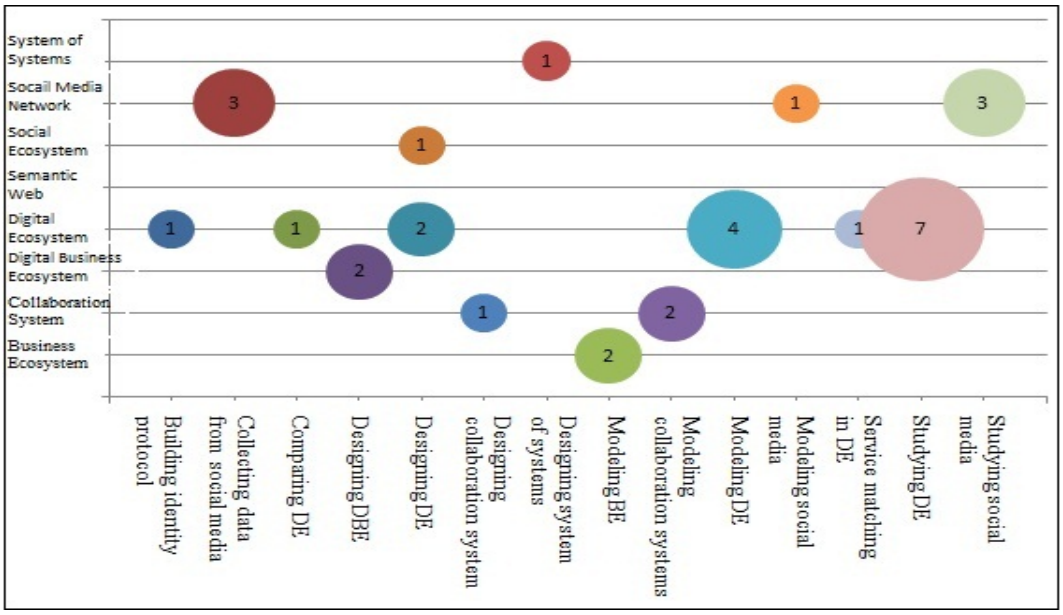

Fig. 1. Mapping the studies with respect to topic and research goal

[11] examines representing digital ecosystems collaborative aspects through sequence diagrams. The paper proposes the use of UML sequence diagrams to represent interactions between digital ecosystems/digital species/digital organs. The paper gives an example of Microsoft Office package to explain the terminology of digital ecosystem. The Package itself can be considered as a digital ecosystem, whereas the tools of this package, Microsoft Word, Microsoft Excel, Microsoft Access etc., are considered as digital species which themselves are composed of digital organs. For example, Microsoft Excel is a digital species and one of its digital organs function is enabling users to create graphs. The paper differentiates between digital species and organs by defining that digital species can generate output while the later cannot. Therefore, a digital ecosystem consists of interrelated and interconnected digital species where each digital species produces unique output. Digital species differ from each other based on their output. Digital organs cannot produce this output by themselves. Digital organs work together with other digital organs of the same digital species to produce output specific to this digital species. Different species in a digital ecosystem might communicate with each other and establish a relationship. [11] uses sequence diagram to simply illustrate these relations. (Fig. 2) represent a sequence diagram model of collaborating component within a digital ecosystem as specified in [11].

[1] aims to solve the conceptual ambiguity and help researcher better understand what digital ecosystem is by employing ontology to represent the conceptual model of digital ecosystem. This study views digital ecosystem in terms of concepts that represent the digital ecosystem and its species alongside with the parts that composes them. The relation between those species and composition and generalization links are also represented. The difference between [1] and [11] is that the later focuses on the interaction between digital species in a digital ecosystem while the other describes their structure thoroughly through a conceptual model.

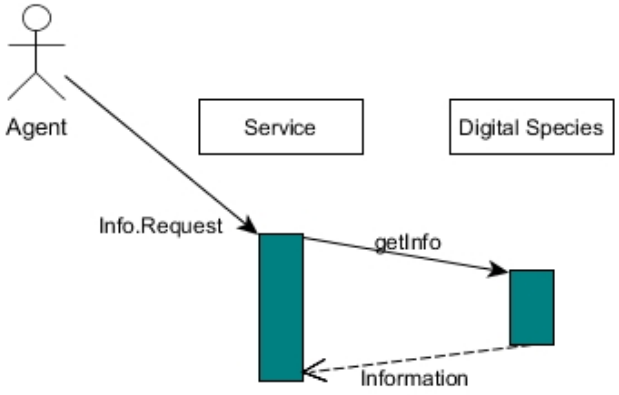

Fig. 2. An example of a sequence diagram representing interactions between digital ecosystem components

The work of [12] explores the topic of smart homes under the aspects of a digital ecosystem. Main goal is to support the transition towards sustainable buildings characterized by minimized energy demands and less carbon dioxide emissions. The resulting system concept is termed ThinkHome. A schematic of the proposed digital ecosystem and an ontology of its knowledge base is presented in this work.

B. What part do collaboration systems take in the field of digital ecosystems?

Several studies focus on collaboration systems as digital ecosystems. They tend to consider the behavior of collaboration systems to be related to digital ecosystems, thus safely allowing viewing collaboration systems as digital ecosystems with all the properties that come with this title.

The question of how information in different systems can be brought together in an understandable way but without

the need to re-engineer either their interfaces or their data needs [13], establishes a gate way to understanding how collaboration systems are related to digital ecosystems, and how it is useful to view it in such way. The importance of such linking of concepts lies in digital ecosystems features of data representation and exchange, and how collaboration systems can harness those features and benefit from them. [13] proceeds to propose an ontology based information management capability (OBIMC) which provides collaboration services for information sharing that is independent of platform or users location. Furthermore, this study introduces the concept system of systems as something incorporated by their ontology system in a way that provides a better semantic links between data.

The work of [14] proposes a framework to facilitate large scale collaboration by developing a collaborative architecture and ways to convert it to supporting technology. The framework uses an ensemble of communities all working to a common vision as the basis for the collaborative architecture. In other words, the framework addresses the issue of extending collaboration systems to larger ecosystems. The paper also recommends the technologies that could be used to implement such a large inter communities collaboration system.

[14] is yet another work addressing the issue of collaborative digital ecosystems. The paper describes a simple framework that encourages a coopetition model of a global - local partnership for sustained development. The framework consists of 6 locally-led innovation lifecycle phases that can be facilitated with a digital ecosystem supported by 4 essential technology components.

[15] studies digital ecosystems as collaborative environments. It takes the readers step by step to understand the development of the terminology from ecological systems to digital systems, reaching finally to digital ecosystems. In this work, the digital ecosystem is studied from a perspective of the underlying architecture that provides the communication links between all components. The aim behind this work is to help apply digital ecosystem ideas, principles and architecture in business, government and other domain disciplines to enhance the productivity, growth, prosperity and social, culture and economic balance and sustainability.

Another work that views collaboration systems as digital ecosystems is [16]. The main research question of this study is what are the conditions under which collective acts of knowledge contribution are started and become self-sustaining? To answer this question, a study is performed on Wikipedia as both a technology platform and a community of collaborative individuals (Wikipedians). The study comes to a conclusion that Wikipedia holds the key factor to sustainability as a collaborative digital ecosystem.

As we can see, the previewed studies highlight the emerging concepts of digital ecosystem and collaborative systems. These studies can be considered as evidence to the correlation between the two concepts. To some extent, we can safely assume collaborative systems to act as digital ecosystems. However, these studies tackle the relation between collaboration systems and digital ecosystems from different angles, but none of which provides a clear model for a collaboration system with the highlight of the digital ecosystem structure or the specific features required to consider a collaboration platform as collaborative digital ecosystem.

From what have been reviewed so far we can conclude the following ideas. These ideas will help us build our own collaborative digital ecosystem model:

- Digital ecosystems consist of digital species that are linked with each other [11] [1] [12].
- Sequence diagram is a good way to present the links and the sequence of interactions between digital species in a digital ecosystem [11].
- Ontology is a good way to present a digital ecosystem model [1] [12].
- Collaboration systems consist of entities that are linked with each other (similar to digital ecosystem) [13] [14] [15] [16].
- Ontology can be used to model collaboration systems [13].

C. What part do social media studies take in the field of digital ecosystems?

This question aims to draw the attention to the role of social media network as a digital ecosystem. What we are investigating here is how this role is represented in current literature.

[17] views social media networks as an interesting digital ecosystem, with two qualitatively different kinds of agents: biological as well as artificial. The paper discusses the entry of artificial agents in human social networks, which thus comprise emerging digital ecosystems.

[18] conducts a research powered by Hewlett-Packard Laboratories. The paper describes a tool called WaterCooler. This tool aggregates shared internal social media and cross-references it with an organizations directory. WaterCooler is deployed in a large global enterprise. The main goal for this tool is to help members of a large organization find each other and share knowledge and insights. A new approach to employ social media networks as collaborative digital ecosystems is considered in the work of [19]. This paper presents a case study developed through action research of how social media technologies such as wikis and collaborative workspaces were used as the main knowledge sharing mechanisms in response to disaster, what influences they made on knowledge sharing, reuse, and decision making, and how knowledge was effectively (and at times ineffectively) maintained in these systems.

From our review we can conclude the following points regarding social media networks:

- Social media networks can be viewed as digital ecosystems [17], hence, can be modeled as such.
- Social media networks are sources of information and we can derive knowledge from it [18] [19].

D. The Model for Collaboration Systems as Digital Ecosystem

Based on the ideas presented earlier we can deploy the work of [1] and [11] to model a collaboration system with

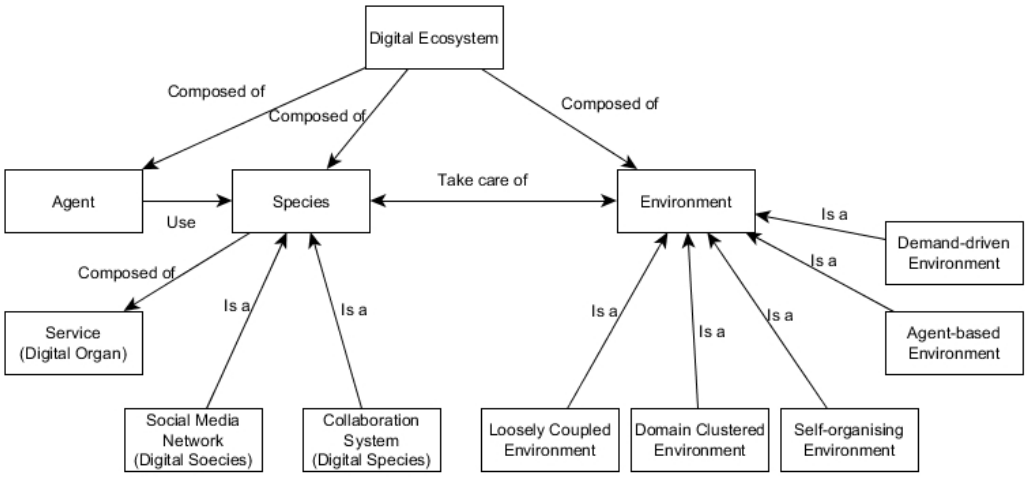

Fig. 3. Ontology model of collaboration system as digital ecosystem

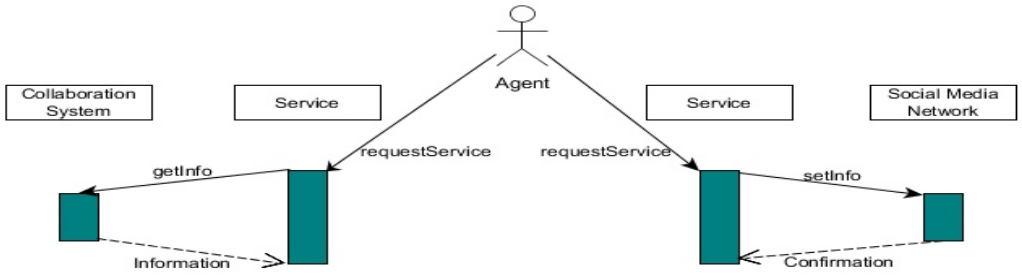

Fig. 4. A sequence diagram with the agent interacting with digital ecosystem

its environment as a digital ecosystem using the ontology presented in [1], and then present the collaborative nature of this system by using sequence diagram adopted from the work in [11].

The idea behind our model is simple. The ontology we adopt specifies the digital ecosystem to be consisted of two basic parts digital species and an environment [1], and we added the concept of an agent to our model. Each species can be viewed as an individual, an organization or a system and has its own role to play. One specialisation of species is that they are collaborative and usually work in a group, and a leader leads all other followers in the group. We take this ontology of the digital ecosystem and introduce the collaboration system as digital species. The environment, according to the definition of digital ecosystem provided earlier in this study, has the specification of open, loosely coupled, demand-driven, domain clustered, self-organizing and agent-based. Next, the sequence diagram adopted earlier is used to present the collaborative nature of our digital ecosystem. It has been proven by [11] that sequence diagram is a good tool to model collaborative activities in the digital ecosystem.In our diagram, we also introduce the agent, which forms a part of the digital ecosystem, as the center of all interactions. The diagram shows an agent surrounded by digital organs providing services upon request.

The ontology model of the collaboration system as digital ecosystem is present in (Fig. 3), and the modeling of the collaborative component of this digital ecosystem is present in (Fig. 4) as a sequence diagram.

It is important to point out that (Fig. 3) includes but not limited to the digital species and organs represented in our ontology. The nature of our adopted model allows us to extend it and instantiate different digital species and organs along with their environments as long as they comply to the definitions provided by [1] and [11]. As an example of this extensibility, we can look into MEMORAe and try to include it in our model. As defined by [20], MEMORAe approach is to manage heterogeneous information resources within organizations. The approach is comprised of a semantic model (called MEMORAe-core 2) and a web platform (called MEMORAe) which is based on the semantic model. The model and the platform make together a support to enhance the process of organizational learning. If we are to model MEMORAe as a collaboration system in our model, we can think of it as digital species. Based on the definition of digital species in [1], MEMORAe has a domain (Knowledge management and collaboration), plays dual roles including the supplier who has available services and the requester who has requested service, follows rules in digital ecosystem, is driven by own profit and carried out tasks that relates to the profit. Hence, MEMORAe can be considered as digital species. In the same manner, if we are able to define the domain, role, rules, profit and tasks of a concept, we are able to model it as digital species in a digital ecosystem. Therefore, we

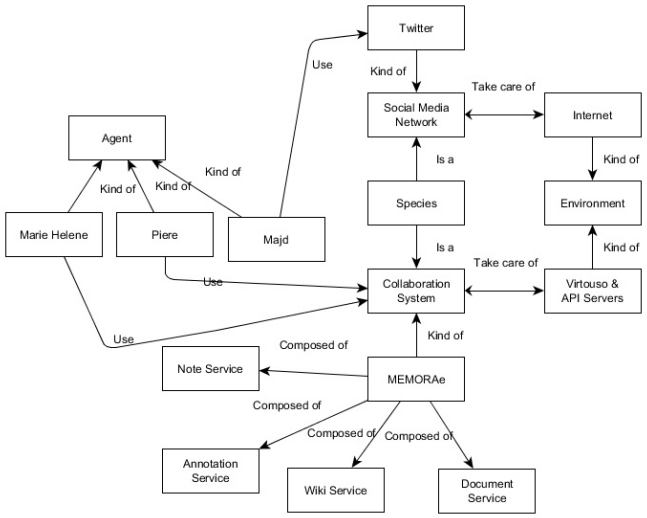

Fig. 5. An example of MEMORAe and twitter as digital species

can include other digital species (social media networks for example). This is illustrated in (Fig. 5). (Fig. 5) represents the collaboration system MEMORAe and social media network as digital species in the digital ecosystem.

V. Conclusion

Our goal was to investigate the similarity between collaboration systems and digital ecosystems by reviewing the studies that can help answering our research questions and construct a model of a collaboration system as a digital ecosystem. To achieve this goal, this paper presented a systematic mapping of studies in the field of digital ecosystem. A total number of 31 studies were included. The main limitations to this mapping are bias and unintentional omission of papers. Some difficulties were faced extracting relevant information from the papers, as some of them do not explicitly address the focus of our research questions.

We found the similarity between collaboration systems and digital ecosystem, and were able to use an ontological model that allows us to present a collaboration system as digital species in a digital ecosystem. The potentials of this model could permit a wider representation of different systems labeled as digital species working together in collaboration under the leadership of a leader digital species in what we might call a system of systems, or a collaborative digital ecosystem. We can safely assume that our goals were met, but the need to conduct more interrogative studies in this field is still present.

The next step is to expand our work and introduce a model of collaborative digital ecosystem (system of systems) based on the knowledge presented in this study, and further research of our own. The model should provide a clear guidance on the features required in a collaborative digital ecosystem, and how to build such system.

VI. Acknowledgement

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