COLLA 2019

The Ninth International Conference on Advanced Collaborative Networks, Systems and Applications

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Lasse Berntzen, University of South-Eastern Norway, Norway

Samia Ben Rajeb, University of Brussels, Belgium

COLLA 2019

Foreword

The Ninth International Conference on Advanced Collaborative Networks, Systems and Applications (COLLA 2019), held between June 30 – July 4, 2019 - Rome, Italy, continued a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra-organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2019 Technical Program Committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to COLLA 2019. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the COLLA 2019 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2019 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of collaborative networks, systems and applications.

We are convinced that the participants found the event useful and communications very open. We also hope that Rome provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

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Modularization of Research Software for Collaborative Open Source Development

Christian Zirkelbach
Software Engineering Group
Kiel University
Kiel, Germany
email: czi@informatik.uni-kiel.de

Alexander Krause
Software Engineering Group
Kiel University
Kiel, Germany
email: akr@informatik.uni-kiel.de

Wilhelm Hasselbring
Software Engineering Group
Kiel University
Kiel, Germany
email: wha@informatik.uni-kiel.de

***Abstract*—Software systems evolve over their lifetime. Changing conditions, such as requirements or customer requests make it inevitable for developers to perform adjustments to the underlying code base. Especially in the context of open source software where everybody can contribute, requirements can change over time and new user groups may be addressed. In particular, research software is often not structured with a maintainable and extensible architecture. In combination with obsolescent technologies, this is a challenging task for new developers, especially, when students are involved. In this paper, we report on the modularization process and architecture of our open source research project *ExplorViz* towards a microservice architecture. The new architecture facilitates a collaborative development process for both researchers and students. We describe the modularization measures and present how we solved occurring issues and enhanced our development process. Afterwards, we illustrate our modularization approach with our modernized, extensible software system architecture and highlight the improved collaborative development process. Finally, we present a proof-of-concept implementation featuring several developed extensions in terms of architecture and extensibility.**

Keywords–collaborative software engineering; open source software; software visualization; architectural modernization; microservices.

I. Introduction

Software systems are continuously evolving during their lifetime. Changing contexts, legal, or requirement changes such as customer requests make it inevitable for developers to perform modifications of existing software systems. Open source software is based on the open source model, which addresses a decentralized and collaborative software development. Open research software [1] is available to the public and enables anyone to copy, modify, and redistribute the underlying source code. In this context, where anyone can contribute code or feature requests, requirements can change over time and new user groups may appear. Although this development approach features a lot of collaboration and freedom, the resulting software does not necessarily constitute a maintainable and extensible underlying architecture. Additionally, employed technologies and frameworks can become obsolescent or are not updated anymore. In particular, research software is often not structured with a maintainable and extensible architecture [2]. This causes a challenging task for developers during the development, especially when inexperienced collaborators like students are involved. Based on several drivers, like technical issues or occurring organization problems, many research and industrial projects need to move their applications to other programming languages, frameworks, or even architectures. Currently, a tremendous movement in research and industry constitutes a migration or even modernization towards a microservice architecture, caused by promised benefits like scalability, agility, and reliability [3]. Unfortunately, the process of moving towards a microservice-based architecture is difficult, because there a several challenges to address from both technical and organizational perspectives [4]. In this paper, we report on the modularization process of our open source research project *ExplorViz* towards a more collaboration-oriented development process on the basis of a microservice architecture. We later call the outdated version *ExplorViz Legacy*, and the new version just *ExplorViz*.

The remainder of this paper is organized as follows. In Section II, we illustrate our problems and drivers for a modularization and architectural modernization. Afterwards, we illustrate our software system and underlying architecture of *ExplorViz Legacy* in Section III. The following modularization and modernization process as well as the target architecture of *ExplorViz* are described in Section IV. Section V introduces our proof of concept in detail, including an evaluation based on several developed extensions. Our ongoing work in terms of achieving an entire microservice architecture is presented in Section VI. Section VII discusses related work on modularization and modernization towards microservice architectures. Finally, the conclusions are drawn and an outlook is given.

II. Problem Statement

The open source research project *ExplorViz* started in 2012 as part of a PhD thesis and is further developed and maintained until today. *ExplorViz* enables a live monitoring and visualization of large software landscapes [5], [6]. The tool has the objective to aid the process of system and program comprehension for developers and operators. We successfully employed the software in several collaboration projects [7], [8] and experiments [9], [10]. The project is developed from the beginning on GitHub with a small set of core developers and many collaborators (more than 30 students) over the time. Several extensions have been implemented since the first version, which enhanced the tool's feature set. Unfortunately, this led to an unstructured architecture due to an unsuitable collaboration and integration process. In combination with technical debt and issues of our employed software framework

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and underlying architecture, we had to perform a technical and process-oriented modularization. Since 2012, several researchers, student assistants, and a total of 25 student theses as well as multiple projects contributed to *ExplorViz*. We initially chose the Java-based Google Web Toolkit (GWT) [11], which seemed to be a good fit in 2012, since Java is the most used language in our lectures. GWT provides different wrappers for Hypertext Markup Language (HTML) and compiles a set of Java classes to JavaScript (JS) to enable the execution of applications in web browsers. Employing GWT in our project resulted in a monolithic application (hereinafter referred to as *ExplorViz Legacy*), which introduced certain problems over the course of time.

1) Extensibility & Integrability: ExplorViz Legacy's concerns are divided in core logic (core), e.g., predefined software visualizations, and extensions. When *ExplorViz Legacy* was developed, students created new git branches to implement their given task, e.g., a new feature. However, there was no extension mechanism that allowed the integration of features without rupturing the core's code base. Therefore, most students created different, but necessary features in varying classes for the same functionality. Furthermore, completely new technologies were utilized, which introduced new, sometimes even unnecessary (due to the lack of knowledge), dependencies. Eventually, most of the developed features could not be easily integrated into the master branch and thus remained isolated in their feature branch.

2) Code Quality & Comprehensibility: After a short period of time, modern JS web frameworks became increasingly mature. Therefore, we started to use GWT's JavaScript Native Interface (JSNI) to embed JS functionality in client-related Java methods. Unfortunately, JSNI was overused and the result was a partitioning of the code base. Developers were now starting to write Java source code, only to access JS, HTML, and Cascading Style Sheets (CSS). Furthermore, the integration of modern JS libraries in order to improve the user experience in the frontend was problematic. Additionally, Google announced that JSNI would be removed with the upcoming release of Version 3, which required the migration of a majority of client-related code. Google also released a new web development programming language, named *DART*, which seemed to be the unofficial successor of GWT. Thus, we identified a potential risk, if we would perform a version update. Eventually, JSNI reduced our code quality. Our remaining Java classes further suffered from ignoring some of the most common Java conventions and resulting bugs. Students of our university know and use supporting software for code quality, e.g., static analysis tools such as *Checkstyle* [12] or *PMD* [13]. However, we did not define a common code style supported by these tools in *ExplorViz Legacy*. Therefore, a vast amount of extensions required a lot of refactoring, especially when we planned to integrate a feature into the core.

3) Software Configuration & Delivery: In *ExplorViz Legacy*, integrated features were deeply coupled with the core and could not be easily taken out. Often, users did not need all features, but only a certain subset of the overall functionality. Therefore, we introduced new branches with different configurations for several use cases, e.g., a live demo. Afterwards, users could download resulting artifacts, but the maintenance of related branches was cumbersome. Summarized, the stated problems worsened the extensibility, maintainability, and comprehension for developers of our software. Therefore, we were in need of modularizing and modernizing *ExplorViz*.

III. *ExplorViz Legacy*

The overall architecture and the employed software stack of *ExplorViz Legacy* is shown in Figure 1. We are instrumenting applications, regardless whether they are native applications or deployed artifacts in an application server like Apache Tomcat. The instrumentation is realized by our monitoring component, which employs in the case of Java *AspectJ*, an aspect-oriented programming extension for Java [14]. *AspectJ* allows us to intercept an application by bytecode-weaving in order to gather necessary monitoring information for analysis and visualization purposes. Subsequently, this information is transported via (Transmission Control Protocol (TCP) towards a server, which hosts our GWT application. This part represents the two major components of our architecture, namely *analysis* and *visualization*. The *analysis* component receives the monitoring information and reconstructs traces. These traces are stored in the file system and describe a software landscape consisting of monitored applications and communication in-between. Our user-management employs a *H2 database* [15] to store related data. The software landscape *visualization* is provided via Hypertext Transfer Protocol (HTTP) and is accessible by clients with a web browser. GWT is an open source framework, which allows to develop JS front-end applications in Java. It facilitates the usage of Java code for server (backend) and client (frontend) logic in a single web project. Client-related components are compiled to respective JS code. The communication between frontend and backend is handled through asynchronous remote procedure calls based on HTTP. In *ExplorViz Legacy*, the advantages of GWT proved to be a drawback, because every change affects the whole project due to its single code base. New developed features were hardwired into the software system. Thus, a feature could not be maintained, extended, or replaced by another component with reasonable effort. This situation was a leading motivation for us to look for an up-to-date framework replacement. We intended to take advantage of this situation and modularize our software system in order to move from a monolithic, to a distributed (web) application divided into separately maintainable and deployable backend and frontend components.

IV. Modularization Process and Architecture of *ExplorViz*

The previously mentioned drawbacks in *ExplorViz Legacy* and recent experience reports in literature about successful applications of alternative technologies, e.g., Representational State Transfer (REST or RESTful) Application Programming Interfaces (API) [16], [17], were triggers for a modularization and modernization. In [18], we gave a very brief description on the modernization process of *ExplorViz* towards a microservice architecture. During the modularization planning phase, we started with a requirement analysis for our modernized software system and identified technical and development process related impediments in the project. We kept in mind that our focus was to provide a collaborative development process, which encourages developers to participate in our research project [18]. Furthermore, developers, especially inexperienced ones, tend to have potential biases during

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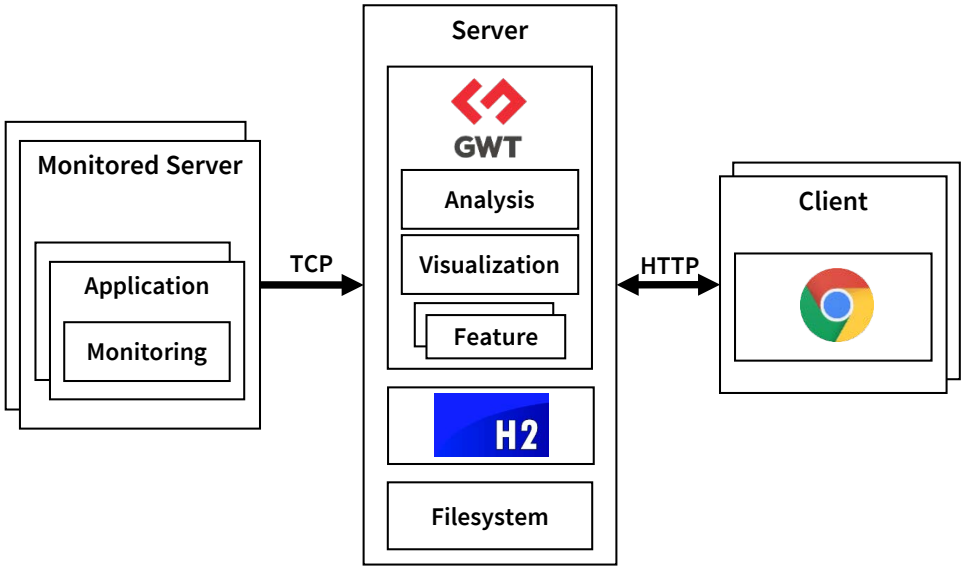

Figure 1: Architectural overview and software stack of *ExplorViz Legacy*.

the development of software, e.g., they make decisions on their existing knowledge instead of exploring unknown solutions [19]. A more detailed description of decision triggers and the decision making process will be published in a technical report [20]. In general, there exist many drivers and barriers for microservice adoption [21]. Typical barriers and challenges are the required additional governance of distributed, networked systems and the decentralized persistence of data.

As a result of this process, we agreed on building upon an architecture based on microservices as shown in Figure 2. This architectural style offers the ability do divide monolithic applications into small, lightweight, and independent services, which are also separately deployable [3], [22]–[24]. However, the obtained benefits of a microservice architecture can bring along some drawbacks, such as increased overall complexity and data consistency [25].

1) Extensibility & Integrability: In a first step, we modularized our GWT project into two separated projects, i.e., backend and frontend, which are now two self-contained microservices. Thus, they can be developed technologically independent and deployed on different server nodes. This allows us to exchange the microservices, as long as we take our specified APIs into account. The backend is implemented as a Java-based web service based on the *Jersey Project* [26], which provides a RESTful API via HTTP for clients. Furthermore, we replaced our custom-made monitoring component by the monitoring framework *Kieker* [27]. This framework provides an extensible approach for monitoring and analyzing the runtime behavior of distributed software systems. Monitored information is sent via TCP to our backend, which employs the filesystem and *H2* database for storage. The frontend uses the JS framework *Ember.js*, which enables us to offer visualizations of software landscapes to clients with a web browser [28]. Since *Ember* is based on the model-view-viewmodel architectural pattern, developers do not need to manually access the Document Object Model and thus need to write less source code. *Ember* uses *Node.js* as execution environment and emphasizes the use of components in web sites, i.e., self-contained, reusable, and exchangeable user interface fragments [29]. We build upon these components to encapsulate distinct visualization modes, especially for extensions. Communication, like a request of a software landscape from the backend, is abstracted by so-called *Ember* adapters. These adapters make it easy to request or send data by using the convention-over-configuration pattern. The introduced microservices, namely backend and frontend, represent the core of *ExplorViz*. As for future extensions, we implemented well-defined extension interfaces for both microservices, that allow their integration into the core.

2) Code Quality & Comprehensibility: New project developers, e.g., students, do not have to understand the complete project from the beginning. They can now extend the core by implementing new mechanics on the basis of a plug-in extension. Extensions can access the core functionality only by a well-defined read-only API, which is implemented by the backend, respectively frontend. This high level of encapsulation and modularization allows us to improve the project, while not breaking extension support. Additionally, we do no longer have a conglomeration between backend and frontend source code, especially the mix of Java and JS, in single components. This eased the development process and thus reduced the number of bugs, which previously occurred in *ExplorViz Legacy*. Another simplification was the use of *json:api* [30] as data exchange format specification between backend and frontend, which introduced a well-defined JavaScript Object Notation (JSON) format with attributes and relations for data objects.

A. Software Configuration & Delivery

One of our goals was the ability to easily exchange the microservices. We fulfill this task by employing frameworks, which are exchangeable with respect to their language domain, i.e., Java and JS. We anticipate that substituting these frameworks could be done with reasonable effort, if necessary. Furthermore, we offer pre-configured artifacts of our

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software for several use cases by employing Docker images. Thus, we are able to provide containers for the backend and frontend or special purposes, e.g., a fully functional live demo. Additionally, we implemented the capability to plug-in developed extensions in the backend, by providing a package-scanning mechanism. The mechanism scans a specific folder for compiled extensions and integrates them at runtime.

V. Proof-of-Concept Implementation

We realized a proof-of-concept implementation and split our project as planned into two separate projects – a backend project based on *Jersey*, and a frontend project employing the JS framework *Ember*. Both frameworks have a large and active community and offer sufficient documentation, which is important for new developers. As shown in Figure 2, we strive for an easily maintainable, extensible, and plug-in-oriented microservice architecture. Since the end of our modularization and modernization process in early 2018, we were able to successfully develop several extensions both for the backend and the frontend. Two of them are described in the following.

1) Application Discovery: Although we employ a monitoring framework, it lacks a user-friendly, automated setup configuration due to its framework characteristics. Thus, users of *ExplorViz* experienced problems with instrumenting their applications for monitoring. In [31], we reported on our application discovery and monitoring management system to circumvent this drawback. The key concept is to utilize a software agent that simplifies the discovery of running applications within operating systems. Furthermore, this extension properly configures and manages the monitoring framework. The extension is divided in a frontend extension providing a configuration interface for the user, and a backend extension, which applies this configuration to the respective software agent lying on a software system.

Finally, we were able to conduct a first pilot study to evaluate the usability of our approach with respect to an easy-to-use application monitoring. The improvement regarding the usability of the monitoring procedure of this extension was a great success. Thus, we recommend this extension for every user of *ExplorViz*.

2) Virtual Reality Support: An established way to understand the complexity of a software system is to employ visualizations of software landscapes. However, with the help of visualization alone, exploring unknown software is still a potentially challenging and time-consuming task. For this extension, three students followed a new approach using Virtual Reality (VR) for exploring software landscapes collaboratively. They employed head mounted displays (HTC Vive and Oculus Rift) to allow the collaborative exploration of software in VR. They built upon our microservice architecture and employed WebSocket connections to exchange data to achieve modular extensibility and high performance for this real-time user environment. As a proof of concept, they conducted a first usability evaluation with 22 probands. The results of this evaluation revealed a good usability and thus constituted a valuable extension to *ExplorViz*.

VI. Restructured Architecture and new Process

Our modularization approach started by dividing the old monolith into separated frontend and backend projects [18]. Since then, we further decomposed our backend into several microservices to address the problems stated in Section II. The resulting, restructured architecture is illustrated in Figure 3 and the new collaborative development process is described below. As reported in Section V, the new architecture already improved the collaboration with new developers who realized new features as modular extensions.

1) Extensibility & Integrability: Frontend extensions are based on *Ember's* addon mechanism. The backend, however, used the package scanning feature of *Jersey* to include extensions. The result of this procedure was again an unhandy configuration of a monolithic application with high coupling of its modules. Therefore, we once again restructured the approach for our backend plug-in extensions. The extensions are now decoupled and represent separated microservices. As a result, each extension is responsible for its own data persistence and error handling. Due to the decomposition of the backend, we are left with multiple Uniform Resource Identifiers (URI). Furthermore, new extensions will introduce additional endpoints, therefore more URIs again. To simplify the data exchange handling based on those endpoints, we employ a common approach for microservice-based backends. The frontend communicates with an API gateway instead of several single servers, thus only a single base Uniform Resource Locator (URL) with well-defined, multiple URIs. This gateway, a *Nginx* reverse proxy [32], passes requests based on their URI to the respective proxied microservices, e.g., the landscape service. Furthermore, the gateway acts as a single interface for extensions and offers additional features like caching and load balancing. Extension developers, who require a backend component, extend the gateway's configuration file, such that their frontend extension can access their complement. The inter-service communication is now realized with the help of *Apache Kafka* [33]. *Kafka* is a distributed streaming platform with fault-tolerance for loosely coupled systems. The decomposition into several independent microservices and the new inter-service communication approach both facilitate low coupling in our system.

2) Code Quality & Comprehensibility: The improvements for code quality and accessibility, which were introduced in our first modularization approach, showed a perceptible impact on contributor's work. For example, recurring students approved the easier access to *ExplorViz* and especially the obligatory exchange format *json:api*. However, we still lacked a common code style in terms of conventions and best practices. To achieve this and therefore facilitate maintainability, we defined compulsory rule sets for the quality assurance tools *Checkstyle* and *PMD*. In addition with *SpotBugs* [34], we impose their usage on contributors for Java code. For JS, we employ *ESLint* [35], i.e., a static analysis linter, with an *Ember* community-driven rule set. All tools are integrated into our continuous integration pipeline configured in *TravisCI* [36].

A. Software Configuration & Delivery

One major problem of *ExplorViz Legacy* was the necessary provision of software configurations for different use cases. The first iteration of modularization did not entirely solve this problem. The backend introduced a first approach for an integration of extensions, but their delivery was cumbersome. Due to the tight coupling at source code level we had to

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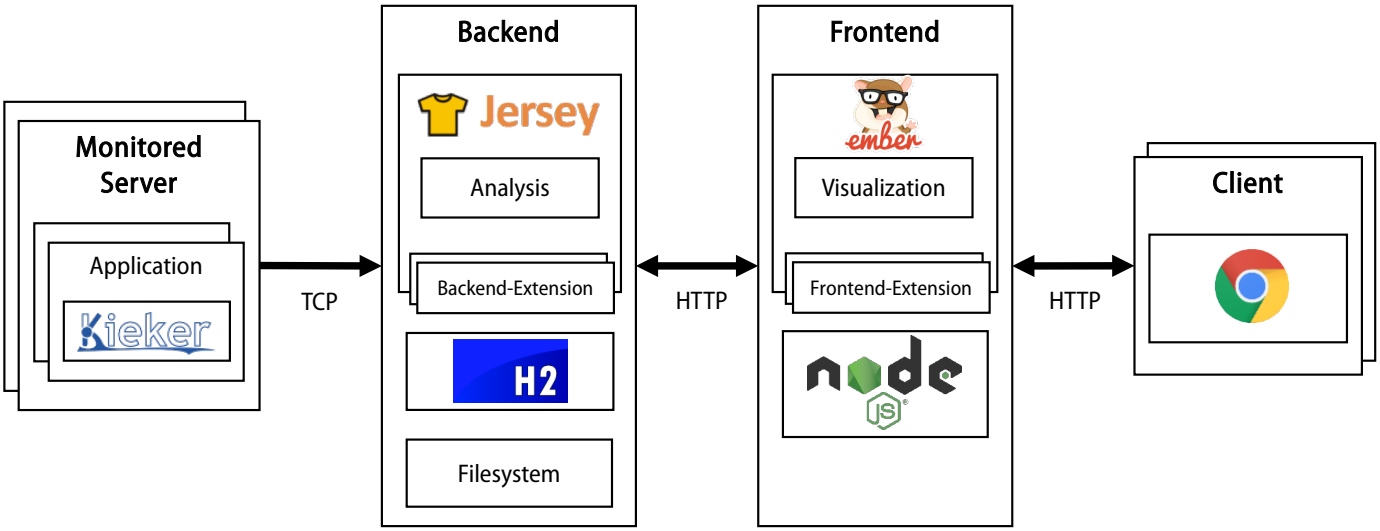

Figure 2: Architectural overview and software stack of the modularized *ExplorViz*.

provide the compiled Java files of all extensions for download. Users had to copy these files to a specific folder in their already deployed *ExplorViz* backend. Therefore, configuration alterations were troublesome. With the architecture depicted in Figure 3 we can now provide a jar file for each service with an embedded web server. This modern approach for Java web applications facilitates delivery and configuration of *ExplorViz*'s backend components. In the future, we are going to ship ready-to-use Docker images for each part of our software. The build of these images will be integrated into the continuous integration pipeline. Users are then able to employ docker-compose files to achieve their custom *ExplorViz* configuration or use a provided docker-compose file that fits their needs. As a result, we can provide an alternative, easy to use, and exchangeable configuration approach that essentially only requires a single command line instruction. The frontend requires another approach, since (to the best of our knowledge) it is not possible to install an *Ember* addon inside of a deployed *Ember* application. We are currently developing a build service for users that ships ready-to-use, pre-built configurations of our frontend. Users can download and deploy these packages. Alternatively, these configurations will also be usable as Docker containers.

VII. Related Work

In the area of software engineering, there are many papers that perform a software modernization in other contexts. Thus, we restrict our related work to approaches, which focus on the modernization of monolithic applications towards a microservice architecture. [25] present a survey of architectural smells during the modernization towards a microservice architecture. They identified nine common pitfalls in terms of bad smells and provided potential solutions for them. *ExplorViz Legacy* was also covered by this survey and categorized by the "Single DevOps toolchain" pitfall. This pitfall concerns the usage of a single toolchain for all microservices. Fortunately, we addressed this pitfall since their observation during their survey by employing independent toolchains by means of pipelines within our continuous integration system for the backend and frontend microservices. [22] present a migration process to decompose an existing software system into several microservices. Additionally, they report from their gained experiences towards applying their presented approach in a legacy modernization project. Although their modernization drivers and goals are similar to our procedure, their approach features a more abstract point of view on the modernization process. Furthermore, they focus on programming language modernization and transaction systems. In [3], the authors present an industrial case study concerning the evolution of a long-living software system, namely a large e-commerce application. The addressed monolithic legacy software system was replaced by a microservice-based system. Compared to our approach, this system was completely re-build without retaining code from the (commercial) legacy software system. Our focus is to facilitate the collaborative development of open source software and also addresses the development process. We are further planning to develop our pipeline towards continuous delivery for all microservices mentioned in Section VI to minimize the release cycles and offer development snapshots.

VIII. Conclusion

In this paper, we report on our modularization and modernization process of the open source research software *ExplorViz*, moving from a monolithic architecture towards a microservice architecture with the primary goal to ease the collaborative development, especially with students. We describe technical and development process related drawbacks of our initial project state until 2016 in *ExplorViz Legacy* and illustrate our modularization process and architecture. The process included not only a decomposition of our web-based application into several components, but also technical modernization of applied frameworks and libraries. Driven by the goal to easily extend our project in the future and facilitate a contribution by inexperienced collaborators, we offer a plug-in extension mechanism for our core project, both for backend and frontend. We realized our modularization process and architecture in

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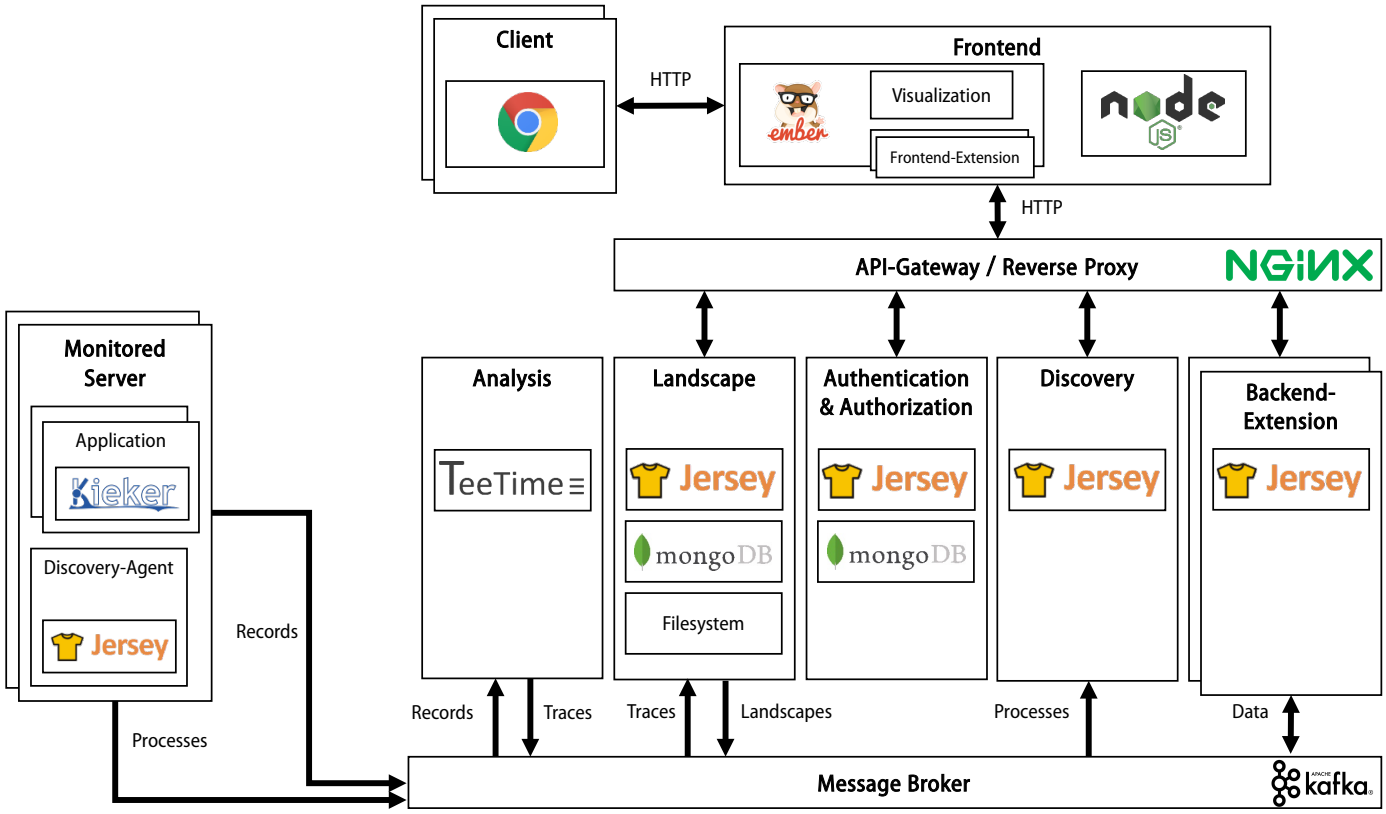

Figure 3: Architectural overview and software stack of the restructured *ExplorViz*.

terms of a proof-of-concept implementation and evaluated it afterwards by the development of several extensions of *ExplorViz*. However, the modularization process is not fully completed, as yet. We are still improving the project in order to achieve a fully decoupled microservice architecture, consisting of a set of self-contained systems and well-defined interfaces in-between. In the future, we are planning to evaluate our finalized project, especially in terms of developer collaboration. Additionally, we plan to move from our continuous-integration pipeline towards a continuous-delivery environment. Thus, we expect to decrease the interval between two releases and allow users to try out new versions, even development snapshots, as soon as possible. Furthermore, we plan to use architecture recovery tools like [37] for refactoring or documentation purposes in upcoming versions of *ExplorViz*.

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Gamification Elements in Immersive Virtual Reality
Comparing the Effectiveness of Leaderboards and Copresence for Motivation

Katharina Jahn
Chair of Information Systems
University of Siegen
Siegen, Germany
e-mail: katharina.jahn@uni-siegen.de

***Abstract*—With the ability to present a completely different environment to users through head-mounted displays, immersive virtual reality (IVR) offers many opportunities to enhance users' motivation and learning. Recent research in the sports context indicates that social facilitation effects occurring with real humans do not necessarily arise when users see a virtual human on a 2D screen. However, whether the increased copresence that immersive virtual reality offers a) can provide increased social facilitation effects compared to 2D screens and b) provides enhanced effectivity compared to traditional gamification elements is still unclear. To investigate this research gap, a 2 (copresence: low vs. high) x 2 (leaderboard: no leaderboard vs. leaderboard) between-subjects laboratory experiment is proposed in this research in progress paper. The expected results can contribute to explain the effects of gamification elements in IVR for intrinsic motivation and performance.**

***Index Terms*—virtual reality; copresence; gamification; multi-user; leaderboards.**

I. Introduction

With Immersive Virtual Reality (IVR) technology becoming more and more affordable, new opportunities arise to facilitate learning. IVR has not only the ability to create a high sense of being in a distant environment (telepresence), it can also create a high sense of owning a virtual body (self-presence), being with others (social presence) and being with others in a distant environment (copresence) [1]–[3]. The experiences made in IVR can indeed affect cognition and behavior [4]–[6]. For example, IVR enables users to see a virtual body visually similar to the self doing sports from both first and third person perspective. When the avatar then gains or loses weight according to activity, long-term activity levels of the user can be facilitated [4]. Such designs relying on embodiment of users are not easily possible without IVR.

The characteristics of IVR offer the possibility to design gamification elements used in traditional devices more effectively, especially in relation to learning scenarios with multiple individuals. Gamification describes the use of game elements in non-gaming contexts and requires the use of gamification design elements [7][8]. Gamification design elements are aimed at motivating or engaging users and are instantiated as objects and mechanics (i.e., interaction rules) [8]. Related to other virtual individuals, they can consist in the inclusion of leaderboards, e.g., a list of the top ten users or displaying multiple users in the application [9][10]. Whereas the inclusion of gamification design elements, such as leaderboards, satisfies individuals' need to feel competent and might induce increased feelings of autonomy, displaying multiple users can satisfy the need for relatedness and can serve a social facilitation effect [11]. According to research on social facilitation and inhibition effects, being observed by other humans while doing a simple task can create social facilitation, whereas it inhibits task performance for complex tasks [12].

For collaborative learning situations, especially the ability of IVR to display quite realistic avatars, which create a high degree of copresence, can create a fundamentally different experience compared to traditional virtual learning environments (e.g., 2D screen at desktop computer). Research on comparing the sense of copresence using a large 2D display or a head-mounted display (HMD) to interact with a single virtual human indicates that individuals can feel the same degree of being colocated in a room with a virtual human in both scenarios [13]. However, their perception in which room they were colocated varied, with participants viewing a 2D environment feeling colocated in the actual room, whereas participants with HMD felt colocated in the virtual room. Additionally, it is still unclear how copresence is affected when copresence with multiple individuals should be elicited.

Up to now, whether the higher immersion offered in IVR a) can be used to recreate social facilitation effects present for real humans and b) can compete against traditional gamification elements is still unclear. To address this research gap, this research in progress paper focuses on the area of facilitating engagement in the sports domain in which users located at different places are colocated in a virtual environment and aims at proposing a design methodology to investigate the following research question:

Research Question. *Which collaborative gamification design elements lead to increased motivation and performance?*

The paper is structured as follows. In Section 2, the hypotheses are developed on the basis of self-determination theory and literature on gamification. In Section 3, the methodological approach is described. Finally, Section 4 concludes with the expected contribution of the proposed experiment and suggestions for future research.

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II. Background and Hypothesis Development

This section describes self-determination theory in relation to gamification to develop hypotheses regarding the effect of copresence and leaderboards on motivation.

A. Self-determination theory and Gamification

Self-determination theory [14][15] describes how humans develop extrinsic and intrinsic motivation. It proposes that the satisfaction of three psychological needs, competence, autonomy, and relatedness, is relevant for the development of motivation. Need for competence describes that individual strive to experience feelings of achievement during interaction with their environment [16]. On the other hand, need for autonomy relates to the experience that actions result from individuals' own volition, whereas need for relatedness describes that individuals strive to belong to other individuals [15]. The development of the research model (see Figure 1) for this research-in-progress paper on the basis of self-determination theory is described below.

For the area of gamification, self-determination theory can act as a theoretical lens to explain how different gamification elements motivate. Sailer et al. [9] could show that the inclusion of badges, leaderboards, and a performance graph increased the satisfaction of need for competence and autonomy compared to presenting only points. On the other hand, when users could choose their avatars and are presented with a story, as well as teammates, their need for social relatedness was more satisfied than when they viewed only points. It is therefore hypothesized that the presentation of leaderboards will increase the satisfaction of need for competence and autonomy.

Hypothesis 1. *Using leaderboards leads to higher satisfaction of need for competence than using no leaderboards.*

Hypothesis 2. *Using leaderboards leads to higher satisfaction of need for autonomy than using no leaderboards.*

Additionally, increased copresence should lead to higher satisfaction of need of relatedness than low copresence.

Hypothesis 3. *High copresence leads to higher satisfaction of need of relatedness than low copresence.*

B. Gamification Elements and Performance

Research on the social facilitation effect of virtual humans can be differentiated in whether it has investigated the effects of virtual humans displayed on traditional 2D screens or in IVR with a HMD.

For 2D screens, research has indicated that being with virtual human has similar effects as being with a real human, at least when the task for which performance is measured is a cognitive task. Specifically with regard to inhibition effects, both virtual humans and real humans inhibit performance for female, but not male participants in a pattern recognition and categorization task [17]. Likewise, with regard to facilitation effects, Liu et al. could show that effects are comparable between virtual humans and real humans, but without detecting gender effects [18]. Additionally, Park et al. could show that social inhibition effects arise for both virtual and real humans in a complex task, whereas for easy tasks, a social facilitation effect could be observed [19]. However, the social facilitation effect comparing presence versus absence of a virtual human of Park et al. could not be replicated in a recent study [20]. Surprisingly, when the task is not a cognitive task but a sports-related, effects between virtual and real humans become apparent, as shown by a recent study [21]. Here, cycling performance could be enhanced when competitive individuals were paired with a real human, but not when they were paired with a virtual human.

In IVR, initial research suggests that social inhibition effects are at a similar level for virtual and real humans, whereas no social facilitation effects could be found for virtual or real humans [22]. Additionally, computer controlled agents seem to provide less copresence than human-controlled avatars, and here, inhibition effects could only be found for human-controlled avatars [23]. One paper compared the effect of HMD and 2D screens, which indicated that inhibition arises only when using IVR but not when using 2D screens for robotic agents [24]. However, all of these studies were conducted in the domain of cognitive tasks. As the research in progress paper at hand is planned in the context of the sports domain, it can be assumed, in line with research on cycling performance [21], social facilitation effects will arise. However, as Snyder et al. could only find social facilitation effects for individuals paired with a real human, it is hypothesized that the high copresence condition will lead to higher performance than the low copresence condition.

Hypothesis 4. *High copresence leads to higher performance than low copresence.*

As previous research on gamification elements has shown that leaderboards increase performance [25], the same is assumed for the context of this study.

Hypothesis 5. *Using leaderboards leads to higher performance than using no leaderboards.*

A meta-analysis in the context of self-determination theory could show that satisfaction of the three psychological needs predicts performance [26]. We therefore hypothesize:

Hypothesis 6. *Performance is positively related to satisfaction of need for competence.*

Hypothesis 7. *Performance is positively related to satisfaction of need for autonomy.*

Hypothesis 8. *Performance is positively related to satisfaction of need for relatedness.*

III. Method

In this section, the set-up of the experiment, the gamification design elements, and the planned data analysis is described.

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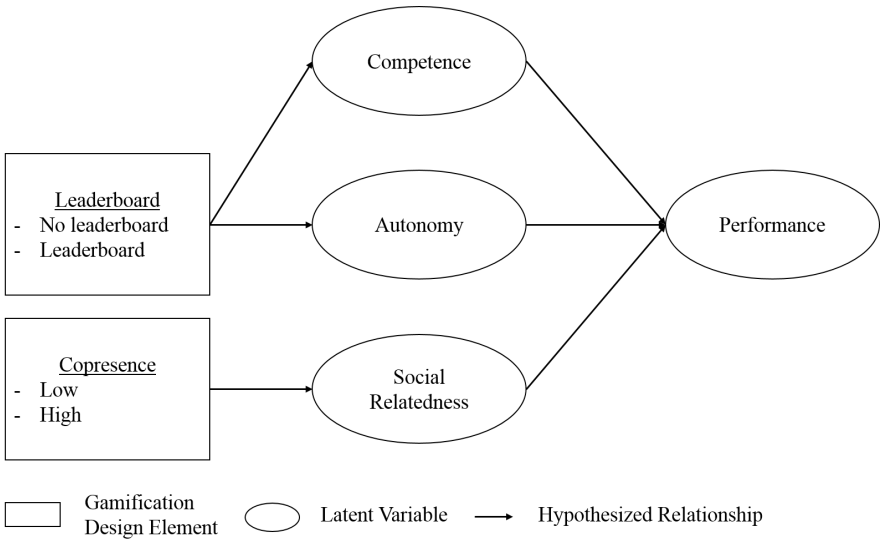

Fig. 1. Research Model

A. Participants and Design

I will use a 2 (copresence: low vs. high) x 2 (leaderboard: no leaderboard vs. leaderboard) between-subjects laboratory experiment with 80 student participants recruited from the local university to test the proposed hypotheses.

B. Materials and Measures

Virtual Reality. Participants will use a virtual environment programmed with Unity 3D displayed with HTC Vive during the experiment. For body tracking, five HTC Vive Trackers (for hip, both feet and both hands) in combination with Hi5 VR Gloves are used. Avatars will be created in Adobe Fuse.

The measurements for the three psychological needs, the manipulation checks, and the indicator for performance are described below. The scales for the three psychological needs and the manipulation checks are measured on a 7-point scale ranging from “strongly disagree” to “strongly agree”.

Satisfaction of Need for Competence. The need for competence scale is taken from Sailer et al. [9] and adapted to the context of the study. The scale consists of four items. One example item is “During the gamified task I had feelings of success”.

Satisfaction of Need for Autonomy. The need for relatedness scale is adapted from the autonomy in relation to task meaningfulness scale from Sailer et al. [9]. The scale consists of three items and one example item is “It was worthwile doing the task”.

Satisfaction of Need for Relatedness. The need for relatedness scale is adapted from Sailer et al. [9]. The scale consists of three items and one example item is “While doing the task I felt like I was part of a team”.

Performance. For learning performance, the times participants have raised their feet in the marching in place task is counted.

Manipulation checks. For copresence, the copresence scale from Poeschl and Doering [27], as well as the copresence scale from Bailenson et al. [28] are used as manipulation check, consisting of three items each. An example item is “”I was aware that other people were with me in the virtual room.” for the Poeschl and Doering scale and “Even when the ’other’ was present, I still felt alone in the virtual room” for the Bailenson et al. scale. For Leaderboards, we use the item ”I was informed about how other players performed on the task” as manipulation check.

C. Gamification Design Elements

Leaderboard. Leaderboards will be implemented by displaying the number of repetitions from five other users. In the no leaderboard condition, an empty leaderboard is presented.

Copresence. In the low copresence condition, participants will see four other virtual humans (2 male, 2 female) who will do the task with them on a television screen. On the high copresence condition, the players will be in the same virtual room as the participants.

D. Procedure

One week prior to the first IVR session, we will invite participants to the laboratory to create pictures for the avatars used in the experiment. One week later, when participants enter the laboratory, they will be fitted with the HTC Vive trackers. When they put on the HMD, they will see a room with a large mirror and a large television screen on the wall in front of them. When they look in the mirror, they see the virtual avatar that looks similar to themselves, which they also see from first person perspective. Participants will see their own points above the mirror and television screen. Additionally, participants in the leaderboard condition see a leaderboard displayed above their points, which they will be made aware of by the experimenter.

For participants in the low copresence condition, the television screen will show four participants who enter the room on the screen and train with them. On the other hand, participants

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in the high co- presence condition, the four trainees enter the same virtual room as the participant. Then, they will be instructed on how to do the marching task. In this task, they have to alternately lift their feet to a specific height displayed in IVR for ten training trials in which the experimenter validates that the participants perform the action correctly. Then, they are told that they can do as many repetitions as they want. After they have finished, participants finish the motivation and presence questionnaire in IVR. Afterwards, they are thanked and debriefed.

Data Analysis: The data will be analyzed using four 2x2 ANOVAs for the three psychological needs competence, autonomy, and social relatedness, as well as performance. Additionally, the complete model will be tested using covariance-based structural equation modeling.

IV. Conclusion and Future Research

The proposed experiment can contribute to literature on gamification and IVR and answering the research question in several ways. First, the study helps to gain insight into which gamification elements are most effective in IVR to increase motivation and performance. Additionally, the experiment contributes to explain motivational working mechanisms of gamification elements against the background of self determination theory. Finally, the experiment can contribute to explain conditions under which social facilitation effects arise. On this basis, future research can investigate whether the proposed working mechanisms of this model generalize to other areas in the sport domain, as well as sport-unrelated domains, such as knowledge work, and application areas outside of IVR. From a practice perspective, collaborative gamification elements can then be used to enhance motivation in multi-user scenarios (e.g., applications supporting health behavior). Furthermore, future research can develop algorithms that implement these collaborative gamification elements efficiently.

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Participatory Approach for a "Collaborative Heritage Observatory"in Tunisia

A (re)appropriation of Tangible Cultural Heritage with and for the citizen

Samia Ben Rajeb
BATir - University of Brussels
Brussels, Belgium
e-mail: samia.ben.rajeb@ulb.ac.be

Hatem Béjar
Edifices & Mémoires Association
Tunis, Tunisia
e-mail: hatembejar@gmail.com

***Abstract*— This article presents an application of a participatory approach that involves the "citizen-participant" for a new appropriation of heritage. It is part of the project " Collaborative Heritage Observatory " funded by the European Union, in collaboration with UNESCO. Via this participatory research approach, we will show 1) how the citizen can support the production of scientific knowledge and 2) how this approach contributes to the construction of a common reference via a shared web platform. The objective is to realign theoretical and technical knowledge with practical and field knowledge. We will examine the complementarity between these two knowledge (theoretical and practical) for the production of new knowledge about the heritage and for a better appropriation of it. We will also dwell on a number of ethical issues imposed by citizen approaches and the limits they face to better apprehend them.**

Keywords- participatory research; heritage; shared database; citizen science; collaborative action research.

I. INTRODUCTION

How to value the richness of the tangible cultural heritage and bring it closer to its citizen? Two opposing visions emerge, faced to this wealth of Tunisian heritage. The first vision is that of the citizen who would judge the value of his heritage in function of its usefulness, its potential of use or its property value, or according to a personal link of the kind "my ancestor lived here ". This first vision, more often than not, generates purely functional and sometimes even destructive solutions. The second vision would be that of the experts (such as architect, researcher, curator, etc.) who would judge the value of the heritage according to a list of national and / or international predetermined criteria. This second vision of heritage, even in the state-of-the-art restoration of buildings, in most cases results in solutions of "museumification" that freeze, isolate and, sooner or later, destroy the heritage through lack of means, maintenance and distancing solutions from the interests of the citizen.

With this "symmetry of non-dialogue", the process of bringing these two visions could be achieved through the definition of a participatory approach that tends to take into account these different points of view and thus gives as much room for the citizen as that granted to the expert for the safeguarding and re-appropriation of built heritage. This article reports feedback on the application of such an approach in the context of a census project, giving rise to a web sharing platform fed by co-reflection between the citizen and the expert.

The contributions of this work consists in setting up a research's methodology called collaborative for 1) allowing an adaptive, self-evolving and controlled approach; 2) aligning the theoretical and practical knowledge for the construction of a common frame of reference, 3) facing ethical questions, 4) perpetuating citizen action to encourage better appropriation of the heritage and to assist and manage the change.

All these points mentioned above are demonstrated in the article. Indeed, it presents, first, the background and the problematic of research that put this research into a context, set its goals and the questions that will be answered within the article. After having identified the epistemological foundations of a participative approach, this article then explains the different stages of the methodology adopted to involve the citizen in the process, while ensuring the validity and reliability of the data relating to the heritage identified. Thirdly, the article shows the results of this approach leading to the development of an online participatory platform that lists several Tunisian buildings of heritage value.

II. RESEARCH BACKGROUND

The subject of this article is part of the project "Collaborative Heritage Observatory" funded by the European Union within the NET-MED YOUTH program, "Cultural Heritage and Civic Engagement of Youth", in collaboration with the UNESCO. The aim of this project is the training of a group of citizens / observers spread all over the Tunisian territory in order to initiate an inventory of fixtures of the architectural heritage, for a duration of two months. The missions of this group were as follows:

- Identify heritage buildings in their respective regions according to pre-defined criteria et inform about the wealth of the existing heritage through publications on the web and in the field;
- Warn about overruns on heritage buildings (total or partial demolition, change of appearance, etc.)

The scientific innovation of this project is on a massive census carried out by non-expert citizens, while involving expert researchers. The aim is to maintain links of dialogue

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and relevant reflections without hierarchical distinction between theoretical knowledge and practical knowledge.

To do this, this research over nine months has brought together three groups:

Edifices & Mémoires (E & M): coordinator and at the initiative of this project, it is an association that works for the re-appropriation and enhancement of the local architectural heritage.

PAE3C - University of Carthage: representing the experts / researchers in this project, this research laboratory brings together several researchers and PhD students specialized in Tunisian architectural and environmental heritage. As part of this project, they have the mission to validate the data collected before distributing it on the web platform.

BATir - University of Brussels: research laboratory specialized in participatory approaches. Its task is to define and implement the participative approach. This article presents this approach, its contributions, its limits and the perspectives recommended to perpetuate this collaboration to support the re-appropriation of the heritage by the citizen.

III. RESEARCH PROBLEM

"To regenerate to not degenerate" is the line that the entire consortium has sought to follow for this project. Today, the aim is to bring the citizen closer to his little-known and often unrecognized heritage by establishing a real mediation between [Table 1]:

- **Two perceptions of the heritage** often in opposition: that of the researchers perceiving the heritage as a testimony of the history, which is necessary to preserve the memory of the past versus that of the citizen perceiving the inheritance as buildings / territories to re-appropriate according to living arrangements today.
- **Two types of actions in relation to built heritage**: that of the researcher whom 1) identifies, 2) diagnoses, 3) classifies, then 4) rehabilitates versus that of the civil society that would instead seek 1) to identify what could be value-added, 2) to make others aware of this not always measurable value, 3) to repair or transform with the means granted to them, 4) to appropriate these new territories according to the needs of the community.

To ensure this mediation, we sought to guarantee a minimum of participative framework allowing these 2 perceptions and actions to converse [1].

The advantages in this context are various to:

- **Reduce** the boundaries between the researcher and the citizen by confronting the theory with the specificity of each context via the various data collected;
- **Go beyond** this reductive definition of the trainer / scientist vs. learner / novice and **transform** rapport to knowledge "learning to learn" by:

Thus, the citizen goes from an actor/learner to actor/trainer who will be responsible for transmitting this knowledge to his immediate entourage.

TABLE I. PARTICIPATORY APPROACH AS A BRIDGE BETWEEN THEORETICAL KNOWLEDGE AND PRACTICAL KNOWLEDGE

Participatory approach *for the safeguarding and the valorization*		
Type of Knowledge	**Theoretical knowledge** Expert actions	**Practical Knowledge** Citizen actions
Actions based on	State of the art	Memory
	History and historical facts	Experience
	Mastery of theories, research and studies conducted around and on Tunisian heritage with a global vision	Increased knowledge of the field with a local vision
	Easy access to documents and privileged links with the legislature	Privileged links with local people
Need for reliability & completeness of information		
Focus	- Documented History - Architectural styles - Conservation techniques - Urban value - Historical value - Remarkable heritage - Classified heritage - Known value ...	- Oral Tradition & Legends - Incorporated know-how -Collective memory - Personal values - Personal story (s) - Noticed heritage - Living heritage - Recognized value...

Nevertheless, the difficulties of such an approach lie in to constantly negotiate the discrepancy and certain contradictions between:

- The needs for framing, standards to be imposed and evaluation practices via committees (defined in terms of the knowledge needed for research) to ensure the scientific of the approach and the reliability of the data collected and;
- A more comprehensive approach that adapts itself to the reality and non-expert knowledge of the citizen and takes into account the implementation of such a scientific framework in the field [2].

The scientific innovation of this research project resides, therefore, in the implementation of a participatory methodology able to align these two perceptions while meeting the limits mentioned above. That is why we will seek to answer various questions: How to conduct participatory research? How to apply it to the Tunisian context and under what conditions? Which results can be expected for each of the project actors: researcher (as an expert in heritage) / association (as representative of civil society) / citizen (as an observer of this heritage)? What methods of collaboration and transmission of knowledge will be observed? However, before answering all these questions, it is necessary to specify our epistemological foundations.

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IV. METHODOLOGY

The participatory approach is often presented as a link between the citizen and the experts. But, it seems essential to us to identify the specificities of these approaches in order to adopt the most appropriate one in this type of project around the theme of built heritage, keeping in mind the following questions (as recommended by J. Y. Antoine and al. [3]).

- **Which approach to follow?** Is it adapted to the concerned actor (both researcher/expert and citizen/novice), but also his social universe (both the Tunisian context in overall and the communal context)? In this article, we explain our methodological framework for the definition of an adaptive, self-evolving approach while being controlled to ensure the scientificity of the data identified [see Section V. A].
- **But why ?** What is the aim of this type of approach? We show how this approach contributed to the construction of a shared repository; the aim is to realign technical and scientific knowledge with practical and field knowledge [see Section V. B].
- **How far ?** While the citizen is being trained, it is difficult for him, in a short time, to apprehend science that is more and more complex and specialized. It is necessary to specify the participatory intervention framework of the citizen by posing a certain number of ethical questions imposed by the citizen processes and the limits which they face.. We, therefore, pause on these points to understand the approach with hindsight and in all its complexity [see Section V. C].

A. Epistemological foundations

Several conceptions/re-conversions/rehabilitations are today used without real concern for future users/inhabitants. The current approaches focus mainly on buildings to be retained in terms of "protection / cost / time / structural and functional quality / safety" [4]. In this type of procedure, three postures are most often considered [5]: 1) observant posture and case study, 2) research and development posture and 3) participatory stances. The three positions meet in the will to produce knowledge but are differentiated mainly their finality and in their methodology. The first seeks to know how things happen by observing, analyzing and evaluating a phenomenon or aspects of this phenomenon [6]. The stakes of research are then nomothetic for the development and specification of theoretical knowledge. The second seeks to develop tools, action models and pedagogical or practical theories by analyzing and improving a production process [7]. The challenge here would be pragmatic via the functional resolution of problems. The third participates in the development of reflexivity relative to a practical situation through social commitment and user involvement [8]. The stakes would be political or ontogenetic. As part of this project, we are clearly aligned with this third so-called participatory stance. With a better understanding of the experience of these inhabitants, their experiences, their (bad) understanding and knowledge about the notion of heritage, their needs, their complex environment that is in perpetual mutation and their interactions with their communities and institutions, it is easier to encourage innovation and accept change [9].

Today, several participatory approaches, the objective of which are to integrate the citizen in an upstream reflection for an intervention at the scale of a building or a district in the design, are defined and put in place in various frames. We will talk about co-design [10], but also collaborative approaches [11], or action-research or intervention-research [12]. In this so-called participatory research, two large families emerge [13]. For one, it is about producing knowledge in order to facilitate a dynamic of change [11] [14]. For the other, it is as much a matter of producing knowledge as of training, thus refusing any hierarchy between "learned knowledge" and "action" [8][15]. In the case of this project, we opted for the second trend especially since training is at the heart of our problem. Since the project tends to collect data with the help of the citizen, we focused on the notion of "Citizen Science".

Citizen science relies on the possibility of building science with the participation of the citizen [16]. This approach is generally developed in the field of nature to collect a maximum of data in a limited time. It brings together three types of actors: the one who needs the data (the institution), the one who gathers the data (the citizen) and the one who facilitates the exchange between the two. "Citizen Science" can be divided into three categories according to the actor who is at the origin of the initiative [17]. In the case of our study, the initiative was initially citizen. Contrary to what one might think, this initiative did not come from scientists although they clearly state their need to collect a large amount of data of Tangible Cultural Heritage scattered throughout the Tunisian territory. This is the originality of our research compared to what was previously done in other contexts of implementation of participatory approaches [3]. A question was quickly asked of us: how is it possible to maintain the action and the motivation to guarantee the commitment of each one (Citizen - Researcher) in a sustainable way in the study, and thus better accompany the change? That is why it was necessary to leave this framework "Applicant (Researcher) vs Executor (Citizen)" and push towards a "co-construction" of the objective and the approach to be implemented, between scientists and citizens. The aim is to accentuate the complementarities of the actions and the interests of each one. To do this, the objective of the study has gone beyond the simple data-gathering framework (crowdfunding / crowdsourcing) towards a real collaboration between Citizen & Researcher (co-design). As defined by J. Y. Antoine and al. [3], the co-design in research implies the "co-construction of the scientific question to be tackled, operate a mediation / training that allows all actors to understand the issues involved and think about governance ". Therefore, we focused on a citizen position in which the citizen / non-expert becomes an actor in the research who does not feel excluded from the management of the project.

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B. *Targetted objectives*

With the expert researchers (PAE3C) and members of the association (E & M), we defined the objectives of this project, while trying to involve the citizen in the process:

- To collect and record a massive amount of data in a large territory thanks to and with the citizen ;
- To systematically document each of these data according to a predefined methodology taking into account the specificity of each context ;
- To ensure the reliability of data through regular and online support via a scientific committee and a technical committee ;
- To archive, reveal and disseminate the results via an online platform open to any public ;
- To gradually co-build a shared repository of knowledge and concerns of shared valorization ;
- To bring communities together (scientists vs civil society) and reconcile present and past.

Starting from these objectives, we present here the various gradations of citizen involvement, envisaged for the definition of the methodological process implemented. Indeed, our role was initially pedagogical, in addition to managing the transition between the different partners.

To allow this gradation during this methodological process, we have increased the contribution of the citizen by gradually passing from "observer status for the census project" to the status of "an actor in the valorization project".

C. *Choice of phases of the process*

The phases of the participative methodology have been specified to ensure the monitoring of a scientifically valid data and the reliability of the information. Each of these phases was presented to observers-citizens. Elements had been prepared and put at their disposal according to the objectives of each phase. Tools were had also been developed and tested and updated with and by these citizen-observers for a better appropriation of the methodology that was imposed on them. By involving them in the validation and improvement of the elements provided, we seek to empower them and to involve them as much as possible in the project for more sustainable and effective change management. Table II details each phase (first column) by specifying the different elements that have been given and prepared (second column) according to the objectives targeted by our participative methodology (third column). The results obtained at the end of each phase were also detailed in Table II.

TABLE II. MAIN STEPS OF THE PROCESS

Phases	Prepared / Given Elements		Objectives Targeted	Results
1) Choice of observers	**1.1) Launch of the invitation**	Intensive publication on the web and social networks	Spread the invitation and explain the conditions of participation	239 applications throughout the Tunisian territory
	1.2) Pre-selection by file	First evaluation according to selection criteria: (availability, residence, historical interest for its region)	To reach the widest fringes of society and thus form a multidisciplinary team.	40th of candidatures (2 to 3 candidates per region)
	1.3) Definitive selection	Second evaluation according to selection criteria: (degree of involvement: in the social actions and in local activities in their region)	Objectively identify the applications taking into account each social and regional environment.	15 observers located in the different regions of the Tunisian territory
	1.4) Dissemination of results	Intensive publishing on the web and social networks	Explain and "legitimize" their action in their regions	Make direct contact with local associations
2) Training	> 3 days of co-located training > 5 proposed themes: 1) Historical landmarks and legal framework, 2) Concrete realities of cities and municipal interventions, 3) Diversity of points of view on Tunisian heritage, 4) Methodology of collection and encoding of data 5) "Patrimonialization" & Heritage Value Creation) > Development of a WEB application for information encoding and 1st field test		> Encourage formal and informal moments of exchange, by mixing citizens with scientists, professionals from the field and members of other associations > Train the observers and federate the group for the project > Allow better appropriation of the method by the observers	> Creation of a collective dynamic > Construction of a common reference on Tunisian heritage > Immediate update of the web application according to the first feedback given by the post-test observers.
3) Deployment	Authorizations given by local authorities > Allowance payment per month > Shared web platform with a grid of criteria to be filled in by the citizen observer, guaranteeing: 1 - the ergonomics of the interface, ease of understanding, feeding and use by observers; 2 - possibility of verifying the veracity of the information and its source; 3- automatic processing of these data, so that they are easily communicable for verification and publication.		> Visit and capture officially and legitimately the data on the site > Cover travel and communication expenses during the mission > Facilitate the census task, re-enforce communication, harmonize data, ensure reliability and maintain a rigorous and repeatable methodology	520 sites identified in 2 months indicating various information: - General information - Justification of the relevance of the choice of this building (architectural value, historical, symbolic, potential use, social, urban, landscape, etc.) - Stories of the place - List of information collected

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	4- possibility to declare "I do not know", to not be tempted to fill in some data without control of the content. > Web page for sharing useful documents, communication and feedback	> Ensure regular and repeated monitoring between the different monitoring committees and the citizen observers, etc.	(bibliographic sources, webography, documents, photos, videos, statements, testimonials, etc.)
4) Validation and publication of data	> Specification of a validation method of the data in 3 steps: 1- Validation in principle by the technical committee on: the handling of the grid (have all the data been encoded?) + Correct spelling and comprehensible sentences + relevance of the chosen building 2- Validation of the content by expert readers via a criterion grid 3- Final validation by the technical committee which verifies the availability of all the resources and takes into account the remarks of the scientific committee > Publication of data in a geo-located web platform with: - "No mention" if validation stopped in step 1 of this phase - Mention "Peer Review" if the validation passed through the 3 stages of this phase	> Achieve a publishable and useful verifiable result for future analyzes, diagnostics and research > Indicate the degree of reliability of the encoded data > Guarantee a massive and reliable census of geo-located data	> 487 (/ 520) have been identified on the web platform accessible to all public > 124 (/ 487) are marked "Peer review"

V. FROM PARTIPATORY RESEARCH (CITIZEN SCIENCE) TO PARTICIPATORY ACTION RESEARCH (CO-RESEARCH)

The success of the project lies in two aspects. The first is the massive census capacity that has been realized. The web interface [18], which has been online for more than a year and roughly summarized 160 sites, reveals today more than 520 sites, in two months of the project, with a detailed description and the scientific validation of approximately a quarter of them. The second concerns the process itself. By involving the citizen and bringing together these two types of perceptions (which may seem opposite - cf. Table 1), the approach presented here has allowed to create a dynamic within the group, to involve joint interactions, a reflection on oneself, a mutual adjustment, the co-construction of negotiated meaning and knowledge about how current heritage might be appropriate. This is what we will show by developing our results in this article.

A. Ensure a dynamic, adaptive, self-evolving and controlled approach

The participatory approach applied here aims at being dynamic, considering the citizen as a partner in research, who must jointly assume the credibility of the data collected. As the project develops, we notice that observers also become responsible for disseminating and valuing the data they have collected.

By asking questions to people in their community, residents see themselves as mediators between themselves and the administrators of this heritage that they mix with daily. Their actions with their respective communities become concrete through an educational and empowering process. It is in this that the approach goes beyond the framework of traditional research in social sciences because there is not explicitly a clear separation between the expert and the novice, between the one who does research and the one who lives in the studied situation. These citizens-observers will also seek, little by little, an emancipatory perspective where they claim their will to change the situation after becoming aware of the state of disrepair in which they find their heritage. This awareness grew as the census exercise evolved.

Even if the methodology set up, via the grid and the predefined phases, could seem fixed, the approach adopted here has gone beyond the "citizen science" framework where the citizen becomes an actor only at the level of data collection. It is adaptive and self-evolving in the framework of a process that encourages reflexivity: by empowering citizens/observers, ensuring feedback between the different committees (scientific and technical), encouraging co-analysis where it is demanded. These citizens/observers are asked to present the data they collected themselves and, as far as possible, to be co-authors with the committees. This equivalence relationship between expert/researcher and observer/citizen is an essential condition to ensure the success of the process [19].

It should be noted that the explanation of the objectives, the phases of the process (what? How? Why?) and the joint identification of the working hypotheses confronted with the reality of the field, participated in a better appropriation of the "citizen science" approach, to move little by little towards co-research. This new approach has allowed more space for the expression of opinions and positions where theoretical knowledge and practical knowledge complement each other, opening the possibility for complementary and mutual interactions. Nevertheless, even if the approach is citizen and self-evolving it must be structured and responds to a real need for reliability of the data entered. It is therefore essential not to forget that this approach must also guarantee a scientific approach that introduces certain conditions, such as objectivity, the specification of a framed method, the possibility of controlling these data, peer verification and reproducibility of the operation. This is why the approach proposed here follows very specific steps defined above with the establishment of various committees managing the various aspects of research with feedback from the field.

B. *Building a common reference framework between theoretical knowledge and practical knowledge*

As part of the project "Collaborative Heritage Observatory" the 15 applications that were selected came from various fields of specialization, with an age range varying between 20 and 40 years. Not all of them required extensive knowledge of heritage. Nevertheless, the approach taken here allowed the construction of a group culture through a learning process that arose from the interaction of knowledge between scientific theories and historical facts to the knowledge of the field, and the workings of the environment hosting this building. This interaction not only contributed to the construction of a common feeling, but we notice that new negotiated knowledge emerges by taking into account the knowledge and the aims of each one. These activities of co-construction of knowledge constitute a means 1) of development of expertise relating to the heritage and 2) of self-reflection from the point of view that each one brings as well as on the way of reacting faced with this heritage, which tends to being degraded and/or being demolished without real awareness of its potentialities and values. It is thus a question of creating dynamics of adjustment between the interests, the stakes and the logics of the two communities (between researchers and citizen, between experts and novices). Through the interviews conducted during the project, we were able to observe that this awareness and this process of self-reflection and adjustment concerns the observers/citizens and the experts/researchers involved in the training and the scientific committee. The project's stakeholders were thus positively influenced to support learning and cross-reflections. The driving force behind this project was the ability of the observers 1) to reflect on their census task, the influence it could have on their entourage and knowledge of the heritage, and 2) to act according to their understanding that they have of the context of their actions (social, economic, urban and political). The interviews conduced show the contribution of such an approach in the construction of a common reference system connecting technical and scientific knowledge and practical and field knowledge. This realignment of knowledge is the cornerstone for better understanding and appropriation of built heritage through these material and immaterial data.

C. *Solving ethical issues*

Adopting a citizen approach requires us to ask ourselves a certain number of ethical questions, such as remuneration, the limits of a lack of expertise, the mastery of a specific scientific language and technical terms, copyrights or legitimacy of negotiated knowledge.

Remuneration. Many authors raise the question of the remuneration of collected data in the framework of citizen research [20]. For the definition of our approach, we took the position relative to the economic and social context of the country. Indeed, we have chosen to grant compensation because certain areas of the territory remain inaccessible via public transport. Most observers/citizens have to rent a car to access isolated and little-known buildings. It should be noted that it is thanks to this difficult access that many of these buildings have been preserved from any unauthorized transformation and/or destruction. In addition, this allowance also played the role of some recognition for the work done by these citizens and the time spent on the census, which helps to maintain their motivation. Nevertheless, we were able to observe that the involvement of observers/citizens in the census project was such that they asked not to close their access to the census platform so that they could continue this work on their own merits despite the end of the project.

Lack of expertise. It is essential to maintain motivation shared by the experts and observers involved in the project. This motivation is allowed through the involvement and accountability of all stakeholders in the joint definition of the approach to be implemented and in the collection and reliability of the data. From this implication emerges a set of difficulties relating to 1) the appropriation of knowledge and 2) the capacity of actors to negotiate the difficulties that emerge during the process and the means implemented to mitigate them. This is why it was essential that the approach be adaptive, not depending on the observer's ability to correctly follow the phases of the defined methodology but on the *"real appropriation of the knowledge mobilized in order to modify their social practices, their understanding and their environment "*, as underlined by C. Gonzalez-Laporte [13]. Nevertheless, it is difficult to gauge the ability of observers to appropriate this knowledge. Thus, we equipped them by putting them in direct contact with local experts that they can call on in case of doubt. We also imposed them to put the listing of all the sources used by the observers to give information relative to the listed building. This list is crucial for scientific validation, reliability and cross-referencing of the data. It should be noted that all these sources have imposed the opening of a server in which all collected data (video, audios, documents, pictures, etc.) are deposited and collected before closing a file on a building.

Legitimacy of negotiated knowledge. We must be fully aware that it is difficult to envisage, through this type of participatory approach, the total accuracy of these collected data and the universality of the knowledge that is produced there. It is the knowledge that can be progressively and collectively enriched by the feedback allowed by the platform. Any expert consulting the web page of the map project " Collaborative Heritage Observatory "can make a comment, supplement the information given or contradict it if it demonstrates the source. In this sense, the experience of the citizen and the reality of the environment in which he evolves are as essential to the success of the project as the theoretical and technical knowledge of experts in historic buildings. It is, therefore, a democratic first step in which the advancement of knowledge is discussed and promotes debate by identifying problems and proposing possible solutions adapted to the context in question. But we still notice that it is necessary to guarantee a minimum of critical detachment on both the practical reality and the theoretical conceptualization of a deteriorating heritage.

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Copyright. Collective analysis and the production of negotiated knowledge automatically raise the issue of copyright. Whom does this data belong to? Who could exploit them and for which purpose and for which framework? Initially, this problem was circumvented by having all observers/citizens a signed contract in which they assign the right to the association on all data collected in the context of this project. Nevertheless, it was decided, following a real desire expressed by the entire consortium to integrate a co-research approach, for each data published on the web platform to be indicated the name of the observer who harvested as well all of his resources. This new positioning has contributed to strengthening the accountability and commitment of the various actors in the project.

D. Ensure the sustainability of the "Collaborative Heritage Observatory"

In the association's response to UNESCO's call for proposals, it was proposed to involve "*Lamda*" citizens whose specialization and/or profession does not have a direct relationship with heritage. Nevertheless, by jointly identifying the citizen approach to be adopted, it was decided that this first generation of 15 observers should be selected, not with their specialty, but according to their degree of involvement in associative actions that could directly or indirectly concern the heritage. The reasons for this choice are many.

The first reason being the limited duration of the training, it is difficult to 1) initiate a person to the scientific approach, the variety and the complexity of this heritage, but also 2) bring it closer to the problematic of architectural heritage and debates surrounding it. The second reason is the proximity and involvement of the citizen in the activities and issues of his community. We started from the hypothesis that it is thanks to his level of implication and knowledge of the region that he will be able to open a maximum of doors, to count more easily the buildings challenging to access and to speak directly with the inhabitants about their issues and expectations for the heritage buildings around them. Thus, we also record their visions on this architectural heritage.

The third reason, the most essential, is the durability of the Collaborative Heritage Observatory project. Indeed, thanks to the project, it has been possible to train a group of citizens spread over the entire Tunisian territory. The next objective is to go in each of these regions to directly from the premises where our main interlocutors will be the first observers/citizens. The latter will themselves become trainers and will progressively evolve towards a status of regional heritage referents. Cultural visits to heritage buildings could be organized by observers in their respective regions, with the support of the association in order to continue the observation mission. It is through this strategy that we want to perpetuate the project through knowledge negotiated for the transmission, re-appropriation and conduct of social change to and for the heritage of its citizen and with the support of experts.

VI. DISCUSSION

The whole participatory process defined here aims to lead a collective action for a (re)appropriation of Tangible Cultural Heritage with and for the citizen. In just a few months, the number of buildings surveyed has been multiplied by 3. As a result of the project and despite the fact that the observers are no longer paid, more than 50% of them continued to enrich the content of the platform. Today, the page is visited by 12568 people with an attendance rate of an average of 40 a day. This attendance rate has, among other things, helped the E&M association to federate others observers distributed throughout the Tunisian territory. They gradually shifted from 15 "remunerated" heritage observers to 23 "volunteer" heritage observers, 8 of whom were paid observers in the past who now continue to do so on a voluntary basis. The context was a determining variable that conditioned the explanation of this approach so that it could be dynamic, adaptive and self-evolving while being controlled. That is why the whole participatory process was defined here to lead a collective action for change, even to change it from the "Citizen science" (that is, from a simple census carried out by the citizen) to a "Co-research" that involves the citizen in the different stages of the project, so that the process evolves with and thanks to him. To do this, we were guided by the principle that it should be to ensure to 1) making knowledge equivalent, and 2) clarification of representations that the citizen-observers and experts-researchers make of the social reality will encourage "a process of education, development of consciousness and mobilization for action" [13]. This principle is confirmed. Indeed, 73% of observers continue, till today, to warn local authorities and associations when overruns that tend to destroy the Tangible Cultural Heritage of their region are noted. As a result of the project, more than a quarter of them were either 1) involved in associative actions within their locality (as project managers), or 2) registered in third cycle on topics of research about Tunisian heritage and its valorization (3 Phd in Architecture et 1 Phd in Human Sciences). As a result, citizen observers are now privileged partners who also help to raise awareness in their regions. This research work then tends to logic of "learning to learn" and not only "learning for learning". The objective of this project is to open a perspective towards a new (re)appropriation of heritage for and with the citizen. This change is reflected in the way that the citizen/participant looks today at the richness of his heritage and in his relationship with the experts in the field. The observers, who are basically scattered around the various Tunisian regions, have, on their own initiative, created a community of observers and experts, setting up their own web page, for the communication and the experience sharing. This web page has become in fact the new place for various debates around the notion of heritage value and possible future actions. In one year, approximately 3110 interactions between different observers and experts were recorded; about 10 exchanges per day on average related to Tangible Cultural Heritage. Thus, Reflections and debates concerning heritage are no longer reserved for a certain elite. Through

this framework, the citizen is given the means to also expose his point of view on the question of buildings with heritage value for a better appropriation of these.

One of the main limitations of this project is the lack of availability of the Scientific and Technical Committees for the scientific validation of encoded data. Despite their increased investment in the exchanges, only a quarter of this data was validated in Peer review by the experts. In order not to block the planned publication of the recorded data, it was decided that all data that has been validated by the technical committee could be visible on the web platform but without displaying the "Peer Review". Thus, users of the platform can gauge the degree of reliability of the data recorded and published.

We also hope for a transformation at the level of inter-societal relations, for example, to see in the social structures but it is impossible, at this stage of the project, to gauge this parameter.

VII. CONCLUSION

Contributions. This article has made it possible to highlight the contribution of a citizen-centred approach in a context in particular for the production of knowledge and the appropriation of heritage, under the scholarly supervision of the experts. Also, all the data collected have been published on a unique web platform that is now being consulted and nurtured by experts as well as other citizens (excluding project observers). This platform has made it possible to create a shared repository via a clustered and shared broadcast interface. To date, several proposals for co-research and exploitation of this unique and online database are made within the framework of various projects for tourism, heritage research, urban planning, new citizen actions, etc.

Prospects. A crucial phase is to be expected as a result of this project, which consists of analyzing and linking the information collected by the observers. This analysis work will form a basis for global reflection on the heritage that the association wishes to initiate. The next step is to consolidate the already formed group, to encourage the continuation and to accentuate decentralization. A project of a cycle of conferences has already been planned at the end of this research project in different Tunisian sites, under the supervision of observers from the regions concerned.

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Would you like to Participate? – Stakeholder Involvement in the Development Process of Digital Strategies for Municipalities

Kristina Roeding
Chair of Information Systems
University of Siegen
Siegen, Germany
kristina.roeding@uni-siegen.de

Hans Christian Klein
Chair of Information Systems
University of Siegen
Siegen, Germany
christian.klein@uni-siegen.de

Frederike Marie Oschinsky
Chair of Information Systems
University of Siegen
Siegen, Germany
frederike.oschinsky@uni-siegen.de

Andreas Weigel
Chair of Information Systems
University of Siegen
Siegen, Germany
andreas.weigel@uni-siegen.de

Bjoern Niehaves
Chair of Information Systems
University of Siegen
Siegen, Germany
bjoern.niehaves@uni-siegen.de

***Abstract*—Today there is a high pressure on municipalities to adapt to the digital demands of their citizens and to involve them in decision-making processes. One way to achieve this transformation is with the instrument of digital strategies to guide municipalities' way and to get them involved right at the start. In our case study, we analyzed strategic documents of 22 national and international smart cities regarding participation in the age of digitization. We conducted semi-structured interviews with seven of those cities asking about chances and challenges they had while developing their digital strategies using participatory elements. We also conducted expert interviews and a survey based on our findings from the interviews. One of the key aspects we looked at was the process of involving different stakeholders in the development process of digital strategies. As the development of a digital strategy, as guideline for the digital transformation process of municipalities, we look at the starting point of participatory processes when we look at the development of a digital city. Our results show, that the aim of cities is high to involve different stakeholders. However, it is often hard to encourage stakeholder to participate. We therefore propose important guidelines, which need to be taken care of for participatory processes regarding the development of digital strategies for municipalities.**

Keywords-Digital strategy; digital transformation; participatory process; stakeholder involvement.

I. INTRODUCTION

When it comes to digitization municipalities are often said to be slow and far behind technological developments. Nevertheless, nowadays there are many federal state projects helping to face municipalities' digitization. Federal states try to help their municipalities with state subsidies. The result is that many municipalities use those state subsidies to do projects regarding digitization in different sectors. However, those projects often last only for their duration of funding. Afterwards, the projects cannot be carried on. This is a phenomenon often seen in the public sector. Nevertheless, what can help municipalities to set their projects long lasting? At this point, digital strategies and stakeholder involvement become more and more important.

Recent literature had a look at digital strategies, for example from the business perspective. Digital strategies, in the context of businesses can be defined as "organizational strategy formulated and executed by leveraging digital resources to create differential value", aligned with the existing Information Systems (IS) Literature [1].

Aligning with recent literature that has contributed to a deeper understanding of digital strategies in the IS ([1]-[4]) and digital strategies regarding smart cities [5], we want to aim to continue this tradition in light of current developments regarding stakeholder involvement. Specifically, we seek to shift the focus from previous conceptualizations, to a new form of conceptualization that also takes into account participatory elements of digital strategies, especially for municipalities, regarding stakeholder involvement.

Recognizing the need to get a better understanding of the construct of digital strategies with the focus on stakeholder involvement, the first goal of our study is to contribute to the exiting literature. We want to give clear information about the questions on "how to develop a digital strategy focusing

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on stakeholder involvement?" and "What kind of actors are important to involve in the process of developing a digital strategy?". Our objectives are motivated by the fact, that due to emerging consumer technologies, citizens of different stakeholder groups are more familiar with technological possibilities and have great ideas of how public services should be made available in the digital era.

The remainder of the paper is structured as follows. The second Section gives an overview of digital strategies and participation in the context of smart cities and municipalities. The third Section describes the research design of this study. In Section 4, the findings of the case studies and the survey are presented and in Section 5, we give rise to guidelines for stakeholder involvement. The Discussion is shown in Section 6. Section 7 points out limitations and aspects for future research.

II. BACKGROUND AND BRIEF THEORETICAL REVIEWS

The construct of strategy has been discussed widely in existing literature (e.g., in the IS and management literature) [4]. As an example [3] conducted a comprehensive literature review on IS strategy starting with looking at strategies from the perspective of the management science literature [3]. In their study, IS Strategy was defined as "the organizational perspective on the investment in, deployment, use, and management of information systems" [3]. As a result of their literature review, [3] showed that a variation of expressions (e.g., Information technology (IT) strategy, IS strategy, IS/IT strategy or information strategy) have been introduced in literature to represent the same construct [3]. However, looking at digital strategies shows, that they are understood to be even more, looking not only for examples on the investment and management of information systems but rather on the whole business [1]. Aligning with [1] and [6], such a digital business strategy could be defined as an "organizational strategy formulated and executed by leveraging digital resources to create differential value" [1] and "to support or shape an organization's competitive strategy, its plan for gaining and maintaining competitive advantage"([6] and [15]).

Looking at participation, we notice that participation is widely used as construct for example in the management science literature but also in the smart city literature ([7]-[11],[21],[22]). Against this background and in the context of IS and management science literature, [11] defines participation as "allowing workers to have input regarding a proposed change" (p.134). When we looked at participation, we find that the adaption of the definition of [11] fits best our definition of participation. Aligned with [11], we define participation as allowing citizens to have input regarding a proposed change.

Existing theories have addressed contemporary developments regarding digital strategies or participation in various ways. As an example, Effing et al. [7] developed a Social Smart City framework, which includes a set of digital strategies (e.g., crowdsourcing strategy and open data strategy) for participatory governance in smart cities. Spil et al. [8] showed, using three cities (Hamburg, Berlin and Enschede) as case studies that a quadruple helix structure of citizens, companies, universities and government ensures effective participation. This phenomenon can be seen also by [9], who proposed suggestions regarding actions and projects in smart cities from the quadruple helix, thus creating a "360-degree" model for prioritizing smart city interventions in Greek cities. Ergazakis et al. [10] proposed a Digital City Concept and an integrated methodology for Digital City development in order to help regions and cities to adopt best practices from information technology. However, existing conceptualizations of digital strategies for municipalities and their process of development often did not look at the participatory process, explicitly the involvement of different stakeholders (e.g., politicians, companies, normal citizens, science) in the development process of a digital strategy for municipalities. In order to address our objective, this paper is guided by the following research question (RQ):

RQ: How can different stakeholder be involved in the development process of a digital strategy for municipalities?

III. RESEARCH METHODOLOGY

In order to explore how participatory elements and different stakeholders get involved in the development process of digital strategies for municipalities, we conducted a mixed-method approach of qualitative and quantitative research [13]. The study at hand only shows the results regarding participation. Other elements of the study are published in other formats or conferences. First, we conducted a case study [14] consisting of qualitative and quantitative content analyses of digital strategy documents (aligned to the definition by [15]) in practice (we aligned our process on [15] who followed this methodological approach to conceptualize structural features of digital strategies for municipalities). We looked for criteria as for example, the development process and steps municipalities took to write their digital strategy. Moreover, we looked at how municipalities involved different stakeholders at different levels of their process. From the results of the content analysis, we conducted a qualitative process analysis combined with expert interviews (employees who developed the digital strategy). Afterwards, we reflected our results back to experts (e.g., chief digital officers, chief information officers, digital experts and mayors) in a workshop. Next, we

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conducted with the results from our case studies and based on existing literature a survey addressed towards the digital experts of the municipalities. Our mixed-method approach, aligned with [15] can be seen in Figure 1.

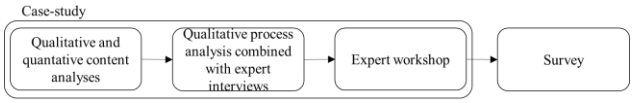

Figure 1. Research Design (aligned with [15])

We used case studies because they are a useful method while investing complex phenomena that have not been fully explored, and do not allow the analysis of causal relationships ([14] and [16]). Furthermore, aligning with [17], case studies allow us an in-depth analysis of phenomena that are related to the context where those phenomena occur [17]. Since our mentioned aspects are relevant to our objective and study, case study research is a well-suited method for the first part of our endeavor [15]. Especially, it is supposed that the strength of case studies lies in their internal validity whilst their weakness is often to be the external validity [15]. In order to increase the external validity of our case study, we introduced two forms of measures: First, our study was conducted in a team. This means, that at least three researchers conducted all phases, which are described in the following. With the use of multiple investigators, we were able to implement triangulation (investigator triangulation ([15] and [16])). As second measure, we included multiple cases to reduce case-specific findings ([14] and [18]). We selected our cases using content-related validity ([15] and [19]). We carefully choose the following 22 cities as cases: Birmingham, Brussels, Cape Town, Copenhagen, Den Haag, Dubai, Duesseldorf, Edmonton, Eindhoven, Gothenburg, Hamburg, Leipzig, London, Manchester, New Orleans, New York City, Oldenburg, Sonderborg, Stavanger, Sydney, Tallinn and Vienna.

With the findings of our case study, we started to develop a survey. Therefore, the survey is comprised out of the findings from different stages of the case studies. In detail, the survey consists out of elements and items, which we hypothesize having an effect on the involvement of stakeholders during the development process of a digital strategy for municipalities. These elements and items are direct findings out of existing digital strategies reflected into the existing literature. For example in our study, we focused on participation as an important dimension evolving out of the qualitative and quantitative analysis of the strategic documents. Participation as possible dimension was confirmed through the expert interviews and later on in the expert workshop. We found a construct fitting our understanding of participation in existing literature. We adapted the construct of participation from [11], e.g., “Which aspects regarding digital strategies play a role regarding participation of citizens? Citizens are able to take part in decision-making processes.”. Aligned with [11] every item of the survey was asked using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). In a next step, we cumulated the answers 1 and 2 from the Likert scale to one new scale called “fully disagree” and 4 and 5 to “fully agree”. Aligned with [15] number 3 of the Likert scale stayed as “neither”. Using relative frequencies [15], we were able to show how often and strong individuals of the municipalities agreed or disagreed with the proposed participatory elements in the development process of digital strategies for municipalities, where each participatory element stayed for itself.

We have to note that our study shows only a small part of a more comprehensive study we conducted regarding digital strategies for municipalities. Therefore, when rolling out our survey, we first run a pretest on 300 municipalities in Germany. We choose municipalities regarding their number of inhabitants in relation to the overall population of the state the municipality is located in. We calculated the number of municipalities taken for a state in relation to the number of municipalities in general [15]. As the survey was going to be run in the federal state of North-Rhine Westphalia (NRW) in Germany, the pre-test was conducted in every state in Germany leaving NRW out of the scope [15].

Afterwards, we adapted our survey regarding the results of the pre-test we conducted. We conducted our final survey in the state of NRW. Aligning with [15], we asked all 396 NRW-municipalities and 31 districts to participate in our study. With a response rate of 34%, 133 municipalities and 12 districts took part in our study.

IV. FINDINGS

Our first findings included findings from the analysis of the strategic documents of 22 smart cities. Those findings from our qualitative and quantitative document analysis showed that in 43% of our analyzed strategic documents of municipalities citizens got involved in developing the digital strategy. In 29% stakeholder from economy and in 52% science got involved. The interviews corroborate this aspect. Developing a digital strategy means setting the direction for the digital transformation. However, a small group of people cannot choose this direction. Different stakeholders need to be involved. Learnings from the interviews showed us that for each smart city it was hard to associate with different stakeholders and to motivate them to get involved in the

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development of a digital strategy as guideline for the digital transformation of their city.

Findings from our survey show that when we asked for responsibilities while developing and implementing a digital strategy we found that mayors take a big part of involvement at this stage. For example, when we asked for "who is responsible for the development of a digital strategy in your municipality?", we found that 82% of the municipalities filled in that the mayor is responsible. In 75% the city counselor, in 84% the head of department, in 42% an employee and in 72% a work group is responsible for the development. When we asked for "who is responsible for the implementation of a digital strategy in your municipality?", we found that 66% of the municipalities filled in that the mayor is responsible. In 64% the city counselor, in 84% the head of department, in 64% an employee and in 60% a work group is responsible for the development. Our findings show that the development stage is one of the responsibilities of the mayor. However, when it comes to the stage of implementing a digital strategy the head of department is responsible for further processes. With this finding, we get to know responsibilities at each stage of the development process of a digital strategy helping us to better understand, who the person in charge is for stakeholder involvement at each step.

Third, we also asked for important aspects regarding citizen participation ("Which aspects regarding citizen participation are important for digital strategies?). We found that in 88% of the municipalities citizens can ask questions. 62% of the municipalities involve citizens in decision-making processes and 51% are getting involved in the implementation of digital strategies. We found that even more than half of the municipalities who took part in our survey are given the possibility to get involved in the process of the development of a digital strategy.

As we concentrated in our study on the involvement of different stakeholders in the development process of a digital strategy for municipalities, we also asked for the involvement of different stakeholders beside citizens. We asked "To which information do you refer to while developing your digital strategy?" and "At your public administration expert knowledge is present." We found that 87% of the municipalities involve external experts in their development of a digital strategy. 50% refer to information from science or involve expert knowledge. 39% involve city-owned companies in the development of a digital strategy.

Aligning with [15], we wanted to control for the employees answering our survey. For this reason, we put a question in the survey, asking for the name and position of the employee. In our study, employees or mayors, who are concentrating on the topic of digitalization in their municipalities, answered each conducted survey.

V. GUIDELINE DEVELOPMENT

With our findings, we were able to give rise to four guidelines for the involvement of different stakeholders in the development process of digital strategies for municipalities. We found, that first, digitalization is a matter of executives, second digitalization needs participatory processes, third digital strategies need competences and fourth digitalization is a joint task.

Digitalization is a matter of executives. The findings show that talking about the development and implementation of digital strategies the person in charge are mayors and the head of the departments. This distribution of responsibility shows that digitalization is a matter of executives who lead the way to digital transformation.

Digitalization needs participatory processes. When we look at the way of how citizens get involved in the development of a digital strategy for their municipality we clearly see that digitalization needs participatory processes. Citizens are often able to ask questions. Nevertheless, when we look at the process of decision-making and implementation, we see that there are still more possibilities to get citizens involved. Municipalities need to work on these possibilities and on ways to get more citizens involved and to make it easier for them to take part in the different processes.

Digital strategies need competences. Looking at the involvement of different experts, science and city-owned companies, we see that the development of a digital strategy needs different competences and different perspectives from a variety of fields of action. Municipalities can still work on the references of information from science and city-owned companies. Different perspectives help municipalities to set their goals long lasting, taking into account different possibilities digitalization can have to help municipalities in their daily life.

Digitalization is a joint task. As last guideline, we see digitalization as a joint task of different stakeholders. Our findings showed us how important it is to get different stakeholders involved. We also could see on which stages of the development process different personas are in charge. Nevertheless, it is important that these different stakeholders

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involved are working together to develop a digital strategy for their municipality.

VI. DISCUSSION

Implications for theory. Aligning with references [7]-[11], we were able to look at participation in the development process of digital strategies. Especially we looked at digital strategies in the public sector for municipalities. Participation in the public sector involves many different stakeholders. Based on our case study we referred to different types of stakeholders extending recent literature ([7]-[9]). Our types of stakeholders involved citizens, economy, and science, functional roles of the public administration, external experts and city-owned companies. We were able to extend the construct of participation from [11] and to adapt it in the public sector.

Implications for practice. With our findings, we were able to give rise to guidelines for municipalities developing a digital strategy. Aligning with the guidelines should help municipalities to define participation their own way and to get different types of stakeholders involved in the development process of a digital strategy.

VII. CONCLUSION

Regardless of the theoretical and practical relevance of our study, it is pointed with difficulties and shortcomings that leave room for future research. Aligning with [15] we have to note, besides the regular limitations of case studies (e.g., its weak internal validations), that our study is of an explorative nature. Its intention is to extend current perspectives on the development process of digital strategies, especially for municipalities regarding the involvement of different stakeholders. Our research can therefore be used to further develop the way different stakeholders can get involved in the development process of digital strategies, but is somewhat weak in its theoretical contribution. Second, in our study the unit of analysis is the municipality. As we asked for the development process of digital strategies for municipalities focusing on stakeholder involvement, only one of the employees of the municipal administration answered our survey representing the whole municipality. We were relying on those employees who answered our survey. Third, as we looked at digital strategies from an IS and management perspective, we defined participation in our study aligning with the results from our case study and aligning with our context of our study. Nevertheless, when we look at participation, this is a construct, which can be seen in a variety of ways. We aligned with the definition of [11], but there are many different possibilities to define participation. We also looked at participation only at the level of the development process of a digital strategy. However, looking at a smart city and their participation processes there is much more which need to be considered as [7] and [8] shows.

In order to overcome these limitations, future research might ask, aligning with [15], more than one employee per municipality and make sure the employees answer the survey by themselves. Future research should also consider a variety of definitions for participation and not only stuck on definitions used in the area of development of digital strategies for municipalities from an IS and management science perspectives. There are more possibilities to define participation. Moreover, looking not only at the development process of digital strategies for municipalities but looking at a smart city gives a wider range of how participation can be defined and realized.

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The role of Social Capital and Collaborative Knowledge Creation in Achieving E-business Innovation:

An Empirical Study

Khaled Saleh Al Omoush
Associate Professor
Al-Zaytoonah University of Jordan
Amman-Jordan
email: k.Alomoush@zuj.edu.jo

Abstract—**The present study aims to examine empirically the interrelationship and impact of social capital and collaborative knowledge creation on e-business innovation. A questionnaire was developed to collect data from manufacturing firms with a sample of 112 respondents. The results reveal a significant impact of social capital on collaborative knowledge creation and achieving e-business innovation. The findings also reveal a direct impact of collaborative knowledge creation on e-business innovations. The present empirical study contributes to a better understanding of the influencing factors of e-business innovations in today's business organizations. This study also provides insights into the interrelationship among social capital, collaborative knowledge creation, and e business adoption and use.**

Keywords-social capital; collaborative knowledge creation; e-business innovation

I. INTRODUCTION

More than ever before, innovation is considered as a necessity for all firms in the new economy due to the ever-growing and fiercely competitive environment [1][2]. With the advent of the knowledge economy, intangible assets have become the main source of competitive advantage. At the same time, advances in e-business technologies are presenting new opportunities to business organizations and entrepreneurs to innovatively rethink and reshape their business strategy. The intangible assets represent the main origin of knowledge, which comes from workforce and firm's relationship with stakeholders [3].

A major part of intangible assets is embodied in the intellectual capital. Prior research conceptualizes intellectual capital as the sum of all knowledge and knowing capabilities that can be utilized to give a company competitive advantage [3]-[5]. The scholars have increasingly focused on the importance of social capital as a major dimension of intellectual capital and an important topic in knowledge management [6]. Social capital, as an approach to understand how people interact with their environment, is increasingly regarded as a vital predictor of innovation. Many previous studies [7]-[12] confirmed the association between social capital and e-business applications.

Social capital is considered as the new approach, which explains the success of innovation [13]. The previous research [14]-[17] emphasized that the organizations are not an isolated entity, but is embedded in a social context, where organizations consistently use their social environment networks to get ideas and gather information and learn to support the process of recognition and develop new entrepreneurial innovations. The previous studies confirmed that social capital plays a pivotal role in the way in which e-business models are perceived, implemented and evaluated. Social capital has been defined as resources embedded in social relationships and networks among individuals, communities, or society, which can be mobilized when an actor wishes to increase likelihood of success in a purposive action [3].

Business attained the perception in which, intangible assets have been recognized as the most important sources of innovation and entrepreneurship [10][14]. The intangible assets are the main origin of knowledge which comes from workforce and firm's relationship with stakeholders [18]. Whilst social capital and collaborative knowledge creation are accepted as significant contributors to sustain competitive advantage, there is limited empirical evidence, investigating the interactive relationship between these constructs and e-business innovation. Furthermore, while the strategic values of knowledge creation practices are clear, most firms are not able to comprehend how these elements can be integrated to enhance their e-business innovation [5]. These social and collaborative capabilities are interesting concepts to perceive how they are related and contribute to establishing e-business innovation. Therefore, the present study aims to examine empirically the interrelationship and impact of social capital and collaborative knowledge creation on e-business innovation.

The rest of this paper is organized as follows. Section II reviews related literature. Then, we propose the research model and hypotheses in Section III. Section IV reports instrument development and data collection and presents the results followed by a discussion of these results, conclusion, limitations and future work of research in section V.

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II. LITERATURE REVIEW

Social capital can be defined as resources embedded in social relationships and networks among individuals, communities, or society, which can be mobilized when an actor wishes to increase likelihood of success in a purposive action [8]. Another definition of social capital introduces it as the combined value of the relationship with customers, suppliers, industry association and other business partners, representing the potential an organization possesses as a result of external intangibles [12]. Léger [9] confirmed that social capital represents the portion of a company's market value that is attributable to its portfolios of business relationships.

Ghane and Akhavan [11] showed how certain values collectively held in a society can be a kind of social capital that benefits the society as a whole, even in the absence of specific links between individual members of that society. Common values and a shared vision, the major manifestations of the cognitive dimension of social capital, may also encourage the development of trusting relationships [8]. A trusting relationship between two parties implies that common goals and values have brought and kept them together [11].

Although individual causal relationships are relatively easier to understand, studies indicate that humans have considerable difficulty in deducing the collective impact of multiple interrelated causal relationships [10]. Nahapiet and Ghoshal [18] use the term intellectual capital to refer to the knowledge and knowing capability of a social collective, such as an organization. It is reflected by the collective abilities of the firm in producing a better solution based on the knowledge possessed by the employees [19]. Social capital ensures that all the collaborating firms trust each other and their collective commitment toward customer satisfaction [20]; therefore, individual firms devote their resources toward their specific competence and expertise in the order fulfillment process. Among the individuals and the formalized organizational structure of a firm, social capital can be defined as the knowledge embedded within, available through, and utilized by interactions among individuals, working groups, and their networks of relationships in a collective way, but without the formality and rigidity of organizational capital [18]. In fact, innovation has also been defined as the most knowledge-intensive organizational process that depends on a firm's individual members and collective knowledge [21].

In general, innovation refers to the generation, acceptance and implementation of new ideas, processes, products or services [2]. According to Rogers [15], innovation is an idea, practice, or object that is perceived as new by the unit of adoption. In the context of business, Scheepers et al. [2] describe innovativeness as the creation of new products, services and technologies. Advances in e-business applications are presenting new opportunities to business organizations to innovatively rethink and reshape their business strategy [1][21]. E-business innovation capabilities can be described as a firm's ability to enhance its technological innovativeness and create new business value propositions by acquiring, utilizing, and using new valuable e-business applications [1].

The literature [9]-[12] has widely investigated the association between social capital and e-business applications. For example, Liu et al. [12] concluded that social capital is a critical driver of substantive performance improvement in the context of e-business. Sambamurthy et al. [22] advocate that, in contemporary firms, e-business innovation results from the collaborative and collective actions of IS and business executives. In the context of social capital, Ghane and Akhavan [11] also suggest that e-business requires a strong intimacy and collaboration among business partners. A considerable stream of research [16][17][23] affirmed that e-business adoption is subject to the values, standards, and expectations shared among business partners and other members of social networks, such as professional and trade associations and accreditation agencies, to attain effective coordination and collaboration and to meet the requirements of professionalization.

A primary factor of productivity and competitiveness in the current economic paradigm includes the capacity of individuals and organizations to create, process and transform knowledge into economic assets [24]. Many previous studies [3][10][12] advocate that, social capital represents the knowledge embedded within, available through, and utilized by interactions among individuals, working groups, and their networks of relationships. Social networks have long been described as effective mechanisms for the transfer and exchange explicit and tacit knowledge [8][10]. They are used not only for information and knowledge exchange, but as a mechanism for identifying who knows what within the network context. Such networks can promote collective and distributed cognition among organizational participants [25]. In this context, Borgatti and Cross [26] asserted that organizational social capital is realized through members' levels of collective goal orientation, which create new knowledge by facilitating successful collective actions. Faccin and Balestrin [27] claimed that one challenge facing today's organization is that knowledge increasingly extends beyond the boundaries of the organization, and the ability to build external collaboration is an important source of new ideas and information that leads to technology and innovations that promote business performance.

The previous studies [1][13][27] confirmed that the characteristics of the processes by which firms search for creating new knowledge strongly effect innovation and can shape the impact of the origins of knowledge on innovation outcomes. Recently, the focus has shifted from knowledge creation within a firm to inter-firm collaborations, towards networks and Communities of Practice (CoPs), and toward knowledge creation in human interactions [8]. The theory of inter-firm collaboration has explained why firms collaborate and how knowledge is created in these collaborative relationships of firms. Knowledge creation often occurs spontaneously as a result of communication and collaboration among individuals or task groups where

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persons with a variety of specializations discover opportunities for practical innovation concealed within a project [14][28]. However, a considerable body of research [3][29][30] has investigated the impact of knowledge creation on different issues concerning e-business adoption and implementation.

III. RESEARCH MODEL AND HYPOTHESES

The research model proposes that social capital has a direct impact on e-business innovation. It also proposes that collaborative knowledge creation has a direct impact on e-business innovation. Finally, the research model proposes that collaborative knowledge creation moderates the impact of social capital on e-business innovation.

Below each dimension of the research model is discussed in more details, followed by the related hypotheses.

A. The impact of social capital

Many previous studies [10][14][31] affirmed that social capital can contribute to the development of innovation capability in organizations. The innovation diffusion theory [15] has described the process by which an innovation is transferred through certain channels between the members of a social system. Organizational social networks have been identified as being significant resources that can lead to innovation [10]). They serve as a conduit where fragments of information and knowledge can be rapidly transmitted and assimilated [10][26]. Subramaniam and Youndt [32] examined how social capital influences incremental and radical innovative capabilities in companies. According to Petti and Zhang [31], the literature of social capital focuses on internal and external network characteristics that might be more conducive to business's innovation capabilities. Many previous studies [9]-[12] confirmed the impact of social capital influence, directly or indirectly, on the way in which e-business models are perceived, developed, implemented and evaluated.

B. The impact of collaborative knowledge creation

Knowledge creation can be seen as the starting point of both KM and innovation [14]. Knowledge management involves a range of strategies, processes and practices utilized by a firm to identify, capture, structure, share and apply an individual or organizational knowledge to attain competitive advantage and create sources for new innovations [27]. New knowledge is frequently engendered by innovative concepts or urgent needs, either arising within the company itself or emanating from external market pressures. The previous studies [1][14][27]) emphasized that to strengthen their innovation potential, organizations need to increase the efforts of collaborative knowledge creation and innovation, so they can build new products, services, or procedures. Significant research has been conducted in this context, emphasizing the connection between knowledge creation and accumulation on one hand, and novel business ideas and practices on the other.

The previous studies [3][29][30] confirmed the existence of a positive impact of organizational learning and creating new knowledge on successful e-business innovation. Cegarra-Navarro et al. [29] investigated how knowledge creation contributes to the employees' productivity and the development of the necessary capabilities for success in the new e-business environment. According to Khamis et al. [5], the ability of e-business companies to be flexible and correspond to the continuously changing electronic environment depends largely on creating new knowledge. Cegarra-Navarro et al. [29] explained how an organization that enhances organizational knowledge application is more likely to implement e-business successfully. Knowledge creation is claimed to produce intelligence and innovation and, thus, positively affects the trading success of e-businesses [22]. Maditinos et al. [30] confirmed that interaction and knowledge sharing among e-business partners is a very important asset for every firm. Drawing upon the previous discussion, the present study hypothesizes the following:

H3: Collaborative knowledge creation has a direct positive impact on e-business innovation.

C. The mediating role of collaborative knowledge creation

Social networks have long been described as effective mechanisms for the transfer and exchange the explicit and tacit knowledge [8]. Previous studies [9][10][32] advocate that organizations with high levels of social capital have more knowledge-management capabilities than other organizations with low levels of social capital. At the same time, the literature [1][22][27] has widely examined the impact of knowledge creation on the firms' innovation capability.

According to Nonaka and Takeuchi [28], the innovative capability of a certain firm depends very closely on the intellectual assets and the knowledge that it possesses, as well as on its ability to deploy them, viewing the innovation process as an intensive knowledge management process. Social capital, as a major element in these assets allows an organization to obtain new knowledge, which is the most important source of innovation [33]. Borgatti and Cross [26] also investigated the importance of social relationships for longer term innovation, since they contribute to enrich knowledge and information exchange. This capital is interrelated with knowledge management practice, as the collaborative learning through social networks is required for the firm to possess new knowledge and develop new technological innovations.

Tallon [34] asserted that social capital determines a firm's capacity for IT-based innovation as a result of its ability to create new knowledge and convert it into strategic applications. Social integration can lower the barriers to information sharing and increasing the absorptive capacity of the firm and, thus, enhancing the opportunity of creating new innovative knowledge. The literature confirms the direct impact of collaborative knowledge creation on e-business innovation. At the same time, the previous discussion suggests that social capital has a direct impact

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on creating new knowledge that can leverage an organization's capability to adopt and use new IT-based innovations. Therefore, the present study proposes the following hypothesis:

H4: Collaborative knowledge creation has a mediating impact on the role of social capital in achieving e-business innovation.

IV. RESEARCH METHODOLOGY

This section provides the research methodology, which includes measures and instrument development, sampling and questionnaire distribution, data analysis and results and finally, assessing the structural model and testing the research hypotheses.

A. *Measures and instrument development*

The present study adopted the measures used to operationalize the constructs of the research model from related previous studies. The scale of social capital was used from Hayton [8] and Zheng [13]. Items for measuring collaborative knowledge creation were derived from the four dimensions of the knowledge creation process, focusing on the extent of collaboration in achieving these dimensions. These four dimensions are socialization, externalization, combination, and internalization [24], [27][28]. The measurements of e-business innovation were derived from Hull et al. [1] and Al Omoush et al. [21].

Empirical data for this study were gathered via a self administered questionnaire. As shown in Table I, the questionnaire includes 22 questions (see APPENDIX I**)** that represent the research model constructs. All items were measured using a five-point Likert-type scale, ranging from 1=strongly disagree to 5=strongly agree).

TABLE I. MEASURES OF RESEARCH CONSTRUCTS

Construct	Code	No. of Items	References
Social capital	SC	5	[8] [13]
Collaborative knowledge creation	CKC	12	[24] [27]
E-business innovation	INNOV	5	[1] [21]

B. *Sampling and questionnaire distribution*

The manufacturing sector is one of the most competitive and innovatively diverse industries with multidimensional and reciprocal relationships, comprising a wide range of business partners [21]. Therefore, this sector is highly attractive for empirical researchers interested in studying e-business adoption and use. The study was conducted on a sample drawn from Jordanian firms. Currently, there are four active industrial parks in Jordan that accommodate more than 400 local, regional and international manufacturing firms, in addition to other industrial clusters.

The targeted respondents were selected from top-level executives, including individuals in such roles as Chief Executive Officer, Vice President, Chief Information Officer, Chief Financial Officer, and Chief Operating Officer. Furthermore, the sample included the directors of IT, sales and marketing, research and development, manufacturing, procurement/purchasing, supply chain directors, and customer service. However, a total of 178 paper questionnaires were distributed among the participants and a total of 120 questionnaires were collected. The researchers received 112 usable responses resulting in a 62.9% response rate.

C. *Data analysis and results*

Smart Partial Least Squares (PLS), version 2.0, was used for data analysis. According to Fornell and Larcker [36], PLS is robust in that it does not need a large sample or normally distributed multivariate data. Further, a PLS path model consists of two elements. These are measurement model (Inner model) to provide the results related to reliability and validity of the scales and the structural model (outer model) to represent the relationships (paths) between the research constructs.

The measurement model was examined for internal consistency and convergent and discriminant validity. As suggested by Hair et al. [37], the factor loadings, composite reliability and the average variance extracted were used to assess convergent validity. Factor loadings analysis was applied to purify scales with the goal of improving their measurement. The results indicate that the factor loadings of some items are less than 0.50 on their own constructs and must be removed from the scale. Specifically, two items were removed from the construct of collaborative knowledge creation (CKC3, CKC8), and one from the e-business innovation scale (INNOV4) due in all cases to low item loading at level (α = 0.05). Internal consistency reliability was measured using Cronbach's alpha, rho_A, and Composite Reliability (CR). Tables II lists the measurement model results, including information about Cronbach's alpha, rho_A, and CR. As shown in Table II, all constructs exhibited acceptably high scores exceeding the 0.70 threshold. Furthermore, an Average Variance Extracted (AVE) value of 0.50 or higher indicates that the construct explains more than half of the variance of its indicators. Table II shows that all values of AVE are larger than 0.5, which suggest a convergent validity.

TABLE II. VALIDITY AND RELIABILITY OF RESEARCH CONSTRUCTS

Construct	alpha	rho_A	CR	AVE
Social capital	0.834	0.838	0.882	0.600
Collaborative knowledge creation	0.897	0.899	0.915	0.520
E-business innovation	0.841	0.841	0.894	0.678

One popular approach to assess the discriminant validity followed in the current research was through examining the cross-loading comparisons between constructs [36]. Specifically, the AVE of each latent construct should be higher than the construct's highest squared correlation with

any other latent construct. As shown in Table III, all constructs in the research model achieved this criterion because none of the off-diagonal elements exceeded the respective diagonal element. Thus, discriminant validity was demonstrated.

TABLE III. DISCRIMINANT VALIDITY

No.	Constructs	1	2	3
1	Social capital	0.774		
2	Collaborative knowledge creation	0.697	0.721	
3	E-business innovation	0.659	0.651	0.824

D. *Assessing the structural model and testing the research hypotheses*

The results of the structural modeling analysis are illustrated in Figure 1. Path analysis was conducted to provide a graphic of the links between the groups of factors. The path coefficient (β) analysis and the t-value test serve as the basis of evaluation of the hypotheses.

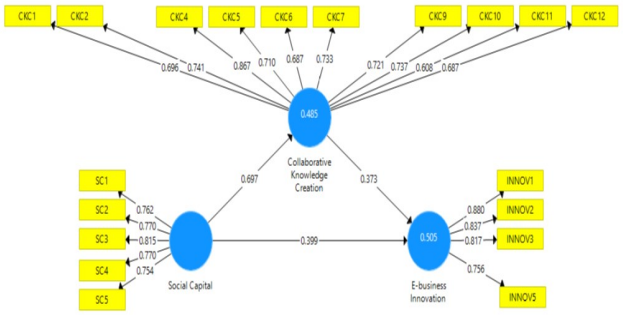

Figure1. Path coefficient analysis

It is recommended that the t-value should be larger than 2. The strength of the hypothesized paths and whether the path significant is evaluated by the standardized path coefficient. Standardized or (β) coefficients are the estimates resulting from an analysis performed on variables that have been standardized so that they have variances of 1. Table IV presents the results of testing research hypotheses.

TABLE IV. THE RESULTS OF TESTING RESEARCH HYPOTHESES.

H	β	T value	Sig.	The results
1	0.399	4.452	0.000	Supported
2	0.697	14.083	0.000	Supported
3	0.373	3.563	0.000	Supported

To evaluate the mediating role of collaborative knowledge creation in the impact of social capital on e-business innovation was analyzed using the Sobel Test [38].

TABLE V. THE RESULTS OF SOBEL TEST

H	z-value	P value	The results
4	3.481	0.001	Supported

The results in Table V reveal that the mediating role of organizational learning in the impact of top management support on e-business entrepreneurship (H4) is significant (z- value=18.413, (p< 0.000).

V. DISCUSSION AND CONCLUSION

The present study aimed to investigate empirically the interrelationship and impact of social capital and collaborative knowledge creation on e-business innovation. The results reveal that social capital plays an important role in achieving e-business innovation. These results are consistent with previous studies [7][9]-[12], which confirm the pivotal role of social capital in creating an innovative business environment to develop new ideas and initiatives concerning adoption and use of e-business innovations. The findings of the present study also indicate a significant positive impact of social capital on e-business innovation. The prior studies [4][5][8][33] clarified that collaborative knowledge creation is a direct outcome of social capital. Tallon [34] explained that social integration can help firms to lower the barriers to information sharing, increasing the absorptive capacity of the firm and, thus, enhancing the effectiveness and efficiency of knowledge creation.

The results reveal that collaborative knowledge creation has a direct positive impact on e-business innovation. These findings are in line with many previous studies [3][29][30] that confirmed the positive impact of organizational learning and creating new knowledge on successful e-business innovation. Maditinos et al. [30] affirmed that knowledge sharing among e-business partners is a very important asset for every firm. According to Cegarra-Navarro et al. [29], knowledge creation produces intelligence and innovation and, thus, positively affects the success of e-businesses. Finally, the results indicate that collaborative knowledge creation has a mediating impact on the role of social capital in achieving e-business innovation. These findings are also in agreement with previous studies [8][33][34] that have investigated the impact of social capital on creating new innovative knowledge. According to Nonaka and Takeuchi [28], the innovative capability of a certain firm depends very closely on the intellectual assets and the knowledge that it possesses, as well as on its ability to deploy them, viewing the innovation process as an intensive knowledge management process.

The results of the study highlight the pivotal role of social capital in preparing an organizational environment to support the efforts of knowledge creation and establish e-business innovation. The results also emphasize that to strengthen their e-business innovation potential, organizations need to increase the efforts of collaborative knowledge creation. The results reveal that the combination of social capital and collaborative knowledge creation is a crucial element to the success of e-business adoption and supports competitiveness and sustainability.

The findings of this study contribute to a better understanding of the impact of social capital on e-business innovation. This study also improves our understanding of the pivotal role of collaborative knowledge creation in

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establishing e-business innovation. The findings are important for future research investigating the influencing role of social and collaborative capabilities as factors to consider when studying firms that conduct any e-business innovation activities. For executives, this study provides guidance for senior management in developing successful e-business initiatives. It also provides top managers with dimensions to be used for assessing the firm's attitudes toward e-business innovation. An understanding of the impact of social capital and collaborative knowledge creation will provide the managers with better knowledge on how to manage opportunities of e-business innovation. Organizations must scan and employ their social networks consistently to obtain ideas and gather information to support the process of recognition and develop new e-business innovations based on the continuing advances of e-business applications.

Despite its contributions, there are some limitations, which can serve as directions for future research. Although the design of the research model builds on the theoretical insights of intellectual capital, the study did not consider all of its theoretical dimensions, including human capital and organizational capital. In addition, the study did not reflect all of the theoretical factors that can impact on achieving e-business innovation, such as organization's characteristics, competitive pressures, and top-management support. Finally, knowledge creation often occurs as a result of individual and organizational learning. The present study did not investigate the impact of organizational learning on collaborative knowledge creation and e-business innovation and its interrelationship social capital.

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APPENDIX I. Questionnair items

Construct	Code	Measurement Items
Social capital	SC1	Membership and networking with industrial associations are very important for my firm to acquire innovative ideas.
	SC2	My firm has adequate access to external sources for knowledge, technical, management, and business-related expertise.
	SC3	My firm encourages employees to share their knowledge, experience, ideas, and skills with colleagues from other departments.
	SC4	Our firm and its external stakeholders frequently collaborate to solve problems.
	SC5	The social network of firm has a great impact on improving our products, services and processes.
Collaborative knowledge creation		
Socialization	CKC1	My firm stresses sharing experience with suppliers and customers and engaging in dialogue with competitors.
	CKC2	My firm stresses getting ideas for firm strategy from daily social life, interaction with external experts, and informal meeting with competitors.
	CKC3	My firm stresses creating a work environment that allows peers to understand the craftsmanship and expertise.
Externalization	CKC4	My firm stresses the use of deductive and inductive thinking.
	CKC5	My firm stresses creative and essential dialogues.
	CKC6	My firm stresses exchanging various ideas and dialogues.
Combination	CKC7	My firm stresses planning strategies by using published literature, computer simulation and forecasting
	CKC8	My firm stresses creating manuals and databases on products and services
	CKC9	My firm stresses transmitting newly created concept.
Internalization	CKC10	My firm stresses enactive liaising activities with functional department by cross-functional development teams
	CKC11	My firm stresses searching and sharing new values and thoughts.
	CKC12	My firm stresses sharing and trying to understand management visions through communications with fellows
E-business innovation		
	INNOV1	My firm invests heavily on new e-business systems.
	INNOV2	Employees are encouraged to come up with new ideas concerning the adoption of new e-business applications.
	INNOV3	The firm placed emphasis on introducing new e-business applications into business processes and activities.
	INNOV4	The firm emphasizes continuously on introducing unique e-business processes and activities.

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Digital Strategies as a Guideline for Digital Transformation Processes in Municipalities – A Literature Review

Kristina Roeding
Chair of Information Systems
University of Siegen
Siegen, Germany
kristina.roeding@uni-siegen.de

***Abstract*—Digitalization is one of the words everyone gets to hear almost every day. The need to digitalize information and services is greater than ever. Municipalities try to digitalize themselves to service their citizens. First steps show municipalities starting different projects for digitalization. Nevertheless, a phenomenon, which is often seen, is that those projects do not have a common aim they are aligning to. As an instrument, digital strategies can help municipalities to align their projects, leading the way into digital transformation. However, what is a digital strategy and how is it structured? What can recent literature teach us about digital strategies? How can digital strategies help to support digital transformation processes in municipalities? To answer these questions, we conducted a systematical but selective literature research on digital strategies in the Information Systems (IS) and the public sector. We found that both literature streams show the development of a fusion between business and IS strategies leading to new concepts of capabilities, needed in municipalities to develop and monitor digital strategies.**

Keywords-Digital Strategy; Literature Research; Public Sector.

I. INTRODUCTION

Digitalization is becoming one the most important words nowadays when we talk about transformation processes. With the digital age at hand, we seek for ways to digitalize the world around us, as everything needs to be digitalized. This is a phenomenon, which we can see in the private as well as in the public sector. Especially the public sector, which is interested in the needs of their citizen are on their way to digitalize e.g., their public services [1].

Looking at transformation processes in the past, we can see that strategies are instruments, which were often used to guide ways into the future. Mintzberg [2] defines strategies as patterns in a stream of decisions guiding the way for future actions.

In the last century, the concept of strategy developed in different ways regarding the stream of research we are looking at. For example, Jahn et al. [3] looked at strategies and tactics from the unit of analysis of employees, whereas Mintzberg [2] and Atkins and Lowe [4] looked at strategies from the perspective of businesses. Gottschalk [5] and Arvidsson et al. [6] looked at strategies from the perspective of Information Technology (IT) in organizations. As an example from IT strategies, Chen et al. [7] conducted a comprehensive literature review on Information Systems (IS) strategies in the IS literature. As an example, Chen et al. [7] showed that different studies named IS strategies in diverse ways. However, after they conducted the reconceptualization, measurement and implications of IS Strategies, recent literature is missing a research based on new developments of strategies which occur due to digitalization. While there has been an extensive debate on digital strategies, especially for municipalities, in practice, recent research has not developed a clear theoretical understanding of the phenomenon describing what digital strategies are and how they can help municipalities as guidelines in digital transformation processes. In order to address our objectives, this paper is guided by the following research question (RQ):

RQ1: How does recent literature define and use digital strategies as a guideline for digital transformation processes?

The remainder of the paper is structured as follows. In the second section, we give a short background of the emergence of digital strategies in practice and science. Section 3, describes the research design of this study. In Section 4, the findings of the literature review are presented showing recent literature regarding the conceptual use of digital strategies. Section 5 discusses implications for theory and practice, especially municipalities, shows the limitations of the study, and gives recommendations for future research.

II. BACKGROUND

An emerging topic for municipalities is the chances and challenges of digital transformation. With IT becoming ubiquitous, phenomenons like IT consumerization emerge. IT consumerization describes the use of consumer market mobile devices (e.g., wearables, smartphones, tablets) and shows the phenomenon of how citizens are able to engage in diverse governmental topics from everywhere at any time [8]–[11]. Thus, digital services around citizens are becoming more and more important [12]. However, not only services are important but also the whole governmental digital transformation becomes necessary (e.g., transformation of internal administrative processes, engaging diverse actors in decision-making processes and planning and implementing projects). At this point, digital strategies can help

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municipalities to set guidelines for digital transformation processes.

Recent literature has already studied the phenomenon of strategies, for example in the management studies [2][4], [13], in IS research [5][7] and of individuals regarding their use of mobile technologies [3][14][15]. In their literature review, Chen et al. [7] give a clear overview of different definitions of IS and IT strategy in literature. They also identified three conceptions of IS strategy: "(1) IS strategy as the use of IS to support business strategy; (2) IS strategy as the master plan of the IS function; and (3) IS strategy as the shared view of the IS role within the organization" [7] (p.233). Niehaves et al. [16] found in their case study structural features of digital strategies for municipalities. They found that the denomination of strategic alignment, strategy formation, core themes and fields of action are features, which structure digital strategies for municipalities. However, since Chen et al. [7] the emerging concept of digital strategies and their development from IS strategies has not yet analyzed from a theoretical point of view. The construct of digital strategies, especially for municipalities is yet understudied. We aim to enrich recent research on digital strategies by showing the development of the term digital strategy and by listing and describing recent research on the construct of digital strategy for municipalities.

III. METHOD

For our literature review, we applied the framework for literature reviewing proposed by vom Brocke et al. [17] consisting of 5 steps: (I) definition of review and scope, (II) conceptualization of topic, (III) literature search, (IV) literature analysis and synthesis and (V) research agenda [17].

We first defined our review scope using Coopers taxonomy of literature reviews [18]. Aligned to Cooper [18], we conducted a literature review of digital strategies for municipalities. Aligned to the taxonomy, we focused during our literature review on research outcomes having the goal to summarize our findings to get a more comprehensive inside of the term of digital strategies for municipalities. We decided to organize our literature review theoretical, as the question we are trying to answer is given. We aim to a neutral representation perspective and choose our audience to be general scholars and practitioners/politicians. We also cover our reviewed literature to central/pivotal to our topic. Table 1 summarizes our categories taken for the literature review.

Second, we conceptualised our topic. We conduct a literature review of digital strategies for municipalities concentrating on the term digital strategy and their support for digital transformation processes. Regarding vom Brocke et al. [17], it is important to pay attention to the fact that a review must begin with "a broad conception of what is known about the topic and potential areas where knowledge may be needed"(p.10).We, therefore, provided a working definition of the key term "digital strategy".

In their study, Chen et al. [7] defined IS strategy as "the organizational perspective on the investment in, deployment, use, and management of information systems" (p. 237). Chen et al. [7] also found that a variation of expressions have been engaged to represent similar constructs such as IT strategy, IS strategy, IS/IT strategy or information strategy. However, aligning to Niehaves et al. [16] digital strategies are understood to be even more, looking not only for examples on the investment and management of information systems but rather on the whole business [19]. Such a digital business strategy could be defined as an "organizational strategy formulated and executed by leveraging digital resources to create differential value" [19] (p.472) and "to support or shape an organization's competitive strategy, its plan for gaining and maintaining competitive advantage"[20] (p.191). Against this background and aligning to Niehaves et al. [16], we define digital strategy as an organizational strategy formulated and executed by leveraging digital resources to create differential value to support or shape an organization's competitive strategy, its plan for gaining and maintaining competitive advantage. Summarized we define it as a fusion of a traditional IS/IT strategy with the business strategy of an organization in the digital age. For municipalities this definition offers a variety of possibilities how to align their digital strategy in practice. For example, it could be their own strategy itself aligned to an urban development strategy or it could be directly integrated in the urban development strategy.

In the third phase (III), literature search, we conducted the actual search-involving database, keyword, backward, and forward search, as well as an ongoing evaluation of the sources [17]. Table II shows the structure and results of our conducted literature review.

TABLE I. TAXONOMY OF LITERATURE REVIEW (FOLLOWING [17][18]) ALIGNED TO OUR RESEARCH

CHARACTERISTICS		CATEGORIES			
1	focus	research outcomes	research methods	theories	applications
2	goal	integration	citicism	central issues	
3	organisation	historical	conceptual	methodological	
4	perspective	neutral representation		espousal of position	
5	audience	specialised scholars	general scholars	practitionars/politicians	general public
6	coverage	exhaustive	exhaustive and selective	representative	central/pivotal

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TABLE II. STRUCTURE OF THE LITERATURE REVIEW PROCESS

	Journal	Database	Search	Search Item	Hits per Item	Reviewed Hits
1	Government Information Quarterly	Science Direct	title, abstract, keywords	digital strategy	11	3
				IS / IT strategy	12	
2	Journal of E-Government Research	IGI Global	all fields	digital strategy	12	3
				IS strategy	13	
3	Transforming Government: People, Process & Policy	Emerald Insight	all fields	digital strategy	9	2
				IS strategy	15	
4	Information Polity	IOS Press	all fields	digital strategy	8	1
				IS strategy	8	
5	European Journal of Information Systems	Palgrave Macmillan	all fields	digital strategy	5	1
				IS strategy	14	
6	Information Systems Journal	Wiley Online Library	all fields	digital strategy	5	0
				IS strategy	23	
7	Information Systems Research	Informs	title, abstract, keywords	digital strategy	0	0
				IS strategy	5	
8	Journal of the Association of Information Systems	AIS	all fields	digital strategy	2	0
				IS strategy	5	
9	Journal of Management Information Systems	JSTOR	all fields	digital strategy	2	0
				IS strategy	6	
10	MIS Quarterly	MISQ	all fields	digital strategy	5	5
				IS strategy	12	
11	Journal of Strategic Information Systems	Science Direct	all fields	digital strategy	10	3
				IS strategy	23	
12	Journal of Information Technology	Palgrave Macmillan	all fields	digital strategy	1	2
				IS strategy	11	
					∑ 218	∑ 20

As recommended by previous literature [17][21][22], we focused on the review articles of high quality. We also looked at rankings. For example, vom Brocke et al. [17] synthesized ranking for the AIS in order to select journals we would search in. Only to take the 10 best-ranked paper did not seem like a comprehensive overview for our topic, as we looked at the development of the term digital strategy since the literature review of Chen et al. [7] supplemented by governmental literature. This is the reason why we decided to look at the description and aim of each high quality journal ranked and take into account the journals, which fit into our topic the best. For our topic, we decided it is best to look at the eight highest ranked IS Journals (European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of the Association of Information Systems, Journal of Management Information Systems, MIS Quarterly, Journal of Strategic Information Systems, Journal of Information Technology), in order to identify "digital strategies in IS". Building upon the research from Chen et al. [7] we filtered, in a second step for research articles since the year 2010. As we look specifically at the formation of digital strategies for municipalities, we choose to look at high quality E-Government Journals with IS reference as well, namely Government Information Quarterly, Journal of E-Government Research, Transforming Government: People, Process & Policy, and Information Polity. As those were not included in the research of Chen et al. [7], we looked at those from their point of existence until now. In general, we looked for journal and publisher homepages in order to do a comprehensive literature search.

Applying our working definition, we used following search items, "digital strategy", "IS strategy" and "IT strategy", during the literature review process. Our working definition would lead us to look also for "digital business strategy" as well as "smart city strategy" or "e-government strategy".

After we conducted the literature search (phase III, resulting list of literature can be seen in Table III), we analyzed and synthesised our literature (phase IV) as recommended and developed by and adapted by Webster and Watson [22]. As our aim was to focus on research outcomes with the goal of current issues, we analysed the current literature on digital strategies and derived key aspects out of the different research papers.

We report that we found 218 Articles in 13 Journals looking for our three search items. However, we have to note that as our working definition let us expect, and as already presented by Chen et al. [7], IS- and IT Strategy led to almost the same results. We found 20 articles to help us get a glimpse of digital strategies as guideline for digital transformation processes, in the public sector and across organizations. Aligning to our taxonomy of literature research and our definition of digital strategy, we were only able to identify 20 research articles, which were able to help us answering our research question. This also shows how understudied this phenomenon is in literature. We conducted our analysis focusing on the unit of analysis explored in each research paper, the context of digital strategy and the key aspects of the research outcomes summarized. We classified the Unit of Analysis in Organizations (O), Government (G) and the Individual (I). As our working definition shows,

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digital strategies are important for the Institutional level. This is the reason why we excluded paper where the Unit of analysis is the individual and concentrated on paper examining governmental institutions and private sector companies.

The analysis of our listed research paper led us to phase V of the framework for literature reviewing proposed by vom Brocke et al. [17]. Phase V describes how the synthesis of literature (phase IV) results in a research agenda (V). In our study, the result of our synthesis is our resulting research questions (RQ1: How does recent literature define and use digital strategies as a guideline for digital transformation processes?).

IV. FINDINGS

The following section will show our findings which are divided into two parts: First, development of the term and use of digital strategies as a guideline for digital transformation processes in E-Government- Literature; Second, development of the term and use of digital strategies as a guideline for digital transformation processes in IS-Literature since 2010.

A. Development of the term and use of digital strategies as a guideline for digital transformation processes in E-Government- Literature.

We noticed a change in definition of the term digital strategy in the E-Government Literature showing that in 2005 Gil-Garcia and Pardo [23] described the term strategy as practical guidelines and systematic long-term approaches to problems in order to further e.g., e-government goals.

In 2009, Yoon and Chae [24] conducted a study of national strategies for ICT (also called "national e-Strategy"), which is supposed to contribute to economic transformation. In this study, the trend to contribute to economic transformation with higher aligned strategies developed.

In 2010, Shareef et al. [25] examined implementation strategies of electronic-government which are used to gain a competitive advantage. In this study, we notice that the development of digital strategies in the public sector seems to direct towards our definition of digital strategies, including competitive advantage of organizations.

Anthopoulos et al. [26] introduced conceptualization, benchmarks and evaluations of the smart city concept. In their study, they discovered eight classes of conceptual models. The classes address smart city architecture, governance, planning and management, data and knowledge, energy, health, people and environment and resulted in an unified smart city model (UFCM) [26].

In 2018, Pedersen [27] recommended in his study to develop more balanced strategies which focus more on eliminating the contextual and organizational challenges instead of just aiming to increase project level capabilities.

B. Development of the term and use of digital strategies as a guideline for digital transformation processes in IS-Literature since 2010.

In 2012, Benitez-Amado and Walczuch [28] found in their study IT capability to be an enabler of proactive environmental strategies. These strategies, as they found, mediate the effects of IT on firm performance. The finding of Benitez-Amado and Walczuch [28] can be seen also in our applied definition of digital strategies. In our literature review, we found in 2013 a special issue in the MIS Quarterly regarding digital strategies and their competitive advantage [19][29]–[31]. For example, Mithas et al. [29] found in their study that "IT both enhances the firm 's current (ordinary) capabilities and enables new (dynamic) capabilities, including the flexibility to focus on rapidly changing opportunities or to abandon losing initiatives while salvaging substantial asset value" (p. 511).

Arvidsson et al. [6] conceptualized in their study the concept of strategy blindness. Strategy blindness describes "the organizational incapability to realize the strategic intent of implemented, available system capabilities" [6] (p. 45).

In 2018, Yeow et al. [32] describe the blurring of the division between business and IT strategies which lead to a fusion between them. The fusion is described as digital strategy. Yeow et al. [32] study, found "an aligning process model that is comprised of three phases (exploratory, building, and extending) and generalizable organizational aligning actions that form the organization's sensing, seizing, and transforming capacities" (p. 43).

With our study, we aim to enrich recent literature regarding digital strategies as a guideline for digital transformation of municipalities analyzing the development of the term and use of digital strategies in the E-Government Literature and the IS Literature (since 2010). A conceptualization of our findings can be seen in Figure 1. As our finding, Figure 1 only shows examples of the emerging literature streams. Every analyzed 20 papers can be seen in the Appendix in Table III.

As we proposed, aligning to Bharadwaj et al. [19] in both literature streams, the term and use of digital strategy develops into the description of a fusion of business and IS strategies. We also can notice that this development leads to new emerging concepts, such as dynamic capabilities and strategy blindness in the digital strategy literature [6][29]. We also found that the use of digital strategy and its definition does not vary if we are looking at smart cities or municipalities in the E-government literature or if we look at companies showing a consensus for digital strategies as guidelines for digital transformation.

V. DISCUSSION AND OUTLOOK

The following section will show the discussion and will give an outlook for future research.

A. Implications for theory and practice.

We aim to enrich recent literature regarding digital strategies as a guideline for digital transformation in E-

Government literature and the IS literature analyzing the development of the term and the use of "digital strategies". We enrich research by Chen et al. [7] by extending their literature review of IS strategy giving an overview of the development of digital strategies in the IS literature since 2010. We also aim to extend research by Pedersen [27] giving empirical evidence that the fusion of business and IS strategies is taking place in theory and practice giving rise to new concepts like dynamic capabilities. Practice can also benefit from our study, as it gives guidance in which directions future digital strategies should be developed and gives research recommendations where to look for even more guidance. But practitioners need to take care, as digital strategies have still special features e.g., in their structuration [16] even if our study shows a consensus on a meta-level. It also shows different ways of developing a digital strategy. For example, a digital strategy for municipalities can stand on its own as digital strategy or it could be integrated into the urban development strategy showing a real fusion of the main strategies.

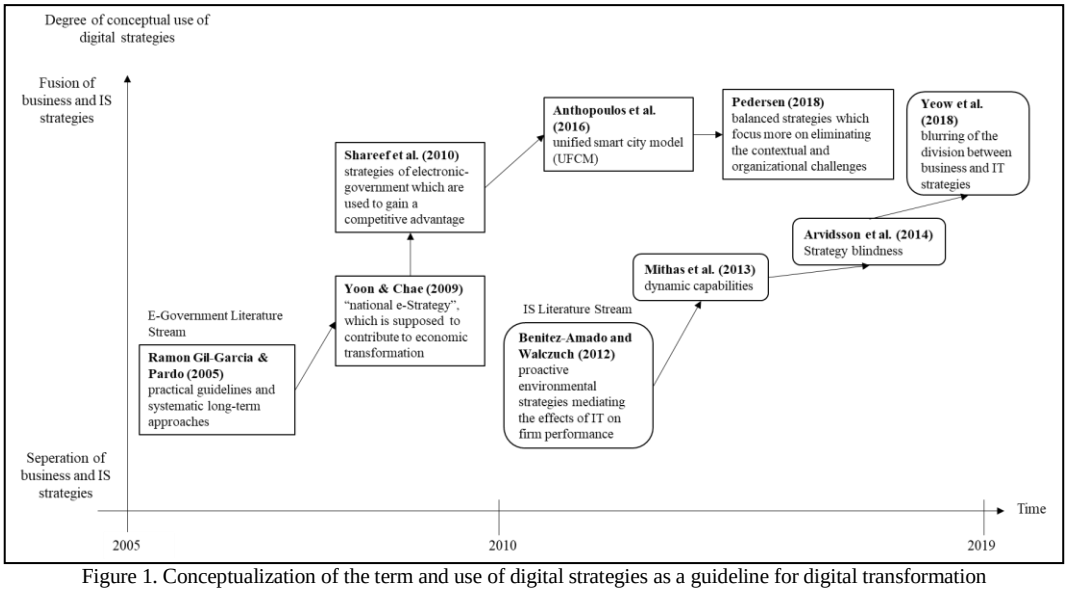

Figure 1. Conceptualization of the term and use of digital strategies as a guideline for digital transformation

B. Limitations and Outlook.

Like every other empirical study, our research as well has limitations that leave room for future research. Apart from the typical limitations of literature reviews [17], it is important to acknowledge that we only searched the highest 8 and 5 ranked journals in the e-government and IS literature. Future research could extend our literature by including conference papers and book publication to extend our conceptualization.

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TABLE III. OVERVIEW OF THE REVIEWED ARTICLES

Journal	Article	Autor	Year
Government Information Quarterly	Conceptualizing smartness in government: An integrative and multi-dimensional view	Gil-Garcia et al.	2016
	E-government success factors: Mapping practical tools to theoretical foundations	Gil-García and Pardo	2005
	Varying criticality of key success factors of national e-Strategy along the status of economic development of nations	Yoon and Chae	2009
Journal of E-Government Research	E-Government Implementation Perspective: Setting Objective and Strategy	Shareef et al.	2010
	The Örebro City Citizen-Oriented E-Government Strategy	Ask et al.	2008
	A Unified Smart City Model (USCM) for Smart City Conceptualization and Benchmarking	Anthopoulos et al.	2016
Transforming Government: People, Process & Policy	E-government transformations: challenges and strategies	Pederson	2018
	Managing continuity and change: a new approach for strategizing in e-government	Saboohi	2010
Information Polity	Whole-of-government approach to information technology strategy management: Building a sustainable collaborative technology environment in government	Ojo et al.	2011
European Journal of Information Systems	Information technology, the organizational capability of proactive corporate environmental strategy and firm performance: a resource-based analysis	Benitez-Amado and Walczuch	2012

MIS Quarterly	Information Technology and Business-Level Strategy: Toward an Integrated Theoretical Perspective	Drnevich and Croson	2013
	How a Firm's Competitive Environment and Digital Strategic Posture Influence Digital Business Strategy	Mithas et al.	2013
	Design Capital and Design Moves: The Logic of Digital Business Strategy	Woodard et al.	2013
	Visions and Voices on Emerging Challenges in Digital Business Strategy	Bharadwaj et al.	2013
	Unifying the Role of IT in Hyperturbulence and Competitive Advantage Via a Multilevel Perspective of IS Strategy	Nan and Tanriverdi	2017
Journal of Strategic Information Systems	Aligning with new digital strategy: A dynamic capabilities approach	Yeow et al.	2018
	Information systems use as strategy practice: A multi-dimensional view of strategic information system implementation and use	Arvidsson et al.	2014
	Information systems strategizing, organizational sub-communities, and the emergence of a sustainability strategy	Henfridsson and Lind	2014
Journal of Information Technology	Strategic IT alignment: twenty-five years on	Coltman et al.	2015
	Aligning business and IT strategies in multi-business organizations	Reynolds and Yetton	2015

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