Facilitating the digital transformation of villages

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Abstract. *The concept of smartness is an essential topic that was only recently extended to rural areas. Although smartness is already incorporated strongly into numerous urban environments, differences between cities and villages prevent direct transfer of the methods and tools used for the smart transformation. To increase the awareness of newly developed or appropriately adapted tools and methods, their incorporation into a uniform platform is advisable. The paper presents the functional requirements and architectural backbone of a Digital Platform, currently being developed within the SmartVillages Project, Smart Digital Transformation of Villages in the Alpine Space. Key functionalities of the developed Digital Platform are (1) Self-assessment, allowing evaluation of smartness according to the different dimensions, (2) input and review of Best Practices regarding smart transformations, (3) Matchmaking, based on the results of self assessment, and (4) collaboration between involved parties. Functionalities are meant to be used by different village representatives, wherein the main purpose of the Digital Platform is to facilitate activities that could improve the smartness level of interested rural areas.*

Keywords. smart villages, digital transformation, platform, self-assessment, smartness assessment, matchmaking, best practices

1 Introduction

After several years of focusing on cities and their smart transformation, i.e. Smart Cities (SC), we now face the challenge to improve the condition of villages, i.e. Smart Villages (SV). This is important, especially for improving the living conditions of villagers and reducing, among other, the brain and youth drain towards cities (SmartVillages, 2019). Although a lot of attention is given towards this attempt, beginning from the political levels (e.g. Smart Villages EU initiatives (European Network for Rural Development, 2019a)), this presents a challenging task. Since cities and villages could not be equated, the reuse of the tools and methods aimed at achieving a smart village transformation is not entirely possible.

This paper describes a combination of tools and methods, aimed at facilitating villages towards their smart transformation. Newly developed and suitably adapted tools and methods are incorporated into a Digital Platform, which goes hand in hand with the notion of a digital transformation, although it should be noted that transformation towards smartness is not necessarily bound to the digital. However, the general purpose of the Digital Platform is to present an accessible, user friendly, modern and effective ("smart") approach facilitating the Smart Village transition. The platform itself is meant to be used by any village representative, aimed at facilitating their activities to improve their smartness status.

The Digital Platform is built around four main features: (1) Self (smartness) assessment, (2) Best Practices, (3) Matchmaking and (4) Collaboration. In the paper we focused on following research question: *"What are the requirements' specifications for the Digital Platform that can facilitate the smart digital transformation of villages?"*. The platform is still in development. Therefore, some functionalities are already implemented and available to interested parties, while others are still subject to research regarding their full specifications and implementation within the Digital Platform. The paper presents requirements' specification, giving an insight on the methodology behind their individual and combined processes, while explaining

the technical aspects of the platform covering the implementation of key functionalities and their position in the architecture of a Digital Platform.

The rest of the paper is structured as follows. In Section 2, basic information and definitions are presented on the novel notion of Smart Villages. Section 3 discusses the requirements' specification of the Digital Platform, with emphasis on key functionalities. The architectural backbone of the developed Digital Platform is covered in Section 4, wherein the interaction of components is included. The paper is concluded with Section 5.

2 Smart Village Concept

Research in the context of smart living evolves rapidly. However, the domain of Smart Village has been, in contrast to Smart Cities, left behind significantly (Visvizi & Lytras, 2018; Fennell et al., 2018). Smart Villages should not be seen just as an extension of Smart Cities, since their focus lies in engaging local communities and improving different aspects of their lives with purposeful and thoughtful use of digital technologies (Directorate-General for Agriculture and Rural Development, 2018).

In order to address the associated challenges effectively, a clear understanding of the Smart Village concept has to be achieved. The definition of Smart Villages is provided by the Smart Villages Portal (European Network for Rural Development, 2019b): *"Smart Villages are rural areas and communities which build on their existing strengths and assets, as well as on developing new opportunities, where traditional and new networks and services are enhanced by means of digital, telecommunication technologies, innovations and the better use of knowledge."*

Smart Villages presents one of the sub-domains of the Smart and Competitive Rural Areas topic covered by the ENRD (European Network for Rural Development, 2019a). Although the concept of Smart Village is still evolving, many different ongoing projects and initiatives can be found (Zavratnik, Kos, & Stojmenova Duh, 2018). Among others, the *SmartVillages* Project, Smart Digital Transformation of Villages in the Alpine Space (SmartVillages, 2019), co-financed by the Interreg Alpine Space Program. The SmartVillages Project combines six European countries in an attempt to improve the framework conditions for innovations covering organizational, social and technical perspectives (SmartVillages, 2019).

2.1 Connection between Smart Cities and Smart Villages

Digital platforms from the 1990's for digital cities are expanded increasingly as Smart City platforms (Aurigi, Willis, & Melgaco, 2016). Anthopoulos and Fitsilis' definition of the label Smart City is: *"An ICT-based infrastructure and services environment that enhance a city's intelligence, quality of life and other attributes (i.e., environment, entrepreneurship, education, culture, transportation, etc.)"* (Anthopoulos & Fitsilis, 2014). Based on this definition, researchers find work on different technological challenges, and a recurring element in these works is the holistic nature of Smart Cities' initiatives (Van den Bergh & Viaene, 2016). As these initiatives are usually technology infused, if not driven, they can tackle issues related to either mobility, economy, energy, environment, e-government, or a combination of those (Caragliu, Del Bo, & Nijkamp, 2011). These issues result in technological challenges for different cities (Caragliu et al., 2011; Van den Bergh & Viaene, 2016).

Digital platforms borrow heavily from Artificial Intelligence (AI) (Jia, Kenney, Mattila, & Seppala, 2018) and frequently use High-Performance Computing (Kołodziej & González-Vélez, 2017), and approaches like Blockchain (Orecchini, Santiangeli, Zuccari, Pieroni, & Suppa, 2018; Zamuda et al., 2019). An important AI aspect of Smart Cities is also the embrace of Computational Intelligence and the learning and optimization methods it provides for automatic problem solving using, e.g., advanced Evolutionary Algorithms (Zamuda, 2016). However, electrification, education, and sustainable entrepreneurship are among the most important aspects of empowering smart communities, especially in the worldwide IEEE Smart Village Initiatives (Anderson et al., 2017).

As a perspective on Smart Cities, a survey on recommender systems for e-governance in Smart Cities is provided in (Cortés-Cediel, Cantador, & Gil, 2017). A further detailed example of the matchmaking recommender system in the Tourism domain is described in (Borràs, Moreno, & Valls, 2014). Several cases identified therein are reviewed and references to literature are provided. Some of them are applicable not only to Smart Cities but also to Smart Villages, since similar challenges like assisting the finding of business partners in government e-services could be found (Case 4, see recommenders like (Lu, Shambour, & Zhang, 2009; Lu, Shambour, Xu, Lin, & Zhang, 2010; Mao, Zhang, Lu, & Zhang, 2014; Shambour & Lu, 2011)), or providing the companies with a personalized, online support in legal and administrative consultancy (Case 6), as well as enhancing the government electronic interoperability (Case 7).

3 Digital Platform

One of the leading enablers of smart transformation is the existence of suitable digital support. In the context of the SmartVillages Project, the developed Digital Platform represents a technical component supporting innovations within interested rural areas. In order to achieve this goal, different aspects have to be addressed and selected specialized functionalities have to

be supported.

3.1 Requirements' specification for the Digital Platform

The development of the Digital Platform started with gathering the functional requirements. The list of needed functionalities was formed in collaboration with the SmartVillages' Project Partners. The list starts with general functionalities like presentation sites, multi-language support, login with social media accounts, adding external resources, visualization of data, export functions for all data and metadata, news broadcasting and editorialized contents for a wide public, tag-based and criteria enabled search, common calendars, collaborative writing, thematic groups of interests, personal areas and others. The mentioned list consists of basic functionalities that are supported within the majority of the existing Content Management System (CMS).

However, in order to facilitate Smart Village transformations efficiently, the platform has to support specialized domains and implement some non-standard functionalities. Thus, the final version of the SmartVillages Digital Platform will implement the following key features:

- Self-assessment,
- Best Practices,
- Matchmaking, and
- Collaboration.

Each specific requirement and goal of the identified features are described in the following subsections.

3.1.1 Self-Assessment

The self-assessment functionality allows interested stakeholders to carry out a guided analysis and assess the smartness for their rural area. The results are presented using six smartness dimensions, following the presented methodology by (Lentini, Polettini, Luè, & Vitale, 2019). The rating is then included in the Digital Platform, supporting examination and graphical representation of the final results. The service provides results that could help the stakeholders in the decision of addressing the most appropriate dimension, and in carrying out the most desirable and necessary steps towards the smart transformation of their own villages.

In order to assess and rate the smartness of rural areas, Lentini et al. propose a novel methodology using an ELECTRE Tri multi-criteria-analysis method (Lentini et al., 2019). According to the method, each interested rural or mountain area can assess its smartness by means of a set of smartness dimensions, namely: (1) Economy, (2) Environment, (3) Governance, (4) Living, (5) Mobility and (6) People, for each of which a subset of four indicators of smartness has been proposed. Indicators have been adopted from the Smart Cities concept based on an analysis of their ability to be used for assessing and rating smartness in mountain areas, and following specific work on the topic in (SmartVillages, 2019). ELECTRE Tri represents a methodology allowing the self-assessment of the level of smartness, given a set of indicators and the creation of a weight vector incorporating the relative importance attributed to each of the six dimensions of smartness by the compiler. It also allows for the rating of smartness in a system of ad-hoc created categories ('high level of smartness', 'satisfactory level of smartness', 'medium level of smartness', and 'low level of smartness') that are separated by specifically selected numerical thresholds.

3.1.2 Best Practices

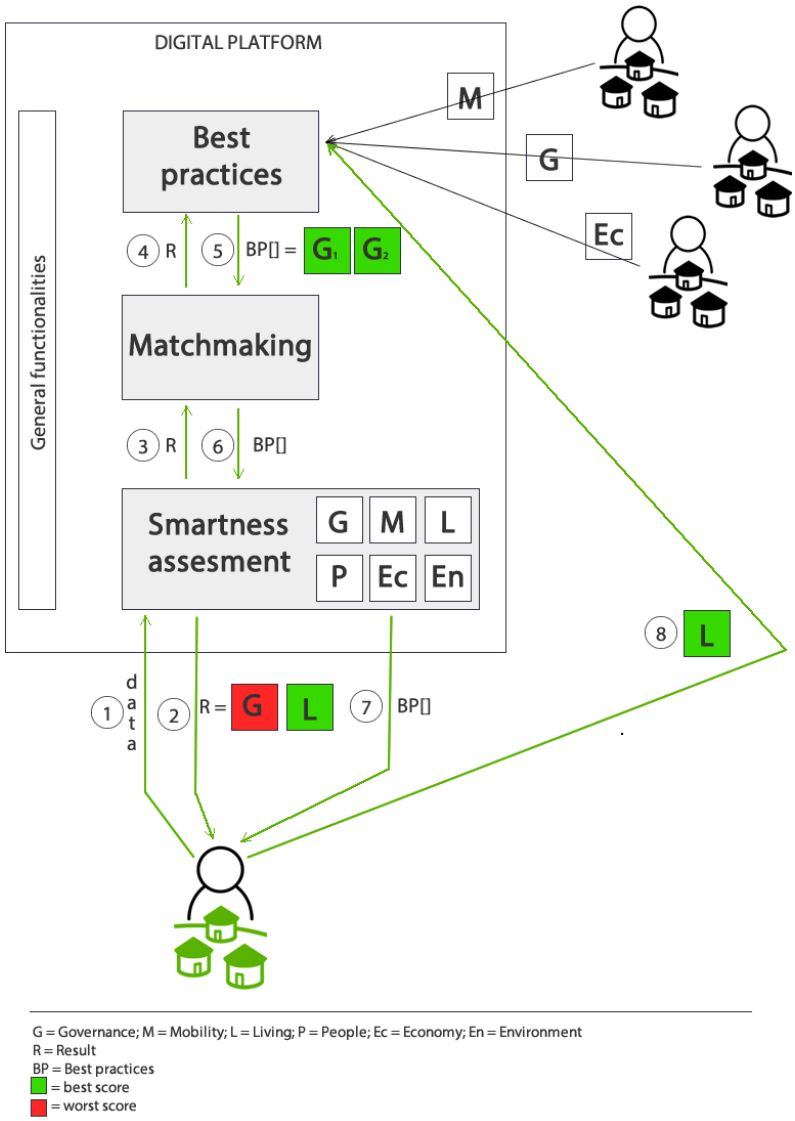
The Digital Platform also includes a knowledge base combining Best Practices from different domains, covering the smartness dimensions and indicators presented in Section 3.1.1. The collection of Best Practices is intended to enable rural and mountain areas to share feasible activities on smart transformation, and to be inspired by actions fostering smart transformation uploaded by areas in similar geographical and socio-economical contexts. Best Practices will be provided by villages within their highest evaluated dimension, that are willing to share their experiences and obtained knowledge with interested parties.

For quicker retrieval and clearer usability, each Best Practice will be uploaded in an agreed format, and will highlight the smart dimension in which the Best Practice is intended, the relevant indicator(s) and a few tags highlighting keywords that are useful to connote and define each Best Practice. Even more, the prepared document format will allow the matchmaking part of the platform to connect similar villages according to the different properties.

3.1.3 Matchmaking

The Matchmaking functionality within the Digital Platform presents a connecting step between Self-assessment and Best Practices. With this, interested parties could look into potential references for their starting steps of the smart and digital transformation. Matchmaking is aimed at connecting interested parties with suitable Best Practices that can help them with their smart transformation. A connection is done based on results from a smartness assessment, matching villages needing help within a specific dimension to the knowledge and experience of another village with a highly evaluated smartness of the same dimension. In addition, the Matchmaking functionality also provides a list of similar villages, based on matching an interested party with its counterpart, using the content, requirements, region or smartness level.

Figure 1: A high-level presentation of the Digital Platform's key-component interaction.



Depending on the objective to be pursued, Matchmaking can be structured in different forms:

- **village to village (v2v)**, whereby the matchmaking process is oriented to put in contact villages with similar degrees of smartness maturity
- **village to project test area (v2ta)**, whereby the matchmaking process is intended to share successful experiences in smartness activities grouped by test areas
- **village to business and vice versa (v2b and b2v)**, where the objective is to connect people and companies so that they can collaborate in the development of goods and services in order to improve smartness capabilities.

3.1.4 Collaboration

Another important aspect that facilitates smart transformation is communication between interested parties. Therefore, one of the key functionalities of the Digital Platform is collaboration. The Digital Platform offers different functionalities supporting communication and collaboration, namely, document exchange functionalities (*DE*), forum (*FO*), events (*EV*) and gallery (*GA*). In order to maximize the efficiency of supported functionalities, the user access level differs according to their properties. Table 1 presents the collaboration and communication functionalities, including four different level of users.

The Digital Platform supports collaboration and communication activities within the SmartVillages Project Partners and Project Test Areas, i.e. villages included in the SmartVillages Project. On the other hand, communication is also supported for interested rural areas and the general public, which are able to

	Project Partners
Project Partners	*FO*, *DE*, *EV*, *GA*
Project Test Areas	*FO*, *DE*, *EV*, *GA*
Interested Rural Areas	*EV*, *GA*
General Public	*EV*, *GA*

	Project Test Areas
Project Test Areas	*FO*, *DE*, *EV*, *GA*
Interested Rural Areas	*FO*, *EV*, *GA*
General Public	*FO*, *EV*, *GA*

Table 1: Collaboration and communication functionalities (*FO* – Forum, *DE* – Document Exchange, *EV* – Events, *GA* – gallery) supported within the Digital Platform.

communicate with Project Test Areas through the forum, and follow project activities through events and gallery.

3.2 Existing digital platforms

A review of the existing digital platforms was carried out, since the implementation of the key functionalities presented in Section 3.1 requires some further analysis. A variety of digital platforms already exists within the EU, e.g., Digitalsocial.eu Platform, European Platform for Rehabilitation, Europeana Europe's Digital Platform for cultural heritage, Cloud-Based Digital Health Monitoring Platform With EU Privacy, Entrepreneurial innovation & education driving Europe's digital transformation, NEM Initiative New European Media Initiative Cboe Europe, INTESI internal platform and Common European Sustainable Built Environment Assessment. Five digital platforms were reviewed for the purpose of collecting the existing knowledge. A short presentation of each is presented hereinafter.

The S3 Platform (European Commission, 2018d) provides advice to EU countries and regions for the design and implementation of their Smart Specialization Strategy (S3). The functionalities include: Providing guidance material and good practice examples; informing on strategy formation and policy-making; facilitating peer-reviews and mutual learning; supporting access to relevant data; and training policy-makers.

The Alpine Think Tank (Swiss Center for Mountain Regions (SAB), 2018) is a platform for the exchange of experiences on Service of General Interests (SGI) provision across the Alps. It identifies upcoming challenges for SGI in the Alps, and the searches for (transnational) solutions. It includes a database of existing strategies, good practices, News, Events, and elements for policy recommendations.

The main objective of the EMYNOS Project (European Commission, 2018a) is the design and implementation of a Next Generation platform capable of accommodating rich-media emergency calls that combine voice, text, and video, thus constituting a powerful tool for coordinating communication among citizens, call centers and first responders.

The European Digital Forum (European Commission, 2018b) is a think tank led by the Lisbon Council and Nesta, in collaboration with the European Commission's Startup Europe Initiative. Founding partners include Banco Bilbao Vizcaya Argentaria (BBVA) and the European Investment Fund. Accenture serves as a partner.

The EPR (European Commission, 2018c) is a network of service providers to people with disabilities committed to high-quality service delivery. EPRs mission is to build the capacity of its members to provide sustainable, high-quality services through mutual learning and training.

Table 2 summarizes the key features of the aforementioned digital platforms. From it, it is apparent that all platforms are lacking a Matchmaking feature. The closest resemblance to the latter is so-called Matchmaking during organized events, where people with the same interests share experiences and knowledge. Another relatively low present feature in digital platforms is Self-assessment. Existing digital platforms are lacking interactive questionnaires that, based on users' answers, provide related places or areas. Furthermore, Best Practices are usually not provided directly, but could be deduced based on published papers on platforms' webpages, e. g., forum and file system. Such a search is very time-consuming and usually not fruitful. Collaboration is the only feature that is present in all of the platforms, either via forums, file sharing systems, etc.

4 Implementing Key Functionalities and Architectural Backbone of the Digital Platform

The goal of the Digital Platform is to facilitate the smart transformation of interested rural areas. Therefore, all of the key functionalities described in chapter 3.1, will be included and implemented complementing general functionalities. Since the development of the Digital Platform is still work in progress, some of the functionalities are not yet implemented, since they still present a work in progress. Therefore, the presented paper, in addition to existing project results, also provides an insight into current research work.

Figure 1 presents a high-level view of the SmartVillages Digital Platform. Key functionalities are connected and built one atop another, aimed at providing a comprehensive set of tools and methods, allowing smartness assessment, supporting Matchmaking and providing Best Practices.

Moreover, the Digital Platform is intended to offer a wide range of functionalities concerning data analysis. These functionalities have the threefold objective of a) Making explicit facts that remained implicit, b) Draw-

Digital platform	Self-assessment	Best practices	Matchmaking	Collaboration
S3 Platform	✗	✓	✗	✓
Alpine Think Tank	✗	✓	✗	✓
EMYNOS	✗	✗	✗	✓
European Digital Forum	✓	✓	✗	✓
EPR	✗	✓	✗	✓

Table 2: Evaluation of digital platforms based on the key features.

ing robust conclusions, and c) Supporting a diverse number of institutions and individuals who can use those conclusions in their decision-making processes. This analysis will be carried out on the data stored in the back-end. Most of these data will come from users' input, although, some data necessary for the analysis will be obtained automatically from knowledge bases such as Wikipedia or DBpedia. With this way of working, we want to make sure that back-end analysis will not interfere with the user operations. In addition, this way of working will facilitate the rapid prototyping of lightweight scripts (e.g. JavaScript, Python, R, etc.) designed specially for very specific tasks. Some examples of tasks are:

- **Village similarity**, in order to obtain reports of villages with similar degrees of smartness maturity
- **Village clustering**, in order to group villages according to user-defined theme characteristics
- **Association rules**, in order to discover the latent inter-dependency between factors that seemed hidden to the naked eye
- **Forecasting**, in order to predict correctly how the degree of smartness maturity will evolve based on experiences in similar villages
- **Advanced visualization**, to represent in a user-friendly way different kinds of information (categorical, geographical, quantitative, etc.) that helps to understand better the information provided through the assessment tool
- **Complex queries**, in order to facilitate the process of searching for information that should meet a high number of heterogeneous restrictions

Obviously, the treatment of all these data will be done in an anonymized form with respect to the legislation in force, and will be made available only to authorized people, although, probably, results will be obtained that may be of interest to a diverse number of audiences (policy makers, journalists, general public, etc.). That is why each result obtained will be published using the appropriate formats and communication channels. It should be noted that comments made by users who are using their natural language have a difficult automatic treatment.

In the Digital Platform, different components representing key features collaborate, wherein the exchange of information among entities is based on seven key procedures (presented in circles in Figure 1). The Smart Villages feed data into the platform, which matches them with Best Practices (`BP[]`) by data fusion from providers. The data types are Governance (`G`), Mobility (`M`), Living (`L`), People (`P`), Economy (`Ec`), and Environment (`En`).

Th Smartness assessment component within the SmartVillages Digital Platform allows the evaluation of rural areas. Algorithm 1 presents an overview of the smartness assessment, wherein steps are presented using a pseudo-code. Algorithm 1 requires vector $QA = (QA_{sm\_dim1}, QA_{sm\_dim2}, \ldots, QA_{sm\_dim_j})$ that contains questionnaire answers of all smart dimensions. Also, vector $SD = (sm\_dim_1, sm\_dim_2, \ldots, sm\_dim_d)$ is required, comprising smart dimensions for $d = [1, 6]$. Thus, the vector can also be presented as $SD = \{G, M, L, P, Ec, En\}$. $V = [v_1, v_2, \ldots, v_m]$ is a vector of m-villages that are not yet assessed. All assessed villages are stored in the $AVD = (v_1, v_2, \ldots, v_a)$ vector, where a represents the number of assessed villages. As a result, Algorithm 1 returns assessments of all smart dimensions, $v_{sm\_dim1\ldots d}$, best rated smartness dimension, v_{sm_dimmax} and smartness dimension evaluated as lowest, v_{sm_dimmin}.

Algorithm 1 getSmartness

Require:
$QA = (QA_{sm\_dim1}, QA_{sm\_dim2}, \ldots, QA_{sm\_dim_j})$
$SD = (sm\_dim_1, sm\_dim_2, \ldots, sm\_dim_d)$
$AVD = (v_1, v_2, \ldots, v_a)$
Ensure:
store $QA, AVD, sm\_dim_{max}, sm\_dim_{min}$

1: **for all** $d \in SD$ **do**
2: $v_{sm\_dimd} = eval(QA_{sm\_dimd})$
3: **end for**
4: $AVD \cup v_{sm\_dim}$
5: $v_{sm\_dimmax} \leftarrow max(v_{sm\_dim})$
6: $v_{sm\_dimmin} \leftarrow min(v_{sm\_dim})$
7: **return** $v_{sm\_dim1\ldots d}$, v_{sm_dimmax}, v_{sm_dimmin}

The Digital Platform also includes a knowledge base consisting of existing Best Practices. Best Practices are an example of used methods or tools that are implemented successfully in the specified village. As shown

in Figure 1, component Best Practices collaborates with component Smartness assessment through component Matchmaking, displaying suitable Best Practices according to the provided Self-assessment.

Algorithm 2 getBestPractices

Require:
$v_i\_sm\_dim$
$SV = \emptyset$
BP
$th \leftarrow threshold$
Ensure:
store SV, BP

```
1: v_i ← data ▷ get data of i-th village from database
2: for all avd ∈ AVD do
3:     if proximity(avd, v_i) > th then
4:         SV ∪ avd
5:     end if
6: end for
7: return SV
8: for all s ∈ SV do
9:     for all d ∈ SD do
10:        if s_dmax is true and v_imin is true then
11:            return BP(s_dmax)
12:        end if
13:    end for
14: end for
```

Algorithm 2 presents the matchmaking steps resulting in a list of Best Practices, $BP(s_{dmax})$, presenting a good practice within the smart dimension evaluated as the lowest (Algorithm 1). Algorithm 2 requires $v_i\_sm\_dim$, presenting smart dimensions of the i-th village and vector BP including Best Practices per smartness dimensions. First, the matchmaking process searches for similar villages, based on the properties of the i-th village, and stores them into the vector SV. In the second part, Best Practices for the i-th village are found, searching for matching results by comparing the smartness dimension of the i-th village that was evaluated as lowest, and Best Practices from the same smartness dimensions that were provided by the villages where a corresponding dimension was evaluated as the best.

5 Conclusion

Digital support presents an important role in the efficient smart transformation of rural areas. An edition of the Digital Platform is currently under development within the SmartVillages Project. In the context of requirements' specification, four key functionalities were identified: (1) Self-assessment, (2) Best Practices, (3) Matchmaking and (4) Collaboration. The paper presents current specifications of each functionality, its interaction, and collaboration with other components and its position in the architecture of the Digital Platform. Some of the functionalities are already implemented and supported in the existing version of the SmartVillages Digital Platform, while others present work in progress and will be implemented based on the further development of existing specifications.

The developing Digital Platform could be transferred to other domains (e.g. cities), allowing the digital smart transformation of chosen areas. Regardless for which domain the platform facilitates the digital transformation, the defined key functionalities could be adapted, whereby strictly in the context of adapted (suitable) smartness dimensions, since these link the platform's functionalities and enable interaction of key components. With this, the customized smartness assessment and corresponding activities could be done within any domain.

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