

LINKS

Strengthening links between technologies and society
for European disaster resilience

D7.2 CONCEPT FOR THE LINKS COMMUNITY CENTER

Research Report

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EXECUTIVE SUMMARY

About the project

LINKS “Strengthening links between technologies and society for European disaster resilience” is a comprehensive study on disaster governance in Europe. In recent years, social media and crowdsourcing (SMCS) have been integrated into crisis management for improved information gathering and collaboration across European communities. The effectiveness of SMCS on European disaster resilience, however, remains unclear, the use of SMCS in disasters in different ways and under diverse conditions. In this context, the overall objective of LINKS is to strengthen links between technologies and society for improved European disaster resilience, by producing sustainable advanced learning on the use of SMCS in disasters. This is done across three complementary knowledge domains:

- Disaster Risk Perception and Vulnerability (DRPV)
- Disaster Management Processes (DMP)
- Disaster Community Technologies (DCT)

Bringing together 15 partners and 2 associated partners across Europe (Belgium, Denmark, Germany, Italy, Luxembourg, the Netherlands) and beyond (Bosnia & Herzegovina, Japan), the project will develop a framework to understand, measure and govern SMCS for disasters. The LINKS Framework consists of learning materials, such as scientific methods, practical tools, and guidelines, addressing different groups of stakeholders (*e.g.* researchers, practitioners, and policy makers). It will be developed and evaluated through five practitioner-driven European cases, representing different disaster scenarios (earthquakes, flooding, industrial hazards, terrorism, drought), cutting across disaster management phases and diverse socioeconomic and cultural settings in four countries (Denmark, Germany, Italy, the Netherlands). Furthermore, LINKS sets out to create the LINKS Community, which brings together a wide variety of stakeholders, including first-responders, public authorities, civil society organisations, business communities, citizens, and researchers across Europe, dedicated to improving European disaster resilience using SMCS.

About this deliverable

The LINKS Community Center (LCC) will be a web-based platform facilitating sustainable advanced learning for the LINKS Community by enabling the Community to exchange information and experiences and to access, discuss and assess research results of the project, such as the LINKS Framework and the LINKS case-based assessments. This deliverable describes the concept and architecture of the LCC based on the previous work presented in deliverable 7.1 (D7.1), which elaborated the needs and potentials for the LCC.

The concept and architecture are described here on a level of abstractness concrete enough to implement technical solutions but too abstract to describe concrete content. This will enable the tech-

nical implementation of the LCC to start while allowing the concrete content structure and the actual content to be developed together with the LINKS Framework and the LINKS Knowledge Bases in an agile manner. This is achieved by transforming the 34 concrete needs identified in D7.1 into eight more abstract need areas that capture the essential technological implication of the needs. While the need areas are used to validate whether the proposed architecture is capable of covering the identified needs, the needs themselves will be transformed into user stories to guide the actual implementation of the LCC. Furthermore, potentials for the implementation of the LCC are identified by researching tools that could be used to satisfy the need areas and by analysing existing approaches related to the goals of the LCC.

The architecture elaborated includes a wiki. The wiki will be used primarily to host the learning processes and materials contained within the LINKS Framework and the Knowledge Bases. The LINKS Community will be able to improve those components and add new ones. Communication within the LCC is facilitated via a forum which itself is coupled tightly to the wiki to form one cohesive platform. Additional support is provided by a cloud collaboration software and activity in the LCC is bundled in a timeline. All tools are based on open-source software, paving the way towards technical sustainability. This architecture is considered to be an artifact in the sense of design science, meaning that it will be iteratively evaluated and improved.

Besides the technological implementation of the LCC, next steps will include the elaboration of the content to be included within the LCC and its continuous improvement. This step involves not only the other LINKS WPs but also the LINKS Community and, once a version of the LCC is public, all visitors and users of the LCC.

A first version (V0) of the LCC is due in M16 (September 2021, D7.3).

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LIST OF ACRONYMS

Abbreviation / Acronym	Description
API	Application Programming Interface
CMS	Content Management System
D	Deliverable
DCT	Disaster Community Technology
DMP	Disaster Management Process
DRPV	Disaster Risk Perception and Vulnerability
GA	Grant Agreement
KMS	Knowledge Management System
LCC	LINKS Community Center
LDM	LINKS Data Model
LMS	Learning Management System
N	Need
NA	Need Area
NaPs	Needs and Potentials
P	Potential
PA	Potential Area
SMCS	Social Media and Crowdsourcing
WP	Work Package

DEFINITION OF KEY TERMS¹

Term	Definition
LINKS Community	A sustainable stakeholder community consisting of multidisciplinary stakeholders from several countries, professions, and schools of thought. The main stakeholders involved in the LINKS Community are: practitioners, industry, decision makers, researchers and networks (the scientific community), citizens and civil society.
LINKS Community Center	The LCC brings together different stakeholders (LINKS Community) in one user-friendly and flexible web-based platform and enables them to exchange knowledge and experiences and to access, discuss and assess learning materials on the usage of SMCS in disasters.
LINKS Framework	<p>A set of learning materials, such as methods, tools and guidelines for enhancing the governance of diversity among the understanding of SMCS in disasters for relevant stakeholders.</p> <p>Methods in LINKS refer to approaches that will enable researchers and practitioners to assess the effects of SMCS for disaster resilience under diverse conditions.</p> <p>Tools are practical instruments supporting first-responders, public authorities, and citizens with the implementation of SMCS in disaster and security contexts.</p> <p>Guidelines are recommendations for improving national and regional governance strategies on SMCS as well as introductions and explanations of how to apply the methods and tools under diverse conditions.</p>
LINKS Knowledge Bases	<p>The outputs and knowledge obtained from the assessments of the three knowledge domains.</p> <p>The knowledge is used to develop the LINKS Framework.</p>
LINKS Knowledge Domains	<p>The three crucial domains of analysis for studying European disaster resilience and SMCS. These include:</p> <p>Disaster Risk Perception and Vulnerability (DRPV), for assessing changes in the citizens' perception of disaster risks induced by SMCS, as well as assessing the changes in the vulnerability of practitioners and citizens.</p> <p>Disaster Management Processes (DMP) for analysis of how SMCS changes the procedures and processes within the crisis and disaster management.</p>

¹ Definitions are retrieved from the LINKS Glossary (forthcoming).

	<p>Disaster Community Technologies (DCT), for assessing SMCS related technologies used by practitioners (and citizens) in disasters.</p>
<p>Sustainable Advanced Learning</p>	<p>A maintainable and evolving collection of knowledge and best practices produced for and by relevant stakeholders. Sustainable Advanced Learning entails a cognitive dimension (the capability to gain in-depth knowledge of e.g. crises and crisis management), a social dimension (the collaborative efforts to implement that knowledge into new practices), and a transformative dimensions whereby reflections are made on how knowledge was learned, what has changed in the process, and how and in what ways new knowledge might continue to evolve.</p>

1. INTRODUCTION

A key objective of the LINKS project is to build a sustainable, multidisciplinary stakeholder community consisting of different actors from various countries, professions, and schools of thought. It is intended that they will learn and benefit from the project development and outcomes while providing their knowledge and expertise to improve LINKS research. The aim of the LINKS Community is to learn and benefit from the project development and results and to provide their knowledge and expertise to improve LINKS research. An important tool for this purpose is the LINKS Community Center (LCC) as it will be the gathering place for the online community.

The LCC brings together different stakeholders (LINKS Community) in one user-friendly and flexible web-based platform and enables them to exchange knowledge and experiences and to access, discuss and assess learning materials on the usage of SMCS in disasters. (LINKS Glossary)

Through the LCC, stakeholders will be able to access materials for sustainable advanced learning (included in the LINKS Framework), such as methods, ready-implementable tools, and easily applicable guidelines to achieve a more effective use of SMCS in disasters. The evaluation and practical application of the LINKS Framework will be carried out through case-based assessments. The LCC therefore plays a vital role in creating and fostering a lively community around the LINKS project and its results. Furthermore, the LCC can be a valuable tool for establishing and sustaining the LINKS Community beyond the duration of the LINKS project.

The LCC directly contributes to the LINKS project objectives by:

- **Sustainable advanced learning on SMCS in disasters (O1):** Integrating the LINKS Framework in an online environment in a dynamic way which enables stakeholders to access, learn and refine the LINKS Framework.
- **Achieve a consolidated understanding of SMCS in disasters (O2):** Supporting the LINKS case-based assessment of the Framework.
- **Govern the diversity of SMCS in disasters (O3):** Providing visibility of the Framework and project results and supporting the ongoing validation and evolution of the Framework by the LINKS Community.
- **Bring multidisciplinary SMCS stakeholders together (O4):** Providing an online interface for diverse stakeholders to learn through discussions, collaborations, and the exchange of knowledge.

This deliverable describes the concept and architecture of the LCC based on the needs and potentials researched and presented in D7.1 (Kiehl et al., 2021). Therefore, the main target audience are researchers and technology providers who have an interest in how the LCC is designed and how similar platforms might be designed in the future. The concept and architecture are described here

on a level of abstractness concrete enough to implement technical solutions but too abstract to describe concrete content. This is intentional as it will enable the technical implementation of the LCC to commence while allowing the concrete content structure and the actual content to be developed together with the LINKS Framework and the LINKS Knowledge Bases in an agile manner. A first version (V0) of the LCC is due in M16 (September 2021, D7.3).

To describe the concept and architecture of the LCC on an appropriate level of abstractness, the methodology used will first be described (Section 2). The needs and potentials from D7.1 are then transformed into need areas and tools which could be used to implement the LCC as well as approaches related to the LCC are identified (Section 3). Based on this, the architecture and accompanying aspects of the LCC (such as the relation to the LINKS Framework) are described in Section 4. Different facets of sustainability of the LCC are elaborated in Section 5. The future work on the LCC is described in Section 6 and a conclusion is presented in Section 7.

2. METHODOLOGY AND CONTEXT

This section will provide a brief overview of the context of this deliverable and the methodology used.

2.1 Context within WP7 and LINKS

The overall scientific methodology used for the development of the LCC is design science as described by Hevner et al. in (Hevner, March, Park, & Ram, 2004) and (Hevner & Chatterjee, 2010). In short, design science approaches a problem by iteratively building and evaluating an artifact (design cycle) while making sure that the artifact is relevant and well-suited for its intended purpose (relevance cycle) and embedded into the state-of-the-art (rigor cycle). The artifact in this case is the LCC. For a detailed description of design science and how it relates to the development of the LCC, please refer to Section 2.1 of D7.1.

In addition to the overall scientific methodology, D7.1 identified and prioritised a first list of needs and potentials (NaPs) for the LCC and the potential stakeholders. This list, albeit being a work-in-progress as more needs and potentials will become known over time while others may become irrelevant, provides a basis for creating the technical foundation and architecture of the LCC. Furthermore, D7.1 already reviewed and presented concepts for building and managing online communities (see Section 3.1 of D7.1), providing guidance on how to organise content and motivate interactions in the LCC.

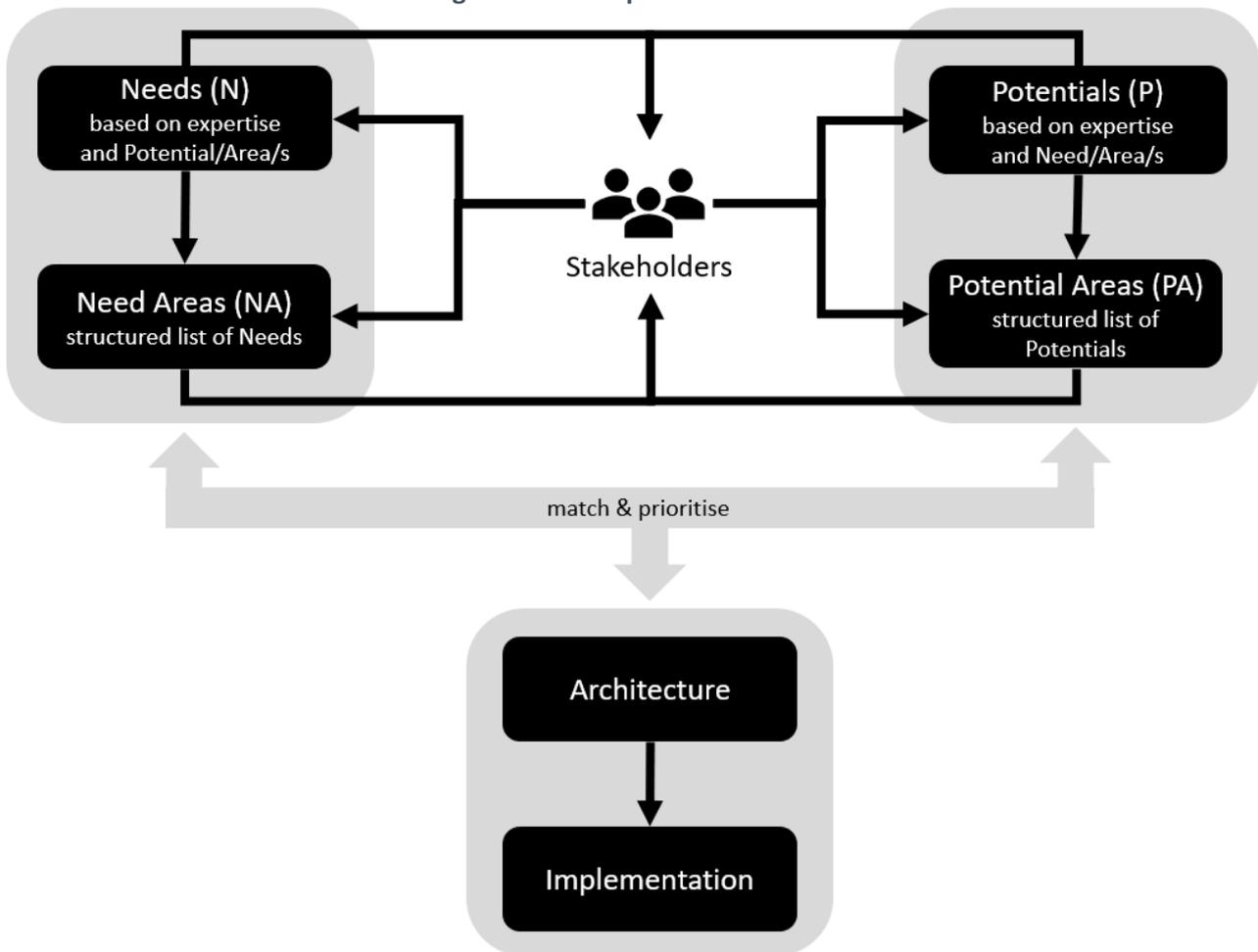
2.2 Deliverable Structure

Figure 1 displays how the concept of the LCC was elaborated and will be refined in the future. The starting point of this process are the Needs and Potentials (NaPs) listed in D7.1. As most of the NaPs listed in D7.1 are needs resulting from workshops and meetings with stakeholders of the LCC and even the potentials listed in D7.1 could also be needs when stated by a stakeholder, the list of NaPs from D7.1 is considered to be primarily needs. These needs (*e.g.* regarding the ability of the LCC to implement the sustainable advanced learning envisioned within the LINKS Framework) are grouped and abstracted into Need Areas (NAs), which summarise the technological implications of the needs (left half of the figure). The result of this is presented in Section 3.1 and will be used to test whether the architecture of the LCC can provide sufficient technological features to cover these needs.

The analysis of potentials shown on the right side of the figure is performed by the researchers developing the LCC based on the identified needs and existing expertise. These potentials include the identification of tools which could be used to implement the LCC and a research of similar approaches to gain input for the design of the LCC. These Potential Areas (PAs) are presented in Section 3.2.

The NAs and PAs are constantly matched and prioritised. The first iteration of this process resulted in the architecture (Section 4) and sustainability (Section 5) of the LCC and will be subsequently implemented. These are considered artifacts in the sense of design science, meaning that they will be iteratively evaluated and improved. Furthermore, the identified needs, need areas, potentials and potential areas will be constantly discussed with stakeholders with the goal of identifying new needs and potentials that could lead to an improvement of the LCC. This future work is described in Section 6.

Figure 1: Development of the LCC



Source: Author's contribution

2.3 User Stories and Software Development

To ensure that the LCC is developed according to the stakeholders' needs, these needs must be understood, prioritised, and agreed by the stakeholders and the developers. They must be verifiable and traceable during and at the end of the project. As it is near to impossible to define a complete and detailed set of needs, the process of finding and adapting them is ongoing and iterative. To simplify and make this process transparent, user stories as described in (DSDM, 2014) are used.

User stories are written from the perspective of a user's goal and lead to one or more technical requirements and subsequent changes that need to be implemented to address the user story. User stories combine three aspects. First, the written description can be used while planning the system and later as a reminder of the purpose of the system. The second aspect is that the developers must conduct conversations over the user stories to find new technological changes or details they must implement. Thirdly, as the project progresses, the user stories can be used to verify and validate the system by comparing the developed system with the documented user stories (Cohn, 2004). The advantages of the user stories is that they focus on the role of the user who is going to be impacted by the system (the LCC). Because of this, the needs are defined from viewpoint of the user role. This helps to clarify why a specific feature is necessary for the LCC. The technological changes which result from user stories are often at a high level and can be split up into low level changes with a lot of detail during the ongoing project (DSDM, 2014). To ensure that the quality of the user stories is high, they will be written using the so-called INVEST criteria *i.e.* they should be independent, negotiable, valuable, estimable, small, and testable. Additionally, it is recommended to use a story card for the creation of the user stories. An example of a story card can be seen in Figure 2 (Plewa, 2019). This story card allows user stories with additional meta-information to be stored and managed using a standardised schema.

To support the collection and management of user stories of the LCC, it is planned to use the de-facto industry standard GitHub². Although GitHub is mainly a collaboration platform for developers allowing them to simultaneously work on the same code, GitHub also provides a project management feature. This feature offers the possibility to collect and structure the user stories with multiple persons online to ensure that the developers involved in the project always refer to the same and newest version of the user stories. It is also possible to create a project board (called Kanban) which supports the management of user stories and available capacity. Through the version history of GitHub, the collection of user stories is transparent and traceable.

The user stories are created from different sources. Initial input is obtained from the needs and potentials described in D7.1 and future input will include the results of workshops on the LINKS Framework and the LINKS Community (see Section 6.2) and any other feedback (*i.e.* through a feedback form inside the LCC). Once input is received, it will be clarified and elaborated together with the person reporting the input until it is well understood and meets the INVEST criteria. The resulting user story will then be taken into account for the iterative development of the LCC.

² <https://github.com>

Figure 2: Example user story

Title: Example		Story ID: US-001	
User Story		Date	
As a citizen, I want short guidance on how to use SMCS in disasters so that I can best use SMCS during a disaster to help me and my community.		20.04.2021	
		Author	
		Kiehl, M	
Verification Criteria		Priority	
A short guidance how to use SMCS during a disaster is available with easy access to the public.		High	
		Responsibility	
		Kiehl, M	

Source: Author's contribution

The dynamic nature of using user stories to manage requirements for the LCC also requires a dynamic software engineering approach. To achieve this, agile development as described in (Abrahamsson, Salo, Ronkainen, & Warsta, 2002) will be used to design, develop, and deliver the LCC. Although two major versions of the LCC are based on deliverables (D7.3 in M16, viewed as a minimum viable product and D7.4 in M24, viewed as a first feature-complete version), smaller versions with incremental changes will be continuously published and tested between M16 and M24 (and beyond). This allows all interested parties to monitor the development of the LCC and to provide input at every stage during the development.

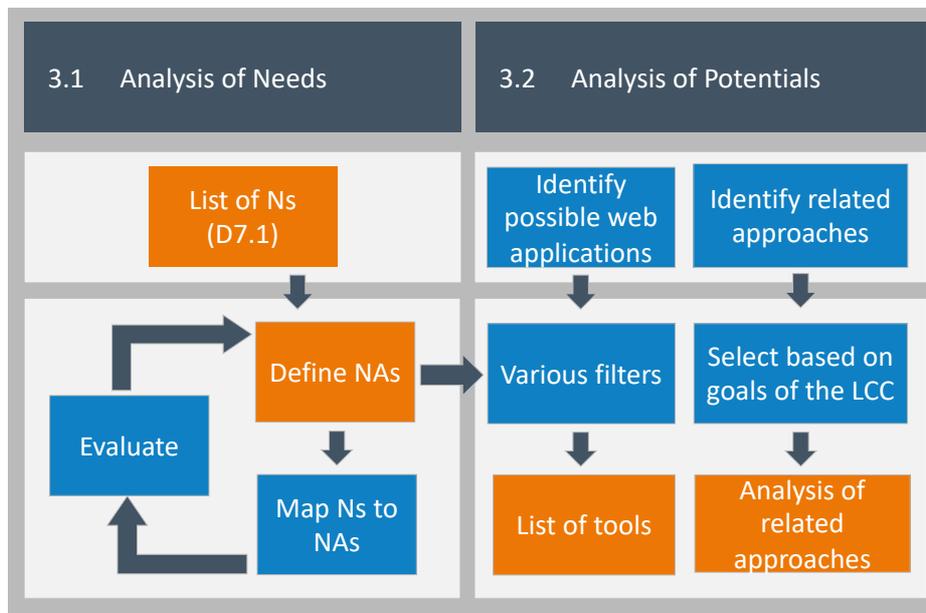
3. NEEDS AND POTENTIALS REFINEMENT

This section provides an overview of how the needs and potentials initially presented in D7.1 were refined. Note that although D7.1 identified needs and potentials for the LCC, it focused mostly on the stakeholder's needs. To avoid confusing terminology, the needs and potentials listed in D7.1 will be henceforth referred to only as needs. Needs are defined as 'stated demand for a (non-) technical solution' and potentials are defined as 'existing (non-) technical solutions that could match a need'.

The approach of this section is shown in Figure 3 with concrete results being shown in orange boxes and intermediate steps shown in blue boxes. As shown on the left side, the list of needs started in D7.1 is used to define need areas (NAs). These NAs summarise the most important technological aspects of the needs and will be used to check whether the concept for the LCC described in this deliverable is suitable to cover all identified needs. The NAs are identified iteratively by defining an NA, mapping needs to the new NA and evaluating whether all needs are sufficiently covered.

The right side of the figure shows the analysis of potentials for the LCC. This analysis is based on two pillars. In the first pillar, a literature search is used to identify web applications which could potentially be used for the implementation of the LCC. The result of this search is then filtered (e.g. to remove duplicates and to identify only applications which are relevant to the LCC by matching them with the identified NAs) and presented as a list of relevant tools. In the second pillar, approaches related to the overall idea of the LCC are identified, filtered and analysed. These approaches are later used as inspiration for the architecture of the LCC.

Figure 3: Needs and Potentials refinement



Source: Author's contribution

3.1 Analysis of Needs

The following sections will explain how the needs presented in D7.1 were transformed into NAs. These NAs will be used in Section 4.3 as a means to verify whether the proposed architecture is suitable for technically covering the Ns.

3.1.1 List of Needs

In D7.1, the needs for the LCC were collected and elaborated using different methods, such as a workshop and a survey. The result of the collected needs can be found in Table 1. At the time of this deliverable, a total of 34 needs have been collected and were analysed using the categories already developed. The needs with an ID larger than 31 have been added since the publication of D7.1, *e.g.* based on discussions with project partners. In addition to the creation of NAs, the Ns will be further used and expanded on in the form of user stories during the development of the LCC.

Table 1: List of needs and the corresponding need areas

ID	Description	NA 1: Learning Materials	NA 2: Structure	NA 3: Interaction	NA 4: Collaboration	NA 5: Filtering	NA 6: Quality Control	NA 7: Communication	NA 8: Technical sustainability	Need covered by any NA?	Sum of covered NAs
1	Provide easy access to guidelines (e.g. SMCS in disasters, DCTs, DMP...)	x				x				yes	2
2	Provide easy access to the knowledge bases	x				x				yes	2
3	Provide easy access to deployment reports	x				x				yes	2
4	Provide easy access to good practise examples	x				x				yes	2
5	Provide easy access to real case studies	x				x				yes	2
6	Provide easy access to other project findings	x				x				yes	2
7	Use a motivation concept to activate and motivate the LINKS Community									no	0
8	Provide a contact list of registered organisations in the LCC				x			x		yes	2
9	Have access to a disaster data base with different types of disasters and lessons learned with regards to social media usage	x				x				yes	2

10	Integration with other LINKS elements (Webpage, Framework, LCW/LAC, Cases)		x	x					x	yes	3
11	Offer different communication functions (bilateral -> chat, comment, forum, etc.)				x			x		yes	2
12	Provide conference tools			x	x			x		yes	3
13	Record user interactions (anonymously) for the evaluation and improvement of the LCC						x			yes	1
14	Filtering and keyword search system		x			x				yes	2
15	Provide an easy way to provide input and give feedback on basically everything			x	x		x			yes	3
16	Development of an intuitive user interface (symbols...)			x						yes	1
17	Provide methods for the collection of quantitative data (e.g. surveys) on crisis-related issues				x					yes	1
18	Serve as a point of contact for problems / in disasters (from an organisational and citizens perspective)						x	x	x	yes	3
19	Provide a wiki	x	x		x					yes	3
20	In addition to a local login, login with Google/Facebook/LinkedIn to simplify the signup process			x						yes	1
21	Provide a forum			x				x		yes	2
22	Offer the possibility to work on confidential content									no	0
23	Enable collaborative research (clear idea missing)				x					yes	1

24	Provide contact information of users in the LCC				x			x		yes	2
25	Define a clear positioning / demarcation between similar national and EU networks									no	0
26	Provide a chat				x			x		yes	2
27	Have all information as publicly visible as possible to make it accessible			x	x		x			yes	3
28	Provide a full-text search for a document database (e.g. PDFs, Word documents)		x				x			yes	2
29	Avoid technical dependence on third parties to ensure that the LCC can be available indefinitely and operate independently to achieve sustainability								x	yes	1
30	Provide content in multiple languages	x		x				x		yes	3
31	Offer compatibility with screen readers	x		x						yes	2
32	Add transparent timestamps as much as possible			x	x	x	x			yes	4
33	Provide a transparent change history			x	x		x			yes	3
34	Add authors and reviewers to a learning material			x	x		x	x		yes	4

Source: Author's contribution

3.1.2 Mapping of Needs to Need Areas

Based on the needs, NAs were created in an iterative process. Initially, six NAs were defined and compared to the needs listed in Table 1. The table displays which need is covered by which NA. As the first iteration did not yield a suitable NA for every need, this process was repeated until the eight NAs shown in Table 2 were identified. These NAs provide guidance on the broad technological features the LCC must support. The listing and mapping are dynamic, just like the collection and elaboration of needs, and will be continuously developed and extended during the project. In particular, the identification of new potentials (such as new technologies) and subsequent elaboration of new needs could lead to new NAs being introduced.

Table 2: Identified need areas

NA ID	Description
1	Learning Materials: Present learning materials (text, images)
2	Structure: Allow structuring and linking the learning materials
3	Interaction: Provide an intuitive and customisable user experience
4	Collaboration: Allow user collaboration on improving or creating new learning materials
5	Filtering: Provide a search function to easily identify and access relevant learning materials
6	Quality Control: Allow content quality control of the learning materials
7	Communication: Enable communication with other users
8	Technical sustainability: Avoid technical dependence on third parties and develop a sustainable platform

Source: Author's contribution

3.1.3 Quality Assurance in the mapping of Needs to Need Areas

To check whether the identified NAs actually sufficiently cover all needs and whether the number of NAs could be reduced, the number of needs covered by each NA and the number of NAs associated with every need were calculated and are also presented in Table 1. No NAs were removed or added in this step, but a total of three needs could not be reasonably covered by any NA. The following needs are not covered by any NA:

- Offer the possibility to work on confidential content (ID 22): This need would need to be covered by its own NA as it does not fit well within the other NAs. However, it also re-

ceived the least priority in the prioritisation survey conducted in T7.1. It is therefore deferred for now but the ability to define access rights will be kept in mind when selecting software solutions for the LCC.

- Use a motivation concept to activate and motivate the LINKS Community (ID 7): This is not a technical need, but it is addressed within Section 3.1 of D7.1 and Section 5.1 of this deliverable.
- Define a clear positioning / demarcation between similar national and EU networks (ID 25): This is not a technical need, but it is addressed within Section 3.2 of D7.1 and Section 3.2.2 of this deliverable.

3.2 Analysis of Potentials

The following sections describe the two pillars of the identification and refinement of potentials for the LCC. Note that the potentials presented here could be also interpreted as potential areas, depending on the context in which they are used.

3.2.1 Identification and Selection of suitable Web Applications

The following section describes how the applications relevant for the LCC were identified.

3.2.1.1 Research Base

To identify the most relevant web applications for the LCC, a literature search was conducted. Various sources were found, and a total of 122 applications and tools were identified. A large part of the applications and tools can be found in (Schneider, 2013), (Fleerackers, 2013) and (Shrinivas & Ganesh, 2007). The first two sources are websites which have provided additional content. Most of the applications shortlisted for the LCC can be found in (Shrinivas & Ganesh, 2007). This article deals with a conceptual framework and research directions for Web 2.0 and is released as a part of the Americas Conference on Information Systems Proceedings in 2007. The procedure for the selection of the tools is described in the following chapter.

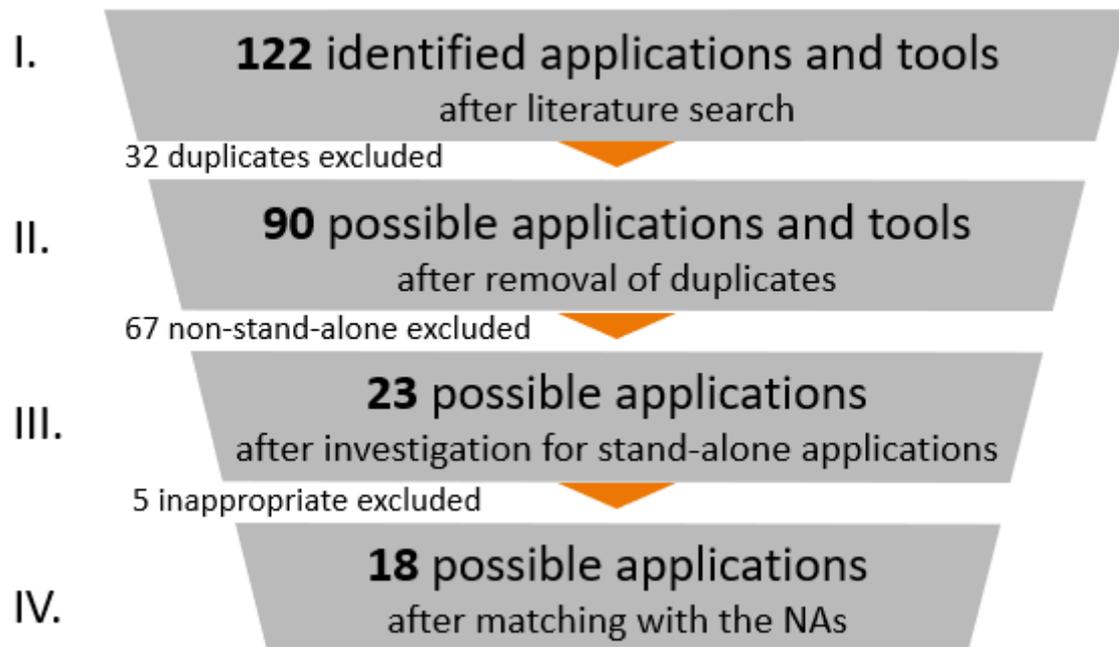
3.2.1.2 Selection of suitable Web Applications

In order to select the suitable application for the LCC, the 122 applications and tools that were identified were then evaluated in several steps according to various criteria. In this way, more and more unsuitable applications were sorted out. The process can be seen in Figure 4. The applications remaining after this process were considered individually and evaluated for their suitability for the LCC. To increase readability, only the remaining applications are presented here. The full list of 122 potential applications is available upon request.

The first step was to remove all duplicate applications. This involved comparing the descriptions of the applications, since not all sources use the same naming. Subsequently, it was investigated whether the applications and tools found can be used as stand-alone applications, or whether they are sub-components of applications, functions (e.g. search-function), methods or something similar.

For usage within the LCC, only stand-alone applications are of interest at this time. The introduction of additional sub-components or functions will be considered at a later stage. The final step was to compare the remaining applications to the identified NAs, which can be found in Table 2, and verify that the application matches one or more of the NAs. With this step, the process of reducing the applications and tools was completed and the individual evaluation of the remaining applications started.

Figure 4: Process for selection of suitable web application



Source: Author's contribution

Now that the process of selecting suitable applications has been completed, there are 18 different applications relevant for the LCC. The applications are listed in more detail in Table 3 and will be further examined in Section 4.4.

3.2.1.3 List of Applications

The list of identified tools is shown in Table 3.

Table 3: Description of the 18 suitable applications

Web Applications	Description
Online notes	Note-taking is the practice of recording information from different sources and platforms. ³

³ <https://www.dictionary.com/browse/notes> & <https://simplenote.com/>

Social Network	A social network is an online service that offers the possibility to exchange information and build relationships. An online community created as a result communicates and interacts in virtual space according to the possibilities of the respective platform. ⁴
Multimedia sharing	Multimedia sharing is a form of social interaction on the Internet in which people send or share media of any kind to personal acquaintances, participants in a community, or strangers. ⁵
Chat	Chat or online chat are an electronic communication through written texts in real time. ⁶
Blog	User-generated website that displays postings by one or more individuals in chronological order and usually has links to comments on specific postings. ⁷
Wiki	The main purpose of wikis is to create a space where people can collaborate in writing a same text on a single topic and relate this text to other texts. In wikis, the users have the permission to add, edit or create new pages. ⁸
Online Office Suite	An online office is an office package as a web application, where office documents can be edited in the browser without the user having to install any application software. ⁹
Online calendars	An online calendar is a web application that allow one or more users to edit, and optionally share with other users, online access to a calendar. ¹⁰
Catalogue	A list, often with pictures, of a company's products or services: The online catalogue is easy to browse, with clear images and product information. ¹¹
Feed Reader	The feed reader (RSS feed) refers to the structured provision of content from a website. RSS feeds are mainly used to get information about changes on an external website as quickly as possible or, if integrated into one's own website, to release them on it. A common example of this would be a new article on a news portal. ¹²

⁴ <https://dictionary.cambridge.org/de/worterbuch/englisch/social-network> & <https://www.businessinsider.de/gruenderszene/lexikon/begriffe/social-network/>

⁵ <https://www.igi-global.com/dictionary/multimedia-sharing/46735> & https://www.researchgate.net/publication/226672685_Multimedia_sharing

⁶ <https://wirtschaftslexikon.gabler.de/definition/chat-27928> & <https://www.seo-analyse.com/seo-lexikon/c/chat/>

⁷ <https://wirtschaftslexikon.gabler.de/definition/blog-51843> & <https://www.seo-analyse.com/seo-lexikon/b/blog/>

⁸ <https://wirtschaftslexikon.gabler.de/definition/wiki-46992> & <https://www.seo-analyse.com/seo-lexikon/w/wiki/>

⁹ <https://www.techopedia.com/definition/10206/office-suite> & <https://www.computerhope.com/jargon/o/office-online.htm>

¹⁰ <https://calendar.online/> & <https://www.thefreedictionary.com/calendar>

¹¹ <https://dictionary.cambridge.org/de/worterbuch/englisch/online-catalogue> & <https://www.wortbedeutung.info/Onlinekatalog/> & <https://www.onpulson.de/lexikon/online-katalog/>

¹² <https://www.seo-analyse.com/seo-lexikon/f/feed-reader/> & <https://www.thefreedictionary.com/Feed+reader>

Web Conferencing	A web conference or online meeting is a 'virtual' meeting organized and held over the Internet between participants who may be located in very different places in real life. ¹³
Microblogging	Blog with shorter messages (often <200 characters). ¹⁴
Forum	A forum is a system on a website that allows participants to communicate with each other asynchronously. Forums are usually flat hierarchically organized discussion places that are focused on specific topics. Participants can create new topics there on their own that fit the overall topic, so-called threads, comment on threads about new contributions, rate them or thank other users for their contributions. ¹⁵
Reference Manager	Reference Managers are software packages to build local libraries that can be used to organize, sort, and reference when writing. Reference Managers can typically be 'plugged in' directly to the researcher's word processing software or web browsers. ¹⁶
Drawing/Whiteboard	Online whiteboards are software solutions that are available as apps or browser-based tools. They help teams collaborate visually across distances in real time. The purpose of a whiteboard is to visualize thoughts and concepts, write down ideas, explain and teach, plan in a group, and more. ¹⁷
Mind mapping/Concept maps	Online mind mapping is a pictorial method for presenting and structuring information. It can be used in many ways. ¹⁸
E-Portfolio	Collection of individual/groups effort, progress, and accomplishments. More than a simple collection of results - it can be used as administrative tool to manage and organise work created with different applications. ¹⁹
Group Manager/Task Manager	Online task managers include planning, managing, monitoring and implementing tasks. ²⁰

Source: Author's contribution

¹³ <https://searchunifiedcommunications.techtarget.com/definition/Web-conferencing> & <https://www.itwissen.info/Webkonferenz-web-conferencing.html>

¹⁴ <https://wirtschaftslexikon.gabler.de/definition/microblog-53992>

¹⁵ <https://wirtschaftslexikon.gabler.de/definition/forum-32140>

¹⁶ <https://www.aje.com/arc/reference-manager-software-what-it-and-what-can-it-do/>

¹⁷ <https://www.collaboard.app/de/blog/was-ist-ein-online-whiteboard-und-wie-kann-ich-es-einsetzen>

¹⁸ <https://www.onpulsion.de/lexikon/mind-map/> & <https://t3n.de/news/mind-mapping-online-tools-568258/>

¹⁹ <https://www.e-teaching.org/lehrszenarien/pruefung/pruefungsform/eportfolio> & <https://medical-dictionary.thefreedictionary.com/e-portfolio>

²⁰ <https://www.dev-insider.de/was-ist-task-management-a-941429/>

3.2.2 Related Approaches and Tools

The following sections briefly presents and discusses approaches and technologies related to the LCC. Aspects of these approaches represent potentials relevant to the LCC will be incorporated into the architecture of the LCC. Note that this section only provides a brief overview and new developments regarded the approaches mentioned here will be continuously monitored to identify new potentials for the LCC (cf. Section 6.3).

3.2.2.1 Knowledge Management Systems

There are many ways to define knowledge management systems (KMS), but most have in common that they focus on the systematic acquisition of knowledge within an organization (Lee & Hong, 2002). Using this definition, the LCC can be seen partly as a KMS but with a focus on a broad range of stakeholders instead of just one organization. The intention is to build a community around the shared goal of enabling sustainable advanced learning on the use of SMCS in disasters. The conceptual advantages of combining KMS with communities are also pointed out in (Oseledchik, Ivleva, & Ivlev, 2018) while (Iskandar, Jambak, Kosala, & Prabowo, 2017) points out that evolving capabilities of KMS and the adoption of new technologies for KMS are some of the currently most researched questions. The approach of the LCC to conceptually and technically combine knowledge management with community and learning features could therefore widen the scope of the field of KMS. This is also in line with (Nonaka, 1994), which postulates the following four modes of knowledge creation:

- Socialisation: Is based on sharing experiences and supported in the LCC through the establishment of a dedicated community.
- Combination: Refers to the creation of new knowledge by recombining and linking existing knowledge.
- Internalisation: Can be interpreted as similar to 'traditional' learning, i.e. reading a book to acquire a new skill.
- Externalisation: Refers to the textualization of knowledge, i.e. in the form of best practises or lessons learned (Alavi & Leidner, 2001)

To best support knowledge management, the LCC should support those modes of knowledge creation.

3.2.2.2 Learning Management Systems

An overall goal of the LINKS Framework and the LCC is to enable sustainable advanced learning. As such, Learning Management Systems (LMS) such as Moodle²¹ or ILIAS²² (Cavusa & Zabadib, 2014) could be important elements of the LCC. LMS facilitate online learning (e-learning) by providing tools for 'presenting information, managing course materials or collecting and evaluating student work'

²¹ <https://moodle.org>

²² <https://www.ilias.de>

(Yueh & Hsu, 2008). However, it is currently envisioned that learning in LINKS will not be achieved through dedicated, didacticized learning materials *e.g.* in the form of online courses or tutorials. Rather, it will be done through materials which serve as a knowledge repository while also enabling learning aspects (cf. Wikipedia). This can also be seen when matching LMS to the four modes of knowledge creation, as most LMS focus mainly on the 'internalisation' aspect of knowledge creation. Therefore, conceptual elements of LMSs such as the ability to offer different learning paths and processes related to the user's interests could be integrated into the LCC while a dedicated LMS might be too much at this point. It should however be easily integrable into the architecture of the LCC if needed (based on feedback *e.g.* by practitioners or the LINKS Advisory Committee) and if complementary to the LINKS Learning Model currently being developed within WP5.

3.2.2.3 Social Networks

Dedicated Social Networking tools such as HumHub²³, BuddyPress²⁴ or Elgg²⁵ have in the past been used to support learning activities (Wang, Woo, Quek, Yang, & Liu, 2012) and could be considered suitable solutions to support the socialisation mode of knowledge creation. As described in D7.1, there are already existing Social Networking sites²⁶ within the safety and security (CMINE²⁶) and professional (LinkedIn²⁷) sectors. Given the already existing social networks and the rather narrow topic of SMCS in disaster management, it might not make sense for the LCC to implement a complete social networking tool with friends, posts, etc. Instead, interfacing with existing approaches such as CMINE and the DG ECHO Knowledge Network could be a better alternative and discussions with these networks have already started. However, aspects of social networks such as the timelines displaying recent activities could be relevant for the LCC as they provide visibility to the communities' activities. Additionally, the interaction features of social networks (*i.e.* the ability to write private messages and to chat) could be highly relevant for the LINKS Community.

3.2.2.4 Content Management Systems

Content Management Systems (CMS) like Wordpress²⁸, Drupal²⁹ or Joomla³⁰ also provide some possibilities for presenting and structuring learning materials. Users can design and publish individual pages and plugins can provide additional features like online calendars or a blog. However, CMS often lack collaborative and community aspects: in order to contribute content, users need to register, login and learn a potentially unfamiliar and rather complex software. Users are also not inherently aware of one another and are not usually provided dedicated community features. Therefore,

²³ <https://www.humhub.com/>

²⁴ <https://buddypress.org>

²⁵ <https://elgg.org>

²⁶ <https://www.cmine.eu>

²⁷ <https://www.linkedin.com/>

²⁸ <https://wordpress.org>

²⁹ <https://www.drupal.org/>

³⁰ <https://www.joomla.org>

lessons might be learned from CMS on how to best publish and link content on individual pages without programming an actual website, but these lessons have to be embedded into a tool also enabling collaboration and communication.

Some approaches have also been proposed on using semantic CMS (and wikis) for learning (Bratsas, Dimou, Ioannidis, Bamidis, & Antoniou, 2012). The semantic approach allows computers to 'understand' the data structured within the system and enables them to link and recombine the data contained within, supporting the combination mode of knowledge creation and making them highly relevant for the architecture of the LCC.

4. ARCHITECTURE AND CONCEPT

This section presents an overview of the key architectural elements and decisions for the LCC.

4.1 Architecture

To cover the NAs (and subsequently the needs presented in D7.1) and the tools presented in Section 3.2.1 and to incorporate the related approaches identified in Section 3.2.2, the architecture presented in Figure 5 was developed. Note that this architecture represents only a starting point and, in line with the research approach of design science, might be adjusted as the development of the LCC progresses.

To structure and present the LINKS Framework learning materials contained within the LCC, a wiki is selected as the key element. It also connects (conceptually and technically) the content contained within the LCC to the other elements of LINKS (e.g. the knowledge bases and the case assessments) via the LINKS Framework. As a wiki, it inherently supports the goal of the LCC to present knowledge and learning materials while at the same time making it possible for users of the LCC to contribute directly by editing pages inside the wiki. The concept of a LINKS Data Model (LDM) is introduced to model the elements of the LINKS Framework and to provide structured access to them. This allows pages inside the wiki to directly query and present data stored in other wiki pages (other learning materials) without any programming or development. This automatic access to structured data creates a versatile platform which can grow and change as the different learning materials are added. For more information on the LDM, please refer to Section 4.5.

While a wiki excels in the management of knowledge, it does not directly contribute to the goal of enabling discussion and communication within the LCC. Therefore, a forum was selected, as it provides the possibility to conduct structured, asynchronous discussions and can be tightly integrated (both conceptually and technically) with the wiki. It can be thought of as a meta-layer on top of the wiki, providing the ability to discuss or comment on content in the wiki. However, there will also be sections in the forum not directly related to the wiki, e.g. exchange of experiences, asking for support, or providing feedback on the LCC or LINKS as a whole.

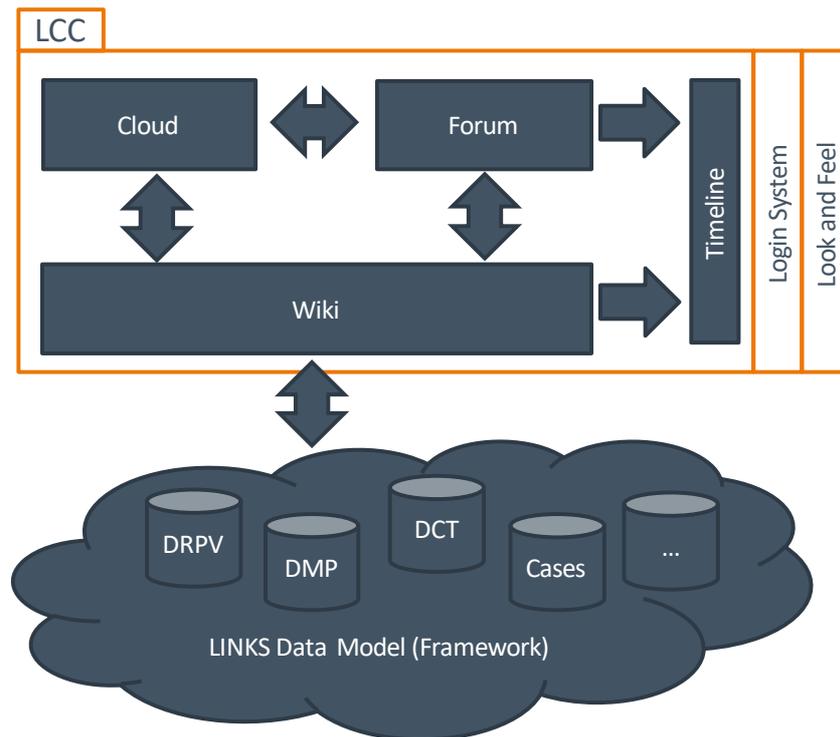
To further enable collaboration between members of the LINKS Community, tools to share large multimedia files (such as learning videos) and to collaboratively edit documents are needed. Although a wiki or forum could also be used for these purposes, a dedicated cloud collaboration software (like Google Docs or Dropbox) is more suited and can also be integrated with the wiki and forum. Furthermore, the cloud software could be extended in the future to provide more functionality if required.

A challenge when developing platforms where user activity is spread across many different pages and tools is creating awareness of the activity happening on the platform for each user. The user might not notice when a certain wiki page is added or edited or when a new reply to a forum topic

is posted. Therefore, an integrated timeline, similar to the timelines provided by social networks such as Facebook or Twitter, is planned to bundle all activities happening on the LCC and to help the users find and engage with new content.

Although the LCC consists of components built using different software tools, it should appear like one coherent platform to the user. A common login system, a common look and feel and technical integrations will therefore be used whenever possible to create a seamless user experience.

Figure 5: The architecture of the LCC



Source: Author's contribution

4.2 Technological implementations

This section will present the concrete technological tools used to implement the architecture presented in Section 4.1.

4.2.1 Wiki

There are many different wiki softwares, such as Wiki.js³¹, BookStack³², DokuWiki³³ available for usage. For the LCC, MediaWiki³⁴ was selected. MediaWiki is the software used by Wikipedia, therefore

³¹ <https://js.wiki>

³² <https://www.bookstackapp.com>

³³ <https://www.dokuwiki.org>

³⁴ <https://www.mediawiki.org/>

it is likely that users of the LCC will already be familiar with the functionality and layout. Furthermore, usage by Wikipedia (and many other wiki sites) all but guarantees that the software will continue to be supported and developed, which are important aspects for the sustainability of the LCC.

MediaWiki also supports many extensions and the Semantic MediaWiki³⁵ extension will be used to create a technical interface between the LCC and the LDM. Semantic MediaWiki allows pages contained within the LCC to query information contained within other pages and to dynamically generate and present results based on these queries, supporting the knowledge creation mode of 'combination'. To increase the usability of Semantic MediaWiki, further plugins such as Page Forms³⁶ and Semantic Results Format³⁷ are used. These plugins enable e.g. the automatic generation of maps for the LINKS case assessments or the automatic generation of calendars based on dates contained within wiki pages.

4.2.2 Forum

Forum functionality is implemented within many tools like phpBB³⁸, MyBB³⁹, Vanilla⁴⁰ and Discourse⁴¹. Best suited for the use case of the LCC is Discourse, as it provides a modern and fast user interface combined with a comprehensive application programming interface (API)⁴². This API allows Discourse to be directly integrated into the wiki, e.g. by displaying comments related to a wiki page directly within the page or by automatically creating forum threads for each wiki page. This integration enables an immersive user experience and allows the users to perform different tasks (reading a wiki article and asking a question about it) on one page without changing their usage context to a completely different system. Furthermore, SIC has had positive experiences with the versatility, performance and stability of Discourse during the H2020-eNOTICE project⁴³.

4.2.3 Cloud

Many collaborative cloud options, such as Google Docs, Office 365, iCloud, or Dropbox Business are proprietary solutions requiring data to be stored on the provider's servers and charging a monthly

³⁵ <https://www.semantic-mediawiki.org/>

³⁶ https://www.mediawiki.org/wiki/Extension:Page_Forms

³⁷ https://www.semantic-mediawiki.org/wiki/Extension:Semantic_Result_Formats

³⁸ <https://www.phpbb.com>

³⁹ <https://mybb.com>

⁴⁰ <https://vanillaforums.com/en/software/>

⁴¹ <https://www.discourse.org>

⁴² <https://docs.discourse.org>

⁴³ <https://www.h2020-enotice.eu>

fee per user. Fortunately, open-source and self-hosted alternatives such as ownCloud⁴⁴ and Nextcloud⁴⁵ are also available and provide a broad range of features beyond simple sharing of multimedia files and an online office suite. Both solutions are almost identical and are based on a common codebase, so Nextcloud was selected for the LCC based on the fact that it has slightly better developer support (as measured by 'stars' by other developers) and slightly more apps available in the integrated app store. A small selection of the apps available for Nextcloud is presented in Section 4.4.

4.2.4 Timeline

No suitable existing tool could be identified for implementing the timeline. Although some options such as TimelineJS⁴⁶ or TimeMapper⁴⁷ are available, they are generally more suitable for implementing timelines for storytelling or visualising history, not for displaying recent activity in the LCC similar to the timelines on Facebook or Twitter. Therefore, an own timeline will have to be developed. The timeline could receive updates provided by MediaWiki and Discourse via an API and could also be integrated with Discourse so that the users have the ability to comment on timeline updates via the Discourse forum. A visual integration either within MediaWiki or Discourse is also crucial, as users should not view the timeline as a separate tool for receiving updates but as a component embedded into the overall concept and visual identity of the LCC.

4.3 Coverage of the identified Need Areas

The architecture and tools described previously cover the NAs identified in Section 3.1 in the following ways:

- NA1 (Learning Materials): MediaWiki provides many possibilities to present learning materials, e.g. as text, tables, lists, maps, and multimedia files. Bigger files can be shared via Nextcloud and embedded into MediaWiki if necessary.
- NA2 (Structure): MediaWiki supports different categories for grouping learning materials and wiki pages can link to each other as needed, facilitating the establishment of learning paths through the learning materials.
- NA3 (Interaction): The three components are all customisable and will be adjusted to present a common look and feel.
- NA4 (Collaboration): MediaWiki as a wiki provides an excellent basis for collaboratively editing the LINKS learning materials. If required, further collaboration tools (i.e. an online office suite) can be integrated into Nextcloud.
- NA5 (Filtering): The Semantic MediaWiki extension provides many different filtering and query options. However, efforts must be made to ensure that there is either only one

⁴⁴ <https://owncloud.com>

⁴⁵ <https://nextcloud.com>

⁴⁶ <http://timeline.knightlab.com>

⁴⁷ <https://timemapper.okfnlabs.org>

search function available to users or that users know when to use which search function to avoid them having to use different search function in all three components to find content.

- NA6 (Quality Control): MediaWiki already provides a broad array of tools for establishing an elaborate content review system as it is the technical foundation for Wikipedia. Similarly, Discourse provides granular access controls and moderation tools.
- NA7 (Communication): Discourse enables communication through public or private forum section as well as through user-to-user messages.
- NA8 (Technical Sustainability): All components are self-hosted, well maintained and mature software without external dependencies.

As shown, the presented architecture covers all identified need areas and is therefore suitable to cover most of the needs listed in D7.1.

4.4 Coverage of the identified suitable Tools

Although the LCC architecture consists of three main components, the implementation of these components covers almost all functionality of suitable tools identified in Section 3.2.1. This is because software solutions often combine the functionality of different tools or can be extended using plugins to implement further tools. The following briefly presents how each suitable tool is covered or could be covered by the LCC architecture:

- Online notes: Wiki pages could be used to take notes or the Notes Nextcloud plugin⁴⁸ could be used if needed by the LCC's users.
- Social Network: The Timeline functionality of social networks is implemented using a dedicated Timeline. Other features, such as the ability to create friendship networks are deliberately not implemented as they are already sufficiently covered by existing sites such as CMINE (cf. D7.1).
- Multimedia sharing: Multimedia files can be uploaded and shared via Nextcloud.
- Chat: Private chats between users or groups of users can be created in Discourse.
- Blog: It is currently unclear whether a dedicated Blog functionality would be beneficial for the users of the LCC. If such a need arises, Blogs could be implemented e.g. using the BlogPage MediaWiki extension⁴⁹ or a dedicated Blog software such as Wordpress.
- Wiki: Covered by MediaWiki.
- Online Office suite: If required, this functionality can be implemented using the Collabora Online plugin for Nextcloud⁵⁰ in combination with a Collabora CODE⁵¹ instance.
- Online calendars: Can be implemented either within MediaWiki⁵² or Nextcloud⁵³ as required.

⁴⁸ <https://apps.nextcloud.com/apps/notes>

⁴⁹ <https://www.mediawiki.org/wiki/Extension:BlogPage>

⁵⁰ <https://apps.nextcloud.com/apps/richdocuments>

⁵¹ <https://www.collaboraoffice.com/code/>

⁵² <https://www.mediawiki.org/wiki/Calendars>

⁵³ <https://apps.nextcloud.com/apps/calendar>

- Catalogue: Catalogue functionality is implemented using Semantic MediaWiki in combination with a plugin such as Semantic Results Format⁵⁴.
- Feed Reader: Feed Readers can be implemented using the News plugin for Nextcloud⁵⁵ or the RSS extension for MediaWiki⁵⁶.
- Web Conferencing: Although one of the least prioritised needs (c.f. D7.1), if required this functionality can be implemented using the Talk Nextcloud plugin⁵⁷.
- Microblogging: Although currently unclear if this functionality would be beneficial for the users of the LCC, it could be implemented using the Social Nextcloud plugin⁵⁸.
- Forum: Covered by Discourse.
- Reference Manager: If required, references could be managed using plain wiki pages or dedicated MediaWiki extensions such as BiblioPlus⁵⁹.
- Drawing/Whiteboards: This functionality could be implemented using the Whiteboard Nextcloud plugin⁶⁰.
- Mind mapping/Concept maps: If required, could be implemented using the Mind Map Nextcloud plugin⁶¹.
- E-Portfolio: The overall content created within the LCC can be seen as an E-Portfolio of the LINKS Community.
- Group Manager/Task Manager: If required, could be implemented using the Tasks Nextcloud plugin⁶².

4.5 LINKS Learning Materials and the LINKS Framework

While the first version of the LINKS Framework will mainly consist of the research design (the three knowledge bases and their methodologies) that will be evaluated in the first case-based assessments, the second version will consist of *ad-hoc* learning materials revolving around the uses of SMCS in disasters. Nevertheless, technical integration of the structure of the Framework into the LCC and development of the Framework itself within the LCC can start long before actual learning materials are available within the Framework.

The Framework is envisaged to embody different learning materials, such as scientific methods, guidelines and procedures, policy documents, practical tools and games to involve the local communities, good and best practices on trainings for different stakeholders (e.g. crisis communication management via SMCS for practitioners), catalogues of tools and filtering options to make sense of the sheer amount of information shared in SMCS, etc. Ultimately, this will enhance the governance

⁵⁴ https://www.semantic-mediawiki.org/wiki/Extension:Semantic_Result_Formats

⁵⁵ <https://apps.nextcloud.com/apps/news>

⁵⁶ <https://www.mediawiki.org/wiki/Extension:RSS>

⁵⁷ <https://apps.nextcloud.com/apps/spread>

⁵⁸ <https://apps.nextcloud.com/apps/social>

⁵⁹ <https://www.mediawiki.org/wiki/Extension:BiblioPlus>

⁶⁰ <https://apps.nextcloud.com/apps/whiteboard>

⁶¹ https://apps.nextcloud.com/apps/files_mindmap

⁶² <https://apps.nextcloud.com/apps/tasks>

of diversity among the understanding of SMCS in disasters across the three LINKS knowledge domains for relevant stakeholders. This includes the social domain of DRPV (WP2), the institutional domain of DMP (WP3) and the technical domain of DCT (WP4). The materials will be made available in the LCC. They are expected to be structured according to three main areas:

- **Thematic areas**⁶³: e.g. inclusiveness, vulnerability, crisis and risk communication;
- **Type of hazard**: e.g. earthquake, flood, etc.
- **Phases of disasters**: prevention, preparedness, response, and recovery

The knowledge will be sorted according to goals and objectives of different stakeholders to facilitate specific 'knowledge and learning paths'. For instance, a fire department may be interested in how to disseminate risk communications to the vulnerable groups. Based on the knowledge in the Framework, the learning path may entail questions for self-reflection related to the departments existing institutional, technical, and social considerations for the actions, helping to expose gaps and areas which can be improved locally. The learning process would also entail providing existing knowledge and examples from others (learning materials), allowing for reflection on how that knowledge and experience could be integrated into the organizations own situational context. While this won't prevent them from exploring, comparing and contributing to all the diverse knowledge within the LINKS Framework, specific 'learning paths' will be recommended through the LCC to ensure an objective-oriented approach also determined by the stakeholders' situational context (e.g. socio-cultural aspects as well as approaches to learning).

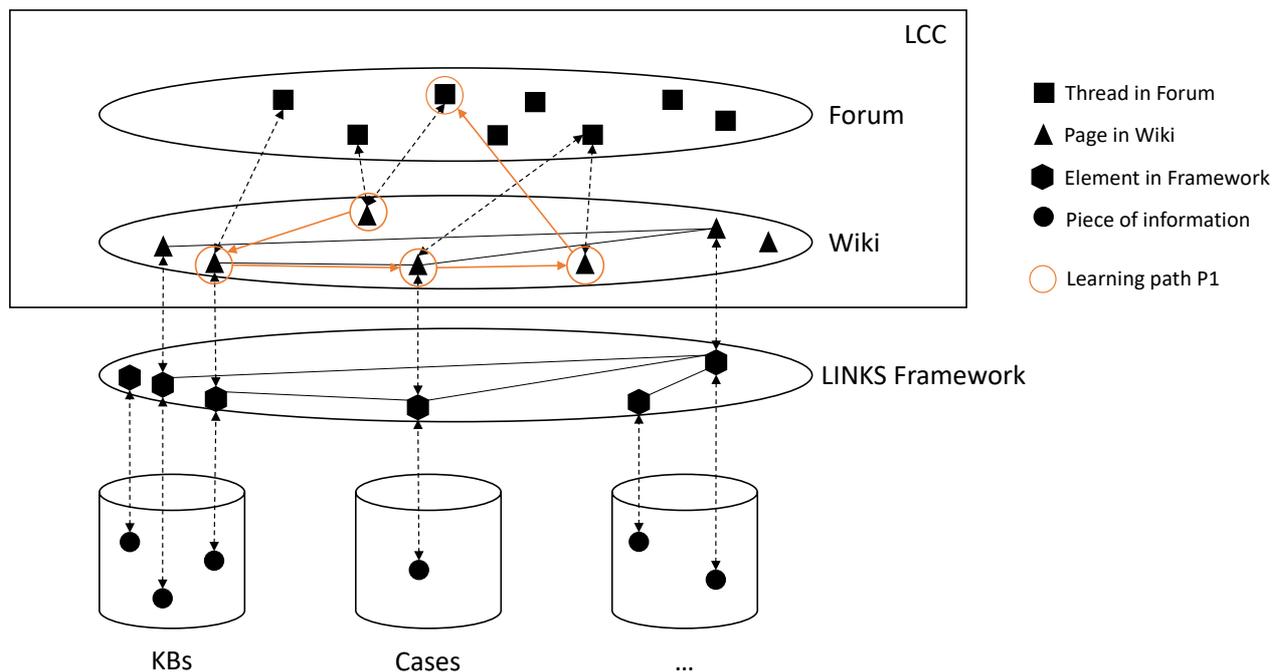
What is key is that learning must not be seen as an outcome, but as a process. In this regard, the learning paths must also contribute to the overarching objective of the project, namely producing sustainable advance learning on SMCS in disasters to strengthen societal resilience. This entails a 'maintainable and evolving collection of knowledge produced for and by relevant stakeholders' (LINKS Glossary). Hence, knowledge sharing and learning are just two components of a more complex process that involves gaining, implementing, and contributing to the knowledge. It is a dynamic learning approach as relevant stakeholders will have the opportunity to expand directly on the knowledge by adding more content to the wiki and/or by sharing their experiences (in the forum) in converting, for instance, best practices and lessons learned via the Framework (or other resources) into organizational changes, adopting procedures on SMCS in their context. The LCC will enable and support this dynamic learning experience so that the knowledge grows and does not turn into a static repository. Ideas on how to achieve this community building were presented in Section 3.1 of D7.1 and are summarised in Section 5.1 of this deliverable.

This overall approach is displayed in Figure 6. From bottom to top, information is initially generated in the knowledge bases and the case-based assessments. Linking, aggregation and enhancement of this information is performed within the LINKS Framework using the concept of the LDM. The

⁶³ The thematic areas are currently being decided and will be refined after the first case-based assessments on the basis on the learning needs emerging from the cases.

Framework forms the basis for the wiki within the LCC, which makes the knowledge contained within the Framework accessible to all users. Furthermore, users can use the forum in the LCC to discuss (amongst other things) pages of the wiki, which in turn reflect elements of the Framework and subsequently *e.g.* the knowledge bases. Note that all connections are bi-directional, *i.e.* that knowledge can be transferred from bottom to top but also from top to bottom. Learning paths (in this example the path Practitioner 1) guide the users through the wiki by providing specific entry points, flows between pages and dedicated areas in the forum which could be used to ask for help regarding the learning path or to provide feedback.

Figure 6: The overall flow of knowledge in LINKS



Source: Author's contribution

4.6 Design Mockups & Case Study: Presenting DCTs in the LCC

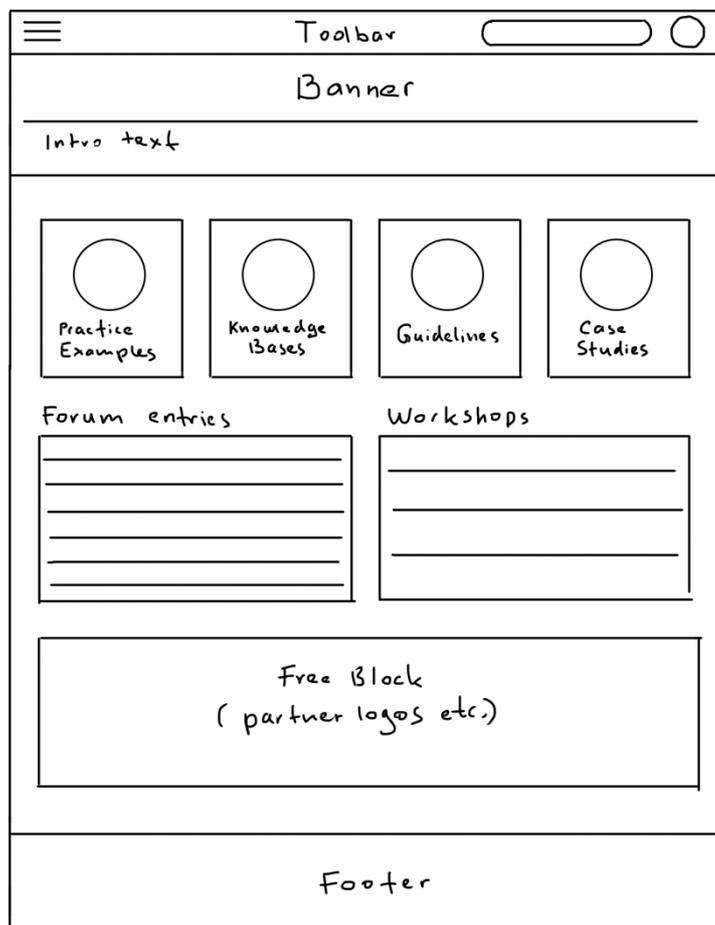
To better visualise the abstract technologies and concepts described so far, mockups for a potential design and implementation of the LCC were created. A short case study on how a user accesses the LCC and uses the DCT Knowledge Base and DCT Schema (described in detail in D4.1 (Habig, Lüke, Sauerland, & Tappe, 2020)) to identify a relevant DCT will be presented in the following. Note that the following images are preliminary ideas and drafts to be used as a starting point for discussions with all stakeholders and will likely be adjusted during the implementation of the LCC.

4.6.1 Landing Page

The landing page of the LCC is shown in Figure 7. The top features a toolbar with a quick access menu (on the left) as well as a search field for accessing the search function. Below, a banner shapes

the visual identity of the LCC and a short intro text briefly describes the purpose of the LCC. Next, a row of buttons provides access to the most relevant areas of the LCC, e.g., practise examples. In the future, this could also be extended for learning paths with user- or stakeholder-specific objectives, i.e., a dedicated entry point for practitioners, policy makers, etc. based on organizational goals. Below the prominent buttons, a timeline displays recent activity (e.g. forum posts) and events in the future (e.g. upcoming LINKS Community Workshops). This timeline creates visibility for the activity in the LCC and could motivate users to contribute themselves to the activity. At the bottom of the page, a free block could present logos of members of the LCC and the footer contains legally required information such as a link to the privacy policy and legal imprint.

Figure 7: Mockup of the landing page



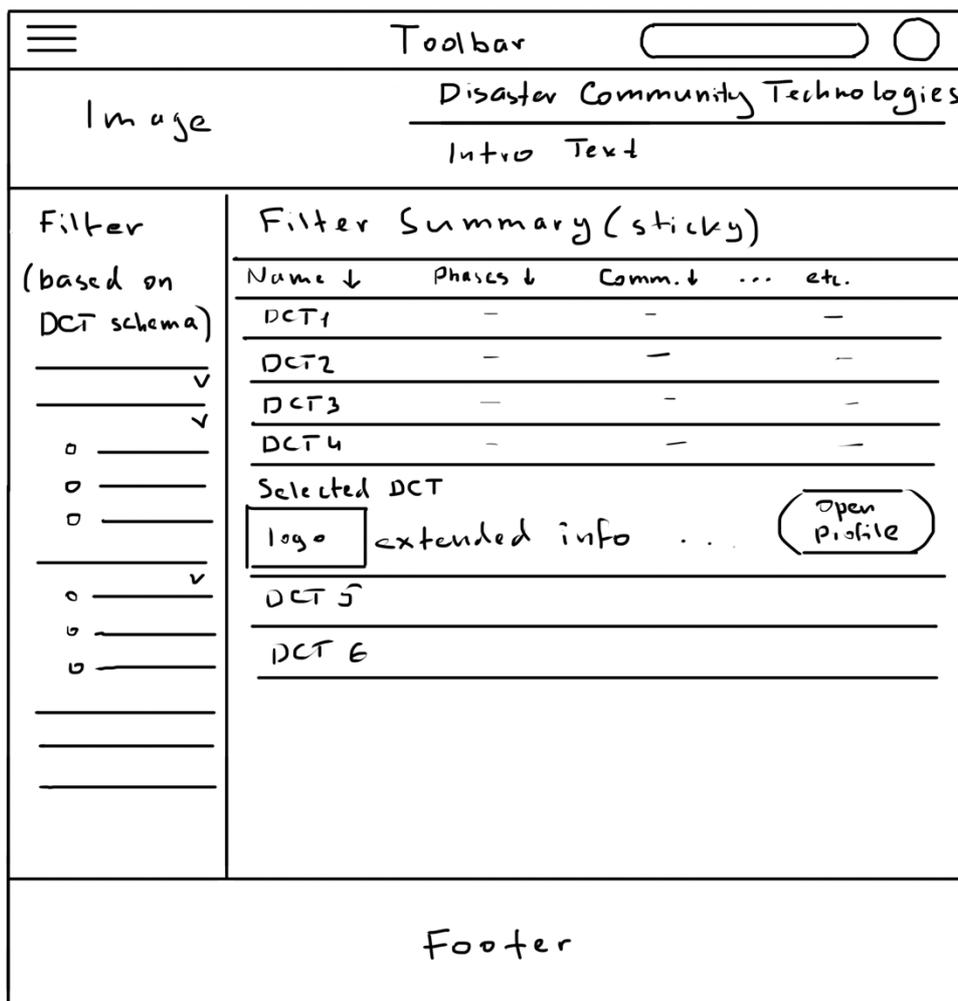
Source: Author's contribution

4.6.2 DCT Knowledge Base

Using the 'Knowledge Bases' button on the landing page, the user could arrive at the DCT knowledge base (KB) displayed in Figure 8. Below the header (which is the same as on the landing page), a short

introduction (including a prominent image) could explain the general idea and concept of the DCT KB. Filter options, based on the DCT schema initially presented in D4.1, are available in a column on the left and can be used to find DCTs according to the user's needs. The filters selected affect the DCT list presented in the centre of the page. This list displays an overview of all DCTs matching the current filters. By clicking one DCT, a slightly more extensive description is displayed within the list and includes *e.g.* the logo and some descriptive text on the selected DCT. Additionally, a link to the profile of a DCT is provided.

Figure 8: A mockup of the DCT Knowledge Base



Source: Author's contribution

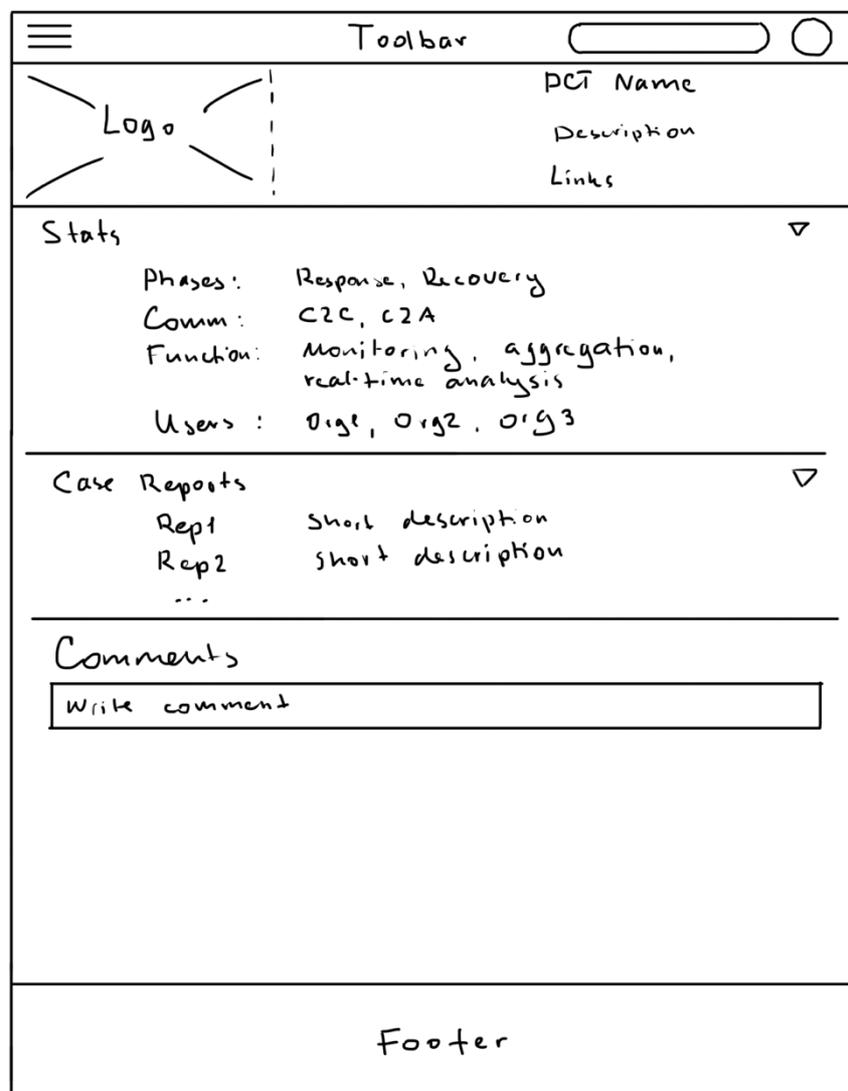
4.6.3 DCT Profile Page

Figure 9 shows a mock-up of the profile page of a specific DCT. As in the previous mock-ups, the header contains a toolbar with quick access to some relevant functions. Below the header, general

information such as a logo or image, the name of the DCT, a description and relevant links are provided. Next, categorised information based on the DCT schema is shown in a structured fashion. Following this, linked data based on the LDM could show links of the DCT to other learning materials, e.g. if the DCT was used in one of the LINKS Cases and a case report contains additional practical information on the DCT. This automatic linking of related information is a key advantage of modelling information in the LCC in a structured data model and a semantic wiki.

The next section also shows a key aspect of the LCC: The integration of community features, in this case a comment function provided by the forum software, into the DCT profile page, contained within the wiki. This comment function allows users to comment on a specific DCT, e.g. to share experiences or ask for opinions.

Figure 9: A mock-up of a DCT profile page



Source: Author's contribution

4.7 Security and Privacy

Although the LCC is not foreseen to contain classified or secret information, security of the used tools and privacy of the users are of the utmost importance. For optimal security, only mature tools with a long track record of updates and a broad userbase were selected. Additionally, standard procedures for increasing web security such as firewalls, encryption and compartmentalization between the different components will be used. For privacy, the General Data Protection Regulation provides a framework on what to do and not do with user data. Wherever possible, the personal data collected in the LCC will be minimized and users will only be asked to input data that is necessary for the operation of the LCC. The analytics tool described in Section 5.4.1 will not collect any personally identifiable information and data in the analytics tool will not be combined or connected with data collected in one of the other tools. All data will be stored inside the European Union on servers rented by SIC and a data processing agreement with the provider of the server will be signed.

5. SUSTAINABILITY

The following sections will highlight different aspects of the sustainability of the LCC.

5.1 Community Engagement

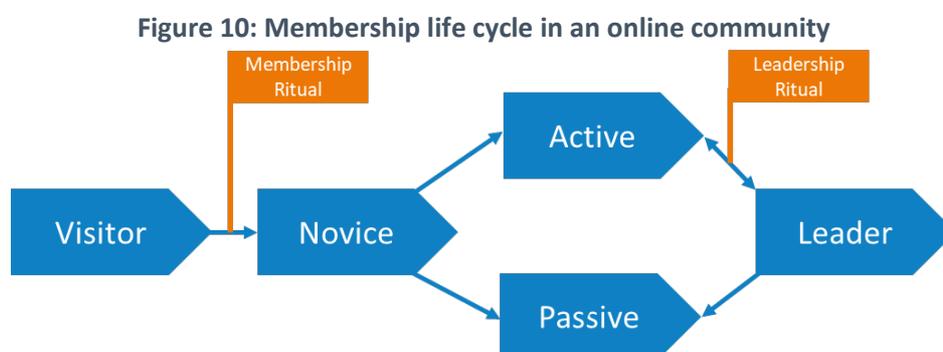
Building on D7.1, which has already presented a three-stage concept for building a community with a focus on motivation, this section will present complementary measures to bind members more effectively to the community.

The long-term establishment and existence of a community depends to a large extent on how well the operator of a community succeeds in (Porter, Donthu, MacElroy, & Wydra, 2011) (Kraut & Resnick, 2011):

- attracting new members,
- motivating the members to continuously participate (contribute user generated content),
- keeping members motivated in the long term.

As mentioned above, the first two bullet points were conceptually addressed in D7.1. In order to keep potential members in the community, it is important for the community operator to understand what stages of development a potential member can go through in the community.

As soon as a potential member visits the community platform (in most cases a homepage), the member enters the membership life cycle, which is shown in Figure 10.



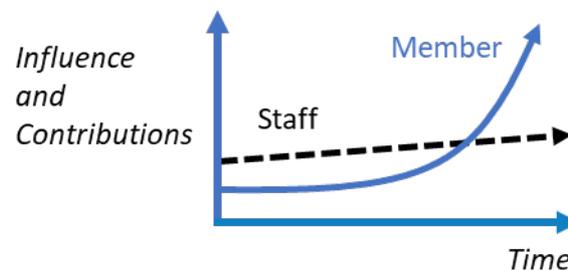
Source: Author's adaption from (Sonnenbichler, 2010)

In this cycle, the member goes through different stages of development from newcomer to experienced user or even beyond with a special position of responsibility or leadership (Sonnenbichler, 2010). In most cases, it is subjective and depends on the community at what point a member gets counts as an active or passive dependent from the amount of participation. However, the jump from a visitor to a member and from an active to a leader can be clearly determined by fixed 'rituals' (e.g. registration or granting of admin rights) (Kim, 2000). As the arrow directions between regular and leader as well as passive suggest, members can of course relinquish their leadership and become a regular member and also switch between passive and active depending on their activity and interest

(Sonnenbichler, 2010). Of course, it can also happen that troublemakers (so-called trolls) participate in the community and want to cause tension with negative contributions. In response, community moderators must be trained in de-escalation. In a rather expert-heavy community like the LCC, the occurrence of trolls is rather unlikely.

A fundamental concept for the retention of members is the **strengthening of their role and competencies** over the time of the community's existence as well as the seniority and affiliation of the members in the membership life cycle. Regular members in particular must be given the feeling that they have a voice in how the community content is designed and how the community is oriented in the medium and long term. The users of the community should become co-creators of content and not remain pure consumers. Figure 11 shows the development of the influence and content contributions of the members and staff (or community operator) over time.

Figure 11: Development of the influence and contributions in an online community



Source: Authors adaption from (Kim, 2000)

The operator of the community transfers more and more influence and responsibility and thus participation into the hands of the members. Approaches would be, for example, to identify, highlight and promote popular contributions through a star-based rating system. In addition, particularly committed members can be entrusted with leadership tasks (e.g. moderator in the forum) or given the opportunity to promote their own topics in their own sections. The concrete implementation of measures is, of course, highly dependent on the community.

Another important element for successful community management is the **implementation of feedback functions** (so-called feedback loops), which would ensure an intensive exchange between the community operator (top down) and the members (bottom up) (cf. Figure 12).

Figure 12: Feedback-Loops as a key principle in online communities



Source: Author's adaption from (Kim, 2000)

If members feel their opinions are taken seriously and bring about changes, their sense of belonging and satisfaction in the community increases (Teichmann, Stokburger-Sauer, Plank, & Strobl, 2015). Depending on the size of the community, it is important to bear in mind that too much feedback can either overburden the people who process it or lead to it not being taken into account. It is also difficult to differentiate whether the feedback is meaningful and objective or whether it has arisen out of frustration, for example, because someone feels they have been treated unfairly. As a solution, the objective should be defined by the number and scope of feedbacks to be considered and answered. In terms of technical support, the feedback should also be structured and aggregated, and, from a certain size, tools should be implemented to simplify the response. In general, the handling of feedback should be embedded in open communication with the community.

In general, the members must be the focus of the design of an online community, as only they can guarantee the existence of the community in the medium and long term (Alicia & Leroy, 2009). Coming from a general and broad approach, these conceptual rules will be transformed into concrete measures within the contexts of T7.4 (Online community management and quality assurance) and WP8 (LINKS Community).

5.2 Connection to WP8 and the LINKS Community

While the previous section described the high-level concepts that will be used to engage the LINKS Community within the LCC, this section will describe the concrete efforts being made to establish the LINKS Community.

To maximise the number of registrations onto the LCC, the consortium will strive to promote the use of the platform. Through the project newsletter for instance, a call for expression of interest to become part of the LINKS Community will be launched. It will underline the benefits of the Community in providing direct access to the LCC and to the learning materials from the project. In order to join the LINKS Community, stakeholders will be invited to fill-in a dedicated questionnaire⁶⁴, where they will be offered the possibility to specifically pinpoint their interest in participating to the LCC by ticking the related box. This questionnaire will also be posted on the project website, hence providing the opportunity to any interested stakeholder to be granted access to the LCC. On the other hand, stakeholders directly targeted by the consortium in the context of setting up the LINKS Community (Philpot & Reuge, 2020) will be approached and offered the possibility to take part in the LCC as well. Examples of these stakeholders can be found in Annex III of D8.1.

In addition to the number of registrations, the involvement of the LINKS Community will also be assessed by looking at the scope of engagement of the stakeholders. As highlighted above, the LCC

⁶⁴ <https://ec.europa.eu/eusurvey/runner/LINKSLCCSurvey2021>

aims to provide access to project results and learning materials, and to fuel discussions among participants on their own experiences and lessons learnt. This information should in turn be used by stakeholders so as to ultimately improve the way in which we use SMCS for disaster resilience. In that respect, feedback from participants regarding their use of the Framework and other content provided is needed. To do so, the platform will be made interactive, thereby allowing stakeholders to provide comments and remarks through discussion forums. Dedicated surveys and questionnaires will also be prepared by the consortium and sent out regularly using the contact details gathered via the registration process (see Section 5.4.2).

5.3 Content Quality Assurance and Governance

Ensuring that the content provided in the LCC is of good quality (in terms of correctness, understandability, etc.) is key to ensuring the LCC's usefulness for its users. Therefore, tools and governance structures for content quality assurance will be needed. As mentioned in Section 4.3 (NA 6), MediaWiki and Discourse already provide appropriate technical tools for content moderation and quality assurance. Regarding governance, it is envisioned that one party (VU as the partner responsible for the LINKS Framework) will be responsible for the overall content quality assurance within the LCC while subject matter experts (to be agreed with WPL and partners) are responsible for quality assurance of content pertaining to specific knowledge domains.

In the long term, after the duration of the LINKS project, content quality assurance could be also performed by subject matter experts who have an interest in maintaining a high-quality repository of knowledge on their area of expertise. Similar approaches are used at scientific conferences or at other online knowledge repositories such as Wikipedia.

5.4 Technological Quality Assurance and Measurement

The following sections provide an overview of the preparations being made to support the online community management and quality assurance (Task 7.4) starting in M16.

5.4.1 Quantitative Metrics

Looking at e-commerce websites provides valuable lessons on how to measure and increase the effectiveness of websites (Turner, 2010). A wide variety of metrics, such as the overall number of visitors and visits, the bounce rate (users who close the website without any interaction), and the duration of visits can be measured using tools such as Google Analytics⁶⁵ or Matomo⁶⁶. Matomo is the better option for the LCC, as it can be self-hosted and all data is stored and processed within the LCC in contrast to Google Analytics, which stores all data gathered in the Google cloud for data

⁶⁵ <https://analytics.google.com>

⁶⁶ <https://matomo.org>

mining. Matomo can be also extended with plugins to define custom goals or to create a heatmaps of user activity⁶⁷. Key to achieving maximal usefulness of Matomo will be the definition of relevant and helpful key performance indicators that can be optimised for.

5.4.2 Qualitative Metrics

In addition to purely quantitative performance metrics, qualitative metrics and options to provide feedback will also be included in the LCC. Regular user surveys using the EUSurvey tool will be conducted to assess whether the LCC meets the user's expectations, what functions it performs well and where it could be improved. Additionally, a constant option for providing direct feedback will be included in the LCC. This could be a simple feedback form or contact email address or a sophisticated tool could be used. Options such as Qualtrics Customer XM⁶⁸ or Usersnap⁶⁹ enable the user to provide feedback on every page and to include e.g. a star rating or highlight a specific part of the page they are referencing in their feedback, however most of these options are cloud-based and would therefore impact the LCC user's privacy. A search for a self-hosted alternative is currently ongoing.

5.5 Technological Sustainability

For the LCC to become a long-running platform, the underlying software tools must be sustainable in a technological sense so that they do not need to be reconfigured, repaired or replaced. This is achieved by selecting only mature and open-source software where it can be expected that development and maintenance of the software will continue by the open-source community. Furthermore, the software being open source allows the LCC to be customised as needed and e.g. additional plugins for MediaWiki or Nextcloud could be developed if needed.

Additional technological sustainability is provided by standardised APIs. The selected tools provide the data stored within them in the following standardised formats:

- Wiki pages stored in MediaWiki can be exported in an XML format
- Semantic information stored in Semantic MediaWiki can be exported using a standardised format called RDF
- Discourse provides an API⁷⁰ to access all stored forum posts
- Files stored in Nextcloud can be exported using WebDAV
- Calendars stored in Semantic MediaWiki and Nextcloud can be exported in the icalendar format

Data stored within the LCC can be transferred and exported using these APIs so that single tools within the LCC could be replaced without losing access to the data stored within them. This helps

⁶⁷ <https://plugins.matomo.org/HeatmapSessionRecording>

⁶⁸ <https://www.qualtrics.com/customer-experience/digital/>

⁶⁹ <https://usersnap.com>

⁷⁰ <https://docs.discourse.org>

the LCC avoid vendor lock-in and keeps the option open to adjust the architecture and exchange tools if required.

5.6 Economical Sustainability

As operation of the LCC is associated with costs for the administration and rent of the servers, measures need to be established to reduce these ongoing costs as much as possible while identifying monetization options that could be used to cover these costs. The minimisation of ongoing costs is achieved by using open-source tools (avoiding licensing fees of proprietary or cloud software), by optimising the used software for low resource usage (resulting in lower hosting costs) and by selecting mature software that generally requires low maintenance. As the content structure of the LCC is elaborated, options for monetization will also be explored. This could include *e.g.* sponsorships (*e.g.* by organisations involved in the usage or promotion of SMCS in emergency management) or advertisements (*e.g.* DCT providers paying to feature their DCT more prominently). Another option is to interface/integrate with existing funded platforms and networks. All monetization options must ensure that the integrity of the content provided in the LCC is not impeded in any way.

6. FUTURE WORK

This section presents a brief overview of the follow-up work to this deliverable in the context of the LCC, the LINKS project and the overall landscape of online communities and research projects.

6.1 Development of the LCC

Development of the LCC has already started in the context of T7.3 by installing and evaluating some of the tools described in Section 4. The tools implementing the overall architecture will be installed on a server, customised with plugins (both existing and potentially newly developed), configured and styled to provide a common look and feel. The tools will also be integrated with each other to provide a seamless user experience. In parallel, the content of the LCC and the LINKS Framework will be elaborated (see Section 4.5 and 6.2) and integrated into the LCC once the first version of the LCC (D7.3) is finished (September 2021). Both processes will be performed iteratively with early involvement of the stakeholders, the possibility to test out different approaches and to adjust course when needed. A second version of the LCC is scheduled for May 2022 (D7.4). Once the first version of the LCC is complete, T7.4 will also start working on the online community management and quality assurance for the LCC.

6.2 Practical Implications and Content Workshop(s)

Elaboration of the content of the LINKS Framework and subsequently the LCC is crucial for the success of the LCC. Therefore, workshops are planned together with WP5 to ascertain which content will be included in the Framework (and subsequently the LCC) and how this content can be best presented in the LCC. These workshops will also be conducted together with WP2-4 (the Knowledge Bases) and WP6 (the Case Assessments). They will also be extended to the whole LINKS project and potentially external members of the LINKS Community to get more diverse feedback and more ideas. The format of the workshops can be based on the methodology described in Section 2.3.2 of D7.1 as this methodology has proven to be an effective tool for actively involving a large number of participants in an online setting. Needs emerging from these workshops will be documented and implemented using the methodology described in Section 2.3. These workshops will mainly take place after M16 (September 2021) as at this point both a first version of the LCC (making the goal of the workshops more tangible) and a first version of the Framework (providing clearer guidance on what content shall be included in the LCC) will be ready but before M24 (May 2022) as this is the milestone for the final version of the LCC (D7.4).

6.3 Identification of further Potentials

In parallel to the identification of new technical and content-related ‘user’ needs, new potentials will also be constantly researched. These potentials, such as new open-source tools, new developments and tools within the web or new and evolving user experience paradigms could provide innovative solutions to existing needs or cover needs not yet documented. When such potentials are identified, they are assessed in relation to the goals and architecture of the LCC and the existing needs. If suitable, these new potentials will be used to extend or revise the architecture of the LCC and to evaluate them together with the LCC’s users.

6.4 In the Context of LINKS

Development of the LCC needs to be synchronised and connected with the work being performed by other WPs in the LINKS project. As the LINKS Framework provides the learning materials for the LCC, content in the LCC cannot be published before the first learning materials are developed. Nevertheless, the LCC can be developed in parallel to the LINKS Framework and could for example be used to find connections between Knowledge Bases and structure the overall content of the Framework. For more information on the workplan for the LINKS Framework, please refer to D5.1 (Fonio & Clark, 2021). To this end, the LCC will also be used during the case-based assessments (WP6), *e.g.* to collect data or to validate features or data implemented in the LCC.

Cooperation with WP8 on the establishment of the LINKS Community is also crucial for the development of the LCC. The LCC must be suitable for the needs of the LINKS Community and the community should use the LCC to exchange knowledge and experiences and to interact. Discussion on how to integrate the LINKS Community Workshops and the LCC are currently ongoing.

6.5 Beyond LINKS

Collaboration and connection with other projects and initiatives is important to ensure the sustainability of the LCC by embedding and rooting it within the broader public safety and security landscape. T7.5 (Integration and communication with other networks) is dedicated to identifying and contacting other projects, networks, and communities with the goal of establishing conceptual integration points and identifying and exploiting synergies. These efforts will be supported by the fact that the LCC focuses on using standardised APIs (see Section 5.5), making potential technical integrations with other platforms feasible.

7. CONCLUSION

This deliverable aims to strike a balance between describing a concept and a technical foundation which can be used to start development of the LCC while trying to keep options regarding the actual content contained within the LCC open. This goal is achieved by analysing the needs and potentials currently known and describing a follow-up methodology on the handling of new or more refined requirements.

The architecture elaborated consists of a semantic wiki used primarily to host the LINKS Framework and to collaboratively create and improve the content together with the LINKS Community. Communication within the LCC is facilitated via a forum which itself is coupled tightly to the semantic wiki to form one cohesive platform. Additional support is provided by a cloud collaboration software and activity in the LCC is bundled within a timeline. All software solutions are based on open-source software, paving the way towards technical sustainability.

Next steps, besides technological development of the LCC, will include the elaboration of the concrete content to be included within the LCC and its continuous improvement. This step involves not only the other LINKS WPs but also the LINKS Community and, once a version of the LCC is public, all visitors and users of the LCC.

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