(L)earning by Doing – »Blockchainifying« Life-long Volunteer Engagement

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Abstract: Volunteering is a vital cornerstone of our society, ranging from social care to disaster relief, being supported by a plethora of web-based volunteer management systems (VMS). These VMS primarily focus on centralized task management within non-profit organizations (NPOs), lacking means for volunteers to privately digitize and exploit their engagement assets, e.g., task accomplishments or earned competences. This may decrease engagement, since appreciation of volunteer work is the only reward available, and hinders the exploitation of engagement assets between NPOs and beyond, e.g., the education or labor market.

We put volunteers in the middle of concern by investigating "how can engagement be digitized and exploited in a life-long way". First, based on a systematic identification of requirements for a trustful digitization and exploitation of engagement assets, a web-based volunteer ecosystem relying on emerging blockchain technology is proposed. Second, for representing various kinds of engagement assets, a generic and adaptable ontology is put forward. Third, for establishing trust across all stakeholders, a prototypical web application is presented allowing to »blockchainify« life long volunteer engagement. Finally, the prototype applies semantic web technologies to offer a machine readable form of engagement assets in terms of Linked Data (LD).

1 INTRODUCTION

Omnipresent and Manifold Volunteering. In times of refugee and health-care crisis, volunteering is a vital cornerstone of our society, covering a broad part of our life, from social care and disaster relief to cultural activities. More than 10% of the world's population is already volunteering, topped by 23% in the EU, and even more than 46% in Austria (UN Volunteers, 2018). Regarding Austria, 2,25 million formal volunteers accomplish more than 400 million voluntary hours a year, supplemented by more than 2,35 million "informal" (i.e., NPO-independent) volunteers who also accomplish 351 million hours, whereby at least every second informal volunteer is engaged formally, too (Holzer, 2017). Currently, new forms of volunteering are emerging (Holzer, 2017), stretching from *(i) Patchwork Volunteers*, being engaged in different NPOs/life phases (e.g., from pathfinders to senior help), over *(ii) Engagement Hoppers*, getting active informal, i.e., NPO-independent, and ad-hoc (e.g., disaster relief), to finally *(iii) Crowd Volunteers* (e.g., open-source projects).

Awareness Deficits about Engagements. These engagements lay the basis for life-long learning following the *"Learning by Doing"* principle. The potential for experience-based acquisition of *informal competences* is a commonly agreed fact of all volunteering domains (Deloitte, 2016). However, volunteers are often *unaware* of their *accomplishments* and *achievements* earned across their engagements (e.g., accomplished tasks or gained competences) (Livingstone, 2006). This prevents *self-exploration* and *personality development* and hinders *exploitation of engagement assets* beyond volunteering, e.g., *education* or *labor market*, being an invaluable substitute for certain formal qualifications (Deloitte, 2016).

Volunteer Management Systems' Focus Differs. Current *VMS* focus either on *centralized task management within NPOs* or on *coordination of informal volunteering* (Schönböck et al., 2016). Supporting digital exploitation of engagement assets across different volunteering forms, e.g., in terms of Linked

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Data (LD), is not an issue up to now, although *adequate IT-support* is of *prior importance* from an economic point of view and lies in the very own interest of all stakeholders, i.e., NPOs, (informal) help seekers, and volunteers (UN Volunteers, 2018).

Digital Exploitation of Life-long Engagement. The goal of iVOLUNTEER is to *put volunteers in the middle of concern*. According to the metaphor *»I am what I do«*, volunteers should be enabled to *digitize engagement assets* not only across the wide spectrum of new volunteering forms, but also *exploit engagement assets* beyond volunteering at the education or labor market. The rational behind is to strengthen the *appreciation of voluntary engagement*, being the only reward available in this domain. This would not only increase a volunteer's engagement motivation, but would also leverage the importance of *life-long learning*, being beneficial for all stakeholders. As technological backbone ensuring "trust" across all stakeholders, *engagement assets are »blockchainified«*, allowing to *irrefutably trace back* each single asset wrt. both, its *content* and its actual *existence*. Furthermore, LD is utilized to exploit engagement assets beyond the the iVOLUNTEER ecosystem.

Structure of the Paper. After investigating related work in Sec. 2, we lay out the *requirements* emphasizing the *process* of trustful engagement digitization and exploitation based upon which we derive a *conceptual architecture* for our digital volunteer ecosystem in Sec. 3. Serving as a *pivotal building block* for digitizing assets, Sec. 4 presents a *generic and adaptable ontology* of engagement assets. Sect. 5 discusses the *prototypical implementation*, which is based on (i) a permissioned blockchain and on (ii) semantic web technologies to provide trustful and machine interpretable data on a volunteer's engagement. In Sec. 6, a comparative evaluation of the iVOLUNTEER prototype is conducted. Finally, Sec. 7 reports on lessons learned and critically reflects our current system.

2 RELATED WORK

Related work is first discussed from the broad perspective of *managing personal data* across *different application areas* including volunteering, before sticking to more closely-related approaches in the area of *digital badges* for *formal and informal learning*. Finally, we investigate on the application of LD and semantic web technologies in VMS.

Human-centric Personal Data Management. Current *management of personal data* across domains like *social media*, *HRM* or *education* is characterized by *organisation-centric data management* (Allard et al., 2017; Abiteboul et al., 2015; Markoulli et al., 2017; Guidi et al., 2018), which is also prevalent in the volunteering domain. Available systems are designed as black-boxes, which can not be exploited across the NPO's borders in a trustworthy and confident way, as encountered in the course of our in-depth evaluation of 18 VMS on basis of a reference model comprising more than 100 evaluation criteria in (Schönböck et al., 2016). Not least since the emergence of the BC-paradigm (Kapsammer et al., 2018), recent research efforts focus on re-empowering users to manage their personal data, often referred to as *human-centric data management* (Abiteboul et al., 2015), putting forward approaches for *decentralized social networks* (Guidi et al., 2018; Chao and Palanisamy, 2019), *personal information management* (Zyskind et al., 2015; Sjöberg et al., 2016) or *digital badges* (Araújo et al., 2017; Facey-Shaw et al., 2017).Especially the area of *digital badges* is closely related to the intentions followed by iVOLUNTEER as digital badges are symbols that are defined and managed by an issuer, being recognized inside a community (Araújo et al., 2017).

Digital Badges in Formal & Informal Learning. Digital badges gain increasing interest in the area of *formal and informal learning* for promoting learner engagement, participation, motivation and achievement (Facey-Shaw et al., 2017). Related approaches for *BC-based personal data management* in terms of *digital badges* can be found in the areas of *formal and informal learning*, namely *UZHBC (University of ZüricH BlockChain)* (Gresch et al., 2019), SPROOF (Brunner et al., 2018), *BCE (Blockchain for Education* (Gräther et al., 2018), *Blockcerts* (MIT Media Lab, 2019) and *EICS (Education-Industry Cooperative System)* (Liu et al., 2018). Although they use various kinds of mechanisms for representing assets, little focus has been given up to now on supporting a flexible and ontological representation of assets throughout their evolution as discussed in detail in Sec. 6.

Linked Data and Semantic Web Technologies in VMS. To the best of our knowledge, none of the previously evaluated VMS (Schönböck et al., 2016) describes their data in terms of LD to publish machine readable data from different sources that may be connected and queried through the use of technologies associated such as RDF or SPARQL.

Since iVOLUNTEER focuses on the digitization of a volunteer's life-long engagements, acquired competencies build a major pillar. Thus, we investigated on competency profile models in the areas of HRM/eRecruitment and eLearning (cf., e.g., (Miranda et al., 2017) for an overview). First of all, several approaches employ simple *semi-structured formalisms* like the IEEE standard CEO/RCD (IEEE, 2007), or the HR-XML standard (HR Open Standards, 2017), aiming to act as a *competency interchange format* and not primarily as a basis for machine interpretable data. One step forward is the Simple Reusable Competency Map (Rifón, 2011) using a *directed acyclic graph* to express different *relationship types* like composition, equivalence or prerequisite. Dedicated *ontology-based models* like InLoc (Integrating Learning Outcomes and Competences) (ICT Standardisation Work Programme, 2013) provide a basis for semantic reasoning, however, conceptualizations for the area of volunteering are lacking.

3 iVOLUNTEER AT A GLANCE

In order to give insight into our web-based digital volunteer ecosystem iVOLUNTEER, a set of requirements is identified, providing the rationale behind the conceptual architecture of iVOLUNTEER presented further on. Thereby, we followed the design science research methodology (Hevner et al., 2004; vom Brocke and Maedche, 2019), including an extensive requirements engineering phase together with our demonstrators in the project (red cross and fire brigade). Based on that, we built a first prototype, which is continuously evaluated and refined, as is common in agile project management settings.

3.1 Requirements

Requirements mainly stem from our goal of *digitization of engagement assets*, comprising the need for *overcoming scatteredness and diversity* and the demand for *maintaining their evolution*. In addition, aiming at volunteer's self *exploitation of engagement assets* rises the need for *achieving sovereignty* and, at the same time, calls for *establishment of trust* for any stakeholder who gets assets transferred by a volunteer.

Overcoming Scatteredness & Diversity. Not least because of the new forms of volunteering (Holzer, 2017), engagements of volunteers are manifold over time, leading to the following requirements:
[REQ1.1] Engagement assets earned through various volunteering work are *scattered* across *data silos* of *proprietary VMS* at different NPOs, representing *partial views*, only. Therefore, a *global view* on these engagement assets is demanded, allowing to gain a comprehensive basis for further exploitation.
[REQ1.2] Engagement assets are naturally *diverse* in various aspects. Their *level of detail* may range from simple engagement confirmations, over detailed task accomplishments to comprehensive achievements. Furthermore, the *evidence* for asset earnings may range from simple textual justifications to formal, NPO-specific rules. To cope with these diversities when establishing a global view, generic representation mechanisms are needed, e.g., LD, together with means for configuration and extensibility, to incorporate the assets' peculiarities.

Maintaining Evolution. As (L)earning-by-doing is an evolutionary process, engagement assets need to co-evolve, leading to the following requirements:
[REQ2.1] Engagement assets should not only be *issued* once by NPOs or informal help seekers, but must be *maintained* to reflect evolution history. Thus, *updates* of already existing assets (e.g., increasing a competences' proficiency level), their *withdrawal* (e.g., due to a missing refreshment training), or *deprecation* in case the assets' status is no longer maintained by the issuer (e.g., if a volunteer resigns engagement for the issuer) should be supported.
[REQ2.2] Engagement assets should be *traceable across their whole life-span* comprising different states and evolution of structure with respect to the time, they became *available*, but also indicating the assets' *validity* start and possible end time.

Achieving Sovereignty. To counteract the prevalent trend of centralized personal data storage in volunteering or HRM (Allard et al., 2017; Abiteboul et al., 2015), volunteers should be empowered to achieve *sovereignty* over their assets, leading to the following requirements:
[REQ3.1] Engagement assets should be *privately storable* by volunteers at an arbitrary location (e.g., local NAS) and it should be definable *which assets to store* (e.g., tasks history, or certain awards).
[REQ3.2] Engagement assets, which are already stored should be *selectively transferable* by volunteers *to other stakeholders* in our digital ecosystem, like NPO's, help seekers, or job recruiters, based on common semantic web standards. Thus a proper transfer format based on LD should be realized. This is a prerequisite not only to obtain personally satisfying volunteering tasks compatible with competences, but also for being able to claim, e.g., the possession of a certain competence for job applications. Addi-

tionally, in case the volunteer revokes the transfer from an NPO, further maintenance of these assets by the NPO (e.g., update of a competence's proficiency level) must be prohibited.

Establishing Trust. To empower volunteers with sovereignty over their assets, establishing trust into them across all stakeholders is crucial for their successful exploitation. This is aggravated by the fact, that sovereignty over the transfer of assets to certain receivers entails their uncertainty about the actual existence of assets, since being claimed by the volunteer themselves, leading to the following requirements:
[REQ4.1] Engagement assets of a volunteer should be described through LD in a way providing a proper basis for the receiver to gain *trust in their content*. For example, evidence about their justification, context of emergence, topicality, issuer, and evolution should be provided to further strengthen plausibility of their emergence. However, it naturally lays in the eyes of the beholders and their perspectives to trust in the content of an asset, not least since the level of trust heavily depends on the reputation of the issuer, i.e., a well-known NPO might be more trustful than an unknown informal help seeker.
[REQ4.2] Engagement assets should be transferable by the volunteer such that *trust in their actual existence*, despite their transfers by the volunteers themselves, can be irrefutably established for receivers. Thus, immutability of the asset's complete evolution and authenticity of its issuer must be guaranteed.

3.2 Conceptual Architecture

Based on the requirements, Fig. 1 shows the conceptual architecture of our ecosystem iVOLUNTEER, depicting four different usage scenarios [A-D].

Decentralized System Components. Since iVOLUNTEER adheres to the principle of subsidiarity and data sovereignty, which puts the volunteer in the middle of concern, we rely on *decentralized system components*. To deal with the isolated data silos of current VMS, four independent components are employed, comprising a *PrivateAssetRepository* establishing a global view on assets [REQ1.1] within the sole sovereignty of a volunteer [REQ3.1-3.2], *VolunteeringHubs* to incorporate NPOs and informal help seekers providing their partial views, *AssetTransferHubs* for the exchange of assets, and an iVOLUNTEER *Blockchain* to establish trust across the ecosystem.

VolunteeringHubs & PrivateAssetRepositories. *VolunteeringHubs* cover VMS functionality like task management or volunteer matchmaking and allow for an experience-based acquisition of engagement assets (cf. (Schönböck et al., 2018; Kapsammer et al., 2017) for details) or generation thereof (e.g., competence derivation based on pre-defined rules). In contrast to existing VMS, volunteers that engage on a VolunteeringHub (cf. Fig. 1 [A.1]), can *download [A.2]* their *issued [A.3]* engagement assets into the PrivateAssetRepository to establish a global view from the VolunteeringHubs' local views [REQ1.1 and 3.1] based on a generic engagement asset ontology [REQ1.2] (cf. Sec. 4). To *exploit* engagement assets for obtaining suitable and personally satisfying tasks, volunteers can selectively provide assets to other VolunteeringHubs (i.e., *publish* [B.1] / *unpublish* [B.2]) [REQ3.2], whereby their existence can be *verified* [B.3] [REQ4.2]. If an engagement asset is *unpublished* from a VolunteeringHub, *deprecating* [B.4] those assets prevent future maintenance through that hub. Data which is explicitly published on volunteering hubs may also be provided in form of LD to provide a machine readable format.

AssetTransferHubs. In order to connect existing VMS, which do not need classical VMS functionality of VolunteeringHubs to our ecosystem as well, *AssetTransferHubs* may be employed. These allow to incorporate engagement assets, which were acquired outside of our ecosystem and were digitized within external VMS. Appropriate interfaces for asset *import [C.1]* (basing on LD - cf. Sec. 5) are provided together with means for the *»blockchainification« [C.2]* of these external assets (cf. Sec. 5), again enabling in a subsequent step their *download [C.3]* by volunteers. AssetTransferHubs also allow to connect third parties like educational or recruitment institutions, by enabling volunteers to *publish/unpublish* ([D.1] and [D.2]) assets at these hubs solely for *verification* purposes through registered third parties *[D.3] and [D.4]*. Overall, AssetTransferHubs are in fact a form of "lightweight" VolunteeringHubs allowing the trustful exchange of already existing assets, coming either from outside or being transferred to parties beyond the volunteering domain.

iVOLUNTEERBlockchain. To establish a layer of trust [REQ4.1-4.2] and to support later *exploitation*, engagement assets, no matter if generated at a VolunteeringHub or imported at an AssetTransferHub are *»blockchainified«*. Due to cost reduction and performance improvements compared to public blockchains, a private, permissioned

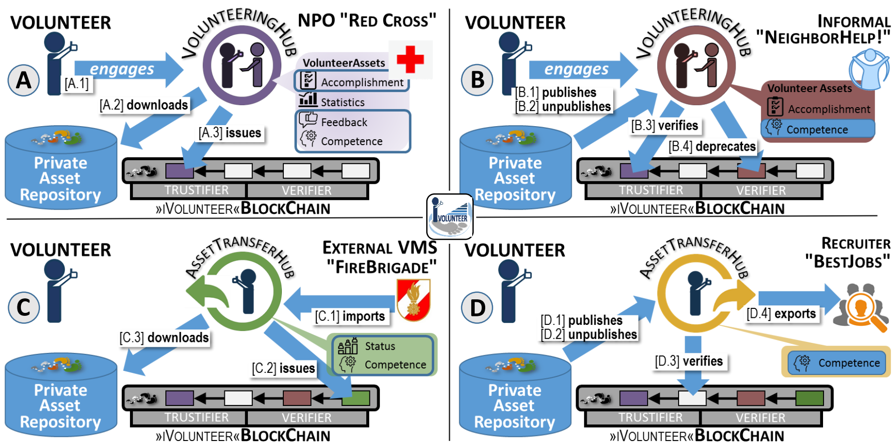

Figure 1: Conceptual Architecture of iVOLUNTEER - Usage Scenarios.

iVOLUNTEER*Blockchain* is used to record all engagement assets *[A.3]* (for privacy reasons encoded as hash-values), allowing to irrefutably trace back each single asset (cf. Sec. 5) An asset's existence, immutability and authenticity can be *verified [B.3]* by both, VolunteeringHubs and AssetTransferHubs [REQ4.2]. Thus, the iVOLUNTEERBlockchain forms the integral backbone of trust for the global view, being maintained by the volunteers themselves.

As *pivotal building block* for digitizing and exploiting assets as outlined above, a conceptual model for engagement assets is presented in the next section.

4 ENGAGEMENT ASSET ONTOLOGY

The following ontology formalizes volunteering concepts and relationships in between. It serves as (i) *design rationale* for PrivateAssetRepositories, (ii) *template* for VolunteeringHubs to manage assets, (iii) *exchange format* for AssetTransferHubs to connect to third parties and (iv) *data structure* being hashed and »blockchainyfied« in the iVOLUNTEERBlockchain. The ontology is depicted in Fig. 2 as UML class diagram, colors additionally grouping closely related concepts. Next, we reason about the ontology's generic core and its means for adaptability followed by a discussion of asset earnings and their types.

4.1 Generic Core and Adaptability

Genericity as Basis for Diversity. Based on the methaphor *»I am what I do«*, a basis for deriving the common core concepts has been found in the area of *linguistic research*, notably in the prominent work of Vendler about the aspectual classification of verbs (Vendler, 1957), as well as by considering well-known *upper ontologies* like SUMO (Niles and Pease, 2001) or DOLCE (Gangemi et al., 2002). Following (Vendler, 1957), the *core of generic concepts* of our ontology builds upon the bold-framed classes shown in the middle of Fig. 2, expressing the fact, that `Engagement` in `Activities` running through certain `States` may lead to `Accomplishments` and various `Achievements`, justified by some `Evidence`. Although our engagement asset ontology focuses on volunteering, special attention has been paid to provide a *core of generic concepts* being applicable to a much broader range of application areas. Proposing a generic core for describing *engagement and its justified recognition by others* contributes also to the research efforts for *integrating formal and informal learning* (Livingstone, 2006), especially emphasizing *transferable competencies* and the *open badges initiative* (Facey-Shaw et al., 2017).

Adaptability - United in Diversity. Building upon this generic core, several *adaptability means* are provided for *uniting these assets while preserving their diversity*. Adaptability is not only supported at a *technological level*, e.g., by using a graph-based NoSQL storage system (cf. Sec. 5), but especially considered at the *conceptual level*. Thus core concepts of our ontology are complemented with a type hierarchy (`Type`) to support *configurability* and *extensibility*. This enables *white-box reuse*, i.e., subtyping to extend the pre-defined type taxonomies, thereby coping with peculiarities of assets issued by, e.g., different NPOs. *Black-box reuse* is supported through explicit *extension points*, allowing to enhance and configure the ontology by specifying, e.g., further properties for types (`Property`) or configuring the state transition of ac-

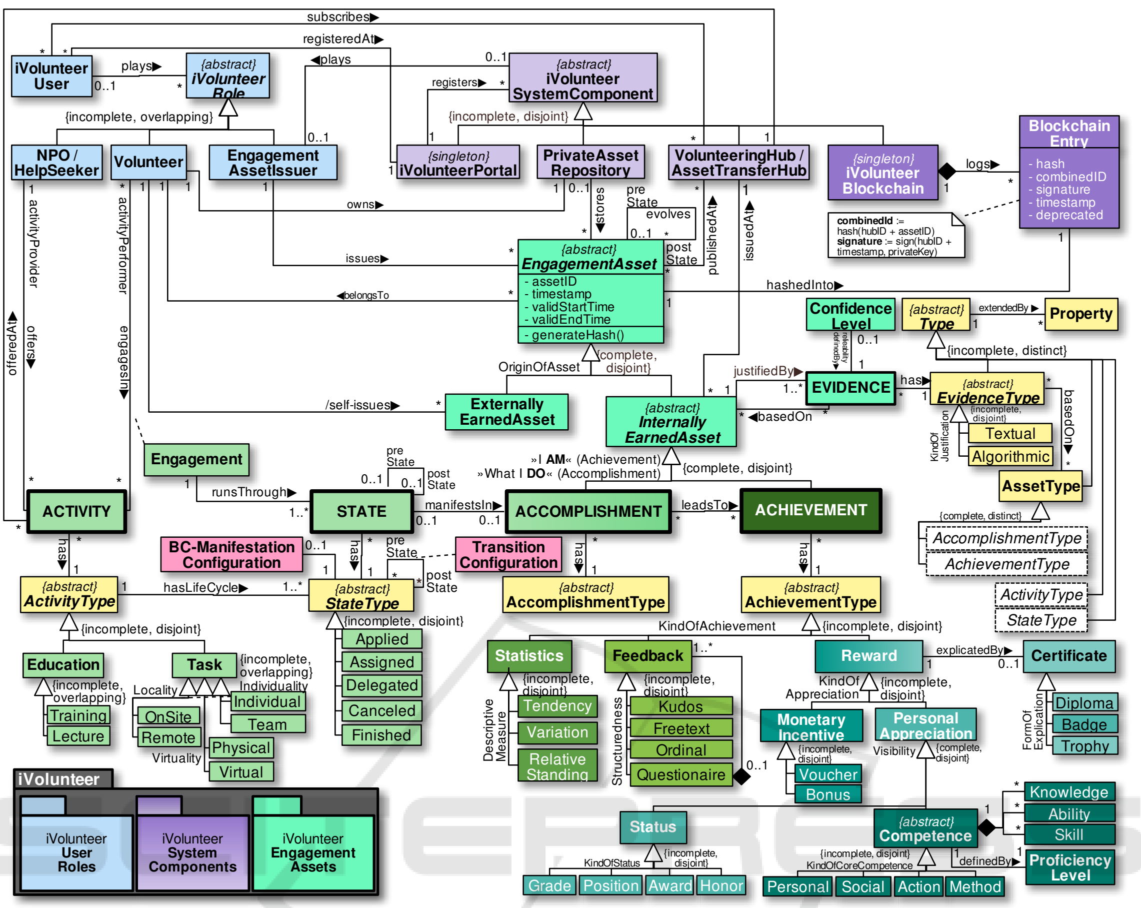

Figure 2: Engagement Asset Ontology.

tivity types (`TransitionConfiguration`). Finally, the concepts of our ontology can be selectively instantiated, thus ensuring, although being more comprehensive, also compatibility with the wide-spread *open badge initiative* (Facey-Shaw et al., 2017).

4.2 Asset Earning

Trust in Asset Content. The scenario of *asset earning* is explicitly reflected by our ontology (cf. upper part of Fig. 2), being a cornerstone for achieving trust in an asset's content [REQ4.1]. Thereby, `EngagementAssets` are primarily earned as a result of accomplished activities forming `InternallyEarnedAssets`. Activities are offered by `ActivityProviders` (e.g., NPOs or help seekers) at certain `VolunteeringHubs` for which `ActivityPerformers`, e.g., volunteers, may engage. These assets are justified by an appropriate `Evidence` (e.g., textual or rule-based, eventually based on other assets) together with an optional `ConfidenceLevel` and are provided by the `EngagementAssetIssuer` (e.g., NPO, help seeker, volunteer colleague, or a VolunteeringHub using an asset generation rule like a competency derivation; cf. Fig 5).

Trust in Asset Existence and Sovereignty. For every `InternallyEarnedAsset` a new `BlockchainEntry` is generated within the `iVolunteerBlockchain` [REQ4.2]. Assets can be downloaded by the volunteer into the `PrivateAssetRepository` [REQ1.1] and [REQ3.1-3.2] and further on published at other `VolunteeringHubs` for getting adequately engaged again or transferred to third parties via `AssetTransferHubs` for further exploitation by means of, e.g., a job application process. A registry of all of the created system components (blockchain and hubs) as well as the registration of users together with their `PrivateAssetRepositories` is maintained by the `iVolunteerPortal`. This component not only provides a lookup mechanism for all registered users, informing them, e.g., about new asset earning possibilities, but also to build-up cross-component functionality, like the provision of NPO-independent core competence ontologies or asset generation rules for all `VolunteeringHubs`.

Evolution of Assets. In order to cope with the evolutionary nature of engagement assets [REQ2.1-2.2] (e.g., increase of a competence's proficiency level) the pre- and post-states of `EngagementAssets` are connected by a reflexive association. Consequently, `EngagementAssets` are considered to be immutable, meaning that every time an evolution takes place, a new `EngagementAsset` is created and connected to its predecessor. This design decision resembles the functionality of temporal databases (Böhlen et al., 2017), thereby establishing the pre-requisite for a life-long digitization and historical exploitation of volunteer engagement.

Externally Earned Assets. Besides internally earned assets, we consider also `ExternallyEarnedAssets`, where volunteers themselves act as self-issuer of assets earned outside of the iVOLUNTEER ecosystem, e.g., a driver's licence or some education diploma. This is not only a means to overcome the "cold start problem" for newly registered volunteers, but also for potential external VMS or third-parties like educational institutions, not yet connected to our ecosystem through `AssetTransferHubs`. Externally earned assets may also be published to a VolunteeringHub, who may decide on an "approval" by issuing an according `InternallyEarnedAsset`.

4.3 Asset Types

In the following, our generic core concepts of `Activity`, `State`, `Accomplishment`, and `Achievement` are further discussed and augmented with *type taxonomies*, reflecting common concepts of the volunteering domain (cf. lower part of Fig. 2).

ActivityType & StateType Taxonomy. The rationale behind the `ActivityType` taxonomy was to explicitly distinguish between assets earned through *formal*, i.e., educational learning activities in terms of `Training` and *informal ones*, i.e., carrying out volunteering `Tasks`, which may lead to the acquisition of formal and informal `Competences` (cf. below). Tasks are further categorized along exemplary criteria most relevant for volunteering work, covering aspects like locality, virtuality, and team-orientation.

Basing on a large body of literature focusing on the conceptualization of activities (Goschnick et al., 2010) and their inter-dependencies in terms of workflows (Heidari et al., 2013; Zur Muehlen and Indulska, 2010), the life-cycle of activity types is represented in terms of `StateTypes`, connecting pre- and post-states using a reflexive association and according exemplary sub-classes covering typical states of volunteering tasks.

Accomplishment & AchievementType Taxonomy. `Accomplishments` are manifestations of certain activity states which could serve as assets (e.g., for computing statistics about a volunteer's willingness to apply for tasks or just about the number of accomplished tasks), thereby representing the *»Do-part«* of the *»I am what I do«-metaphor*, thus having no associated type taxonomy. Complementary, for representing the *»I am-part«*, a comprehensive `AchievementType` taxonomy is provided to cover a broad range of diverse engagement assets usually being a consequence of accomplishments. In the simplest case, `Statistics` may be drawn based on other assets, like means of descriptive statistics as `Tendency` of, e.g, increasing engagement or `RelativeStanding` wrt. other volunteers. All further kinds of achievements (`Feedback` and `Reward`) bear more or less subjectivism in mind, some times also paired with domain-specificity. `Feedback` may naturally range from simple "likes" or `Kudos` (Matteis, 2015) to `Freetext` or be more structured based on `Ordinal` ratings or `Questionnaires`. In contrast to the general concept of feedback, `Rewards` which can be optionally explicated by `Certificates`, e.g., `Badges` (Facey-Shaw et al., 2017) or `Trophies`, are more concrete. According to their focus they can be further specialized into `MonetaryIncentive`, e.g., `Voucher` or `Bonus`, being the exception in volunteering, and more predominant `PersonalAppreciation`. Depending on its visibility to others, one may further split into a rise in one's `Status`, covering mechanisms like `Grade`, `Position`, `Award`, or `Honor` and the acquisition of `Competences`.

Competence Type Taxonomy. Competences represent another cornerstone of our ontology, since being highly valuable for volunteers and also wrt. the overall aim of supporting life-long, formal and informal learning. Our ontology is first of all inspired by the European Qualifications Framework[1] as well as by existing work in the area of *competence ontologies*, and *eRecruitement* (Miranda et al., 2017; Rezgui et al., 2012). Adhering to this work, we distinguish `Knowledge`, `Ability`, and `Skill` to cover qualifications at different `ProficiencyLevels` in education, training, and especially practical tasks. According to the kind of competence which can be acquired, especially in an informal context like volunteering, we adhere to the prominent categorization of Erpenbeck into `Personal`, `Social`, `Action`, and `Method` competences (Erpenbeck,

[1] http://www.cedefop.europa.eu/de/events-and-projects/projects/european-qualifications-framework-eqf

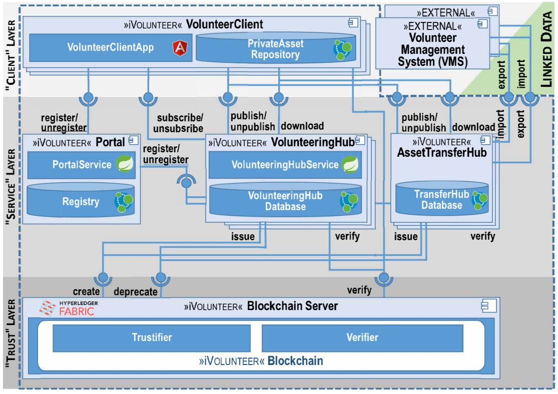

Figure 3: iVOLUNTEER Architecture.

2010) providing a first, generic frame for integrating distinct kinds of (domain-specific) competencies acquirable, e.g., at certain NPOs. To avoid the "cold start problem", i.e., all possible competencies have to be defined when first using iVOLUNTEER, the DISCO project[2] provides a dictionary with more than 100.000 competency definitions.

5 PROOF-OF-CONCEPT PROTOTYPE

This section presents the iVOLUNTEER proof-of-concept prototype based on the requirements and the conceptual architecture outlined in Sec. 3 as well as the engagement asset ontology presented in Sec. 4. The architecture of the iVOLUNTEER-prototype builds upon the inter-working of three layers (cf. Fig. 3), namely *Trust Layer*, *Service Layer* and *Client Layer*, ensuring a decoupled and decentralized architecture. This allows independent components whereby communication between them bases on the *REST paradigm* (Fielding, 2000).

Trust Layer. The *Trust Layer* comprises the iVOLUNTEER-Blockchain (BC), immutably storing obfuscated replicas of `EngagementAssets`, i.e., `BlockchainEntries`. As a technological basis, the modular, extensible and open source platform *Hyperledger Fabric (HLF)* has been used, allowing to operate a permissioned BC (Androulaki et al., 2018). HLF is chosen since (i) as a third generation BC, it provides for a general-purpose, distributed application development platform, characterized by a high level of configurability, especially regarding consensus and storage mechanisms, (ii) it has been already applied in real world settings by major companies,

[2]http://disco-tools.eu

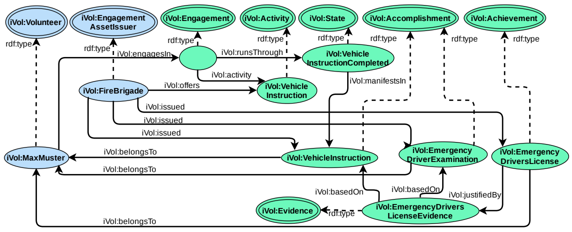

Figure 4: Exemplary RDF Graph of Engagement Assets.

and (iii) its support and maintenance is guaranteed by IBM. The rationale behind using a private, permissioned BC is to minimize transaction costs and response time and to avoid potential limitations of transaction size, which may occur in public BCs. The HLF implementation of the iVOLUNTEER-Blockchain encompasses the *Verifier* and *Trustifier* component, providing REST endpoints for reading from and writing to the BC (i.e., `create`, `deprecate`, and `verify`), triggering their respective smart contract implementations, which will be described in the following.

To protect the privacy of volunteers, their `EngagementAssets` are hashed (stored as `BlockchainEntry.hash`, cf. Fig. 2), being further used as unique ID throughout the BC, enabling fast retrieval by comparison with the calculated hash of an asset and at the same time allowing to *verify the existence* of the asset (cf. `verify` method of *Verifier*). To further guarantee and verify the issuer's *authenticity*, asymmetric cryptography is employed by signing each entry (cf. `BlockchainEntry.signature`), calculated beforehand by the issuer of each asset through digitally signing the concatenation of their respective public key and a timestamp with the private key of the issuer using DSA. Including the timestamp leads to different signatures each time an entry is created, thus precluding the signature's reuse.

In order to allow for *verification beyond simple existence*, verification of an asset's history is needed, requiring a linkage between the individual evolution steps belonging together. This linkage is maintained through the `BlockchainEntry.combinedID`, calculated as a hash of the issuer's ID and the `EngagementAsset.assetID`, thus mitigating possibilities to query information about the issuer. The combination of `BlockchainEntry.hash` and `BlockchainEntry.combinedID` allows for the verification of an asset's (i) *topicality*, (ii) *temporal dependencies*, by further exploiting the provided `timestamp`, (iii) *completeness* of its past evolution, by being able to query all entries for an asset and finally, (iv) *future maintenance*, using the dedicated property `BlockchainEntry.depricate` indicating the termination of an asset's evolution.

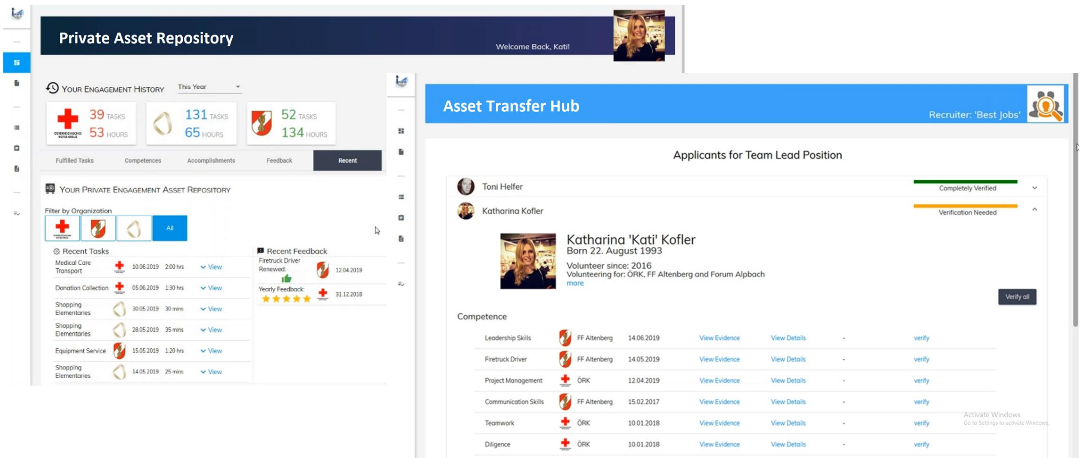

Figure 5: iVOLUNTEER Web Application.

Service Layer. The *Service Layer* allows for (i) volunteer engagement through *VolunteeringHubs* and (ii) incorporates external VMS and external stakeholders by providing *AssetTransferHubs*.

For *VolunteeringHubs*, the Java Spring Boot[3]-based web server implementation of the central *VolunteeringHubService* component focuses on configuration and management of activities, assets, engagements and their evolutions. For life-cycle definition of engagements, the open source workflow engine *Activiti*[4] is utilized, allowing for graphical definition and customization thereof using the Activiti designer available as Eclipse plug-in. For each *VolunteeringHub*, a *VolunteeringHubDatabase* based on the graph-based NoSQL system neo4j[5] stores the local views on `EngagementAssets` earned by volunteers on a certain hub. The rationale behind using Neo4j respectively a graph database is the storage of LD, which they are primed for (Lu and Holubová, 2019). Fig. 4 shows an exemplary RDF graph (A-Box) typed to our conceptual ontology (T-Box) representing the earning of a so-called `EmergencyDriversLicense Achievement` by a volunteer on the volunteering hub of the Red Cross. Additionally, it also shows the preconditions necessary to gain this achievement, e.g., the successful completion of a vehicle instruction as well as passing an emergency driver examination. Changes in the A-Box may be `downloaded` to a volunteer's *PrivateAssetRepository* (see below) to provide a global view by employing a REST endpoint. Additionally, the evolution of the RDF graph is also stored in the blockchain (cf. `create` and `deprecate` REST endpoints in Fig. 3).

The *AssetTransferHubs*, implemented again as Java Spring Boot web server application, allows for integration of external VMS and third party applications through their import/export REST endpoints, thus, enabling usage of externally earned assets within iVOLUNTEER and vice versa. For importing data, a light-weight approach is currently followed, meaning that the provided data needs to correspond to the JSON-LD format allowing to link the internal RDF graph to the newly generated graph from the external JSON-LD data without any need for mappings. For exporting data, the according RDF graph is serialized in terms of JSON-LD to provide a machine readable format. Last, the *PortalService* enables registration/deregistration of volunteers and *VolunteeringHubs*, establishing the global *Registry* of the *iVolunteerPortal*.

Client Layer. Finally, the *Client Layer* comprises access to the functionalities provided by iVOLUNTEER for its users being it volunteers, NPOs, help seekers or other third parties. Foremost, it provides volunteers the *VolunteerClientApp*, enabling them to communicate with the hubs, thereby providing means for engaging in volunteering activities as well as transferring their assets from the hubs to their *PrivateAssetRepository* (i.e., download assets to *PrivateAssetRepository*) and vice versa (i.e., publish assets to a hub). Fig. 5 shows screenshots of the current prototype visualizing a volunteer's earned engagement assets stored in the *PrivateAssetRepository* and a recruiter's view on the *AssetTransferHub*.

6 COMPARATIVE EVALUATION

In the following, related approaches for *BC-based personal data management* in terms of *digital badges*

[3]https://spring.io/projects/spring-boot
[4]https://www.activiti.org/
[5]https://neo4j.com

in the areas of *formal and informal learning* are investigated, namely *UZHBC (University of ZüricH BlockChain)* (Gresch et al., 2019), SPROOF (Brunner et al., 2018), *BCE (Blockchain for Education* (Gräther et al., 2018), *Blockcerts* (MIT Media Lab, 2019) and *EICS (Education-Industry Cooperative System)* (Liu et al., 2018). These approaches are of specific interest as they are (i) using different kinds of mechanisms for *representing their assets*, ranging from unstructured, schema-less to structured, schema-based ones, (ii) tackling *evolution* aspects to a certain extent, (iii) going at least partly *beyond simple issuing and verification* of assets and finally, (iv) providing for a mixture of both, *permissionless and permissioned BC implementations*. Structured along a set of criteria being derived from our requirements (cf. Sec. 3), the evaluation results are summarized in Table 1 and briefly discussed on a per-requirement basis [REQ1-REQ4] in the following, also especially emphasizing on the commonalities and differences to iVOLUNTEER.

Overcoming Scatteredness and Diversity. Regarding our first category of requirements, scatteredness and diversity is not explicitly focused on by the evaluated approaches, i.e., establishing a global view on assets (i.e., digital badges) [REQ1.1] stemming from various sources as targeted by iVOLUNTEER is not an issue. The mechanisms for representing diverse assets [REQ1.2] are manifold, ranging from simply processing PDF-documents (UZHBC), to schema-less asset descriptions (SPROOF) and different schema-based ones, being partly based on Mozilla Open Badges (BCE and Blockcerts). Neither of them provides an engagement asset model, and thus a taxonomy of assets, with a configurable and extensible type hierarchy as provided by iVOLUNTEER.

Maintaining Evolution. Maintenance of asset evolution [REQ2.1] is supported in different, often quite restricted forms. In particular, three systems support *withdrawal* of already issued assets, i.e., revising a previously stated claim (SPROOF, Blockcerts and ECIS), *updates* thereof are only supported by EICS, whereas *deprecating* assets is unique to iVOLUNTEER. Regarding traceability of evolutions [REQ2.2], all approaches allow to capture an assets' *availability time*, and, with the exception of UZHBC, also its *validity time*. Tracing back the *evolution states* of assets is supported by ECIS and iVOLUNTEER, only. Specifically, iVOLUNTEER also addresses *different schema versions* during asset evolution.

Achieving Sovereignty. To achieve sovereignty, all systems except ECIS employ external private storage for assets [REQ3.1], using the BC, as in iVOLUNTEER, for storing their hash values. External storage technologies used are manifold, ranging from distributed (P2P-)file systems to specific groupware, whereas iVOLUNTEER bases on the, in the meantime well established, NoSQL paradigm, allowing for convenient storage of *different asset versions* resulting from both, *structural*- and *state-based evolution*. Finally, although all systems allow for a *selective transfer* of received assets, none of them provide means to *revoke this transfer* (in contrast to the *revokation of an asset*), as available in iVOLUNTEER [REQ3.2], thus preventing an assets further maintainability.

Establishing Trust. Regarding *trust in an assets' content* [REQ4.1], support is restricted in almost all systems to the provision of *textual evidence and URIs to external justifications* only. Similar to iVOLUNTEER, BCE envisions to provide *algorithmic evidence* by means of chain code but misses a *structured representation of the emergence* of assets based on certain accomplishments and/or achievements.

For establishing *trust in an assets' existence* [REQ4.2], the majority bases on the public BCs Bitcoin (Blockcerts) and Ethereum (UZHBC, SPROOF, BCE), only *EICS* employs, analogous to iVOLUNTEER, the permissioned BC HLF. BC-entries can be *issued* in all systems, except SPROOF, by privileged users, only, whereas *receiving* assets is destined to registered users in UZHBC, SPROOF and iVOLUNTEER. *Authenticity* of the asset issuer can be verified by all systems applying asymmetric cryptography, except UZHBC - which, due to its schemaless representation, also lacks ability to verify validity. Beyond, only EICS and iVOLUNTEER provide means for establishing trust in the *topicality* of an asset throughout its evolution. With respect to *completeness of an asset*, SPROOF allows to verify asset bundles, whereas iVOLUNTEER allows to verify completeness of an assets' evolution states.

7 LESSONS LEARNED AND FUTURE WORK

In the following, lessons learned from the employment of BCs while opening up to LD in our digital ecosystems as well as future work are discussed, thereby explicitly considering issues being also valuable to domains beyond volunteering.

Table 1: Comparison of Related Approaches.

Criteria			Approaches	UZHBC [Gresch et al., 2019]	SPROOF [Brunner et al., 2018]	BCE [Gräther et al., 2018]	Blockcerts blockcerts.org, 2019	EICS [Liu et al., 2018]	iVolunteer
Overcoming Scatteredness & Diversity	[REQ1.1]	Global View		✗	✗	✗	✗	✗	✓
	[REQ1.2]	Asset	Representation	schemaless	implicit schema	explicit schema	explicit schema	explicit schema	explicit schema
				PDF	n.a.	Open Badges based	Open Badges based	propriatary	inspired by existing ontologies & standards incl. Open Badges
			Taxonomy	✗	✗	✗	✗	✗	✓
			Configurability	✗	✗	✗	✗	✗	✓
			Extensibility	✗	✗	~	~	✗	✓
Maintaining Evolution	[REQ2.1]	Maintainability	Updateable	✗	✗	✗	✗	✓	✓
			Withdrawable	✗	✓	✗	✓	✓	✗
			Deprecatable	✗	✗	✗	✗	✗	✓
	[REQ2.2]	Traceability	State Evolution	✗	✗	✗	✗	✓	✓
			Schema Evolution	✗	✗	✗	✗	✗	✓
			Availability Time	✓	✓	✓	✓	✓	✓
			Validity Time	✗	✓	✓	✓	✓	✓
Achieving Sovereignty	[REQ3.1]	Private Store	External	✓	✓	✓	✓	✗	✓
			Technology	file system	IPFS (P2P filesystem)	BSCW (groupware)	mobile wallet app	n.a.	NoSQL (Neo4j)
	[REQ3.2]	Transfer	Selectivity	✓	✓	✓	✓	✓	✓
			Revokability	✗	✗	✗	✗	✗	revoke maintainability
Establishing Trust	[REQ4.1]	Trust in AssetContent	Issuer	privileged users	everybody	privileged users	privileged users	privileged users	privileged users
			Receipient	everybody	everybody	registered users	registered users	registered users	registered users
			Evidence	textual	textual	textual + URI	textual + URI	textual	textual + algorithmic
	[REQ4.2]	Trust in Asset Existence	BC Platform	Ethereum	Ethereum	Ethereum	Bitcoin	HLF	HLF
				public	public	public	public	private	private
			Authenticity	✗	✓	✓	✓	✓	✓
			Validity	✗	✓	✓	✓	✓	✓
			Topicality	✗	✗	✗	✗	✓	✓
			Completeness	✗	Asset Bundle	✗	✗	✗	State Evolution

~ *although Open Badges allows, per definition, for extensibility, it is not fully exploited by these approaches*

BC as Battering Ram to Break Walled Silos. Today's application landscape in social media and HRM, which bases on data silos and walled gardens, could be turned upside down by empowering users to get back control over their data and employing BC as a means for establishing trust. Although we tried to take a first step in this direction with iVOLUNTEER, further research is needed to investigate on possible use cases, technological requirements and borders of applicability for different application domains.

BC as Backbone for Transparent Asset Generation. To provide trust in the content of an asset and its evolution, a transparent asset generation and evolution process needs to be provided by the BC. In particular, a library of asset generation rules realized as smart contracts should be provided, allowing NPOs to reflect their "individual culture of appreciation", like rules for award or competency earning, in a transparent way through the BC. This could also lead to the emergence of cross-NPO asset generation rules, e.g., the fire brigade considers qualifications earned at the red cross as pre-requisite for certain tasks, and at the very end to some standardized procedures across different informal learning domains, resulting in a "homogenization" of assets and their evolution.

BC as Mechanism for Ensuring Assets' Existence. Although a BC can ensure the existence of assets, it can not entail *trust in the actual content* of an asset nor prevent *fake assets*. Despite of comprehensively representing an asset's context of emergence through LD, there is no doubt that the issuer's reputation is *the* crucial impact factor. Due to openess of our ecosystem where every registered user is allowed to act in the role of a volunteer or help seeker and since it is uncertain if consensus mechanisms of BCs may always prohibit fake assets, it always lays in the eye of the beholder to assess the plausibility of the provided assets. These are without a doubt some of the most crucial vulnerabilities of our system, although the special culture prevalent in the volunteering domain may reduce these risks to some extent. These are without a doubt some of the most crucial vulnerabilities of our system, although the special culture prevalent in the volunteering domain may reduce these risks to some extent.

BC as Means for Joint Trust Establishment. One crucial issue when employing a private, permissioned BC like HLF is to decide about the distribution and replication of system components to establish the required amount of trust. Therefore, the BC network's components, the committing peers, as well as the ordering service have to be hosted across different trustworthy organizations, preferably with different intentions like the national ministry of social affairs or trustworthy NGOs like the Red Cross.

LD as Enabler for Digitizing & Exploiting Further Assets. Leveraging our digital ecosystem further beyond the volunteering domain, it would be valuable to allow e.g., educational institutions (providing, e.g., qualification certificates), companies (providing, e.g., job references) or governments (providing, e.g., a driving license) to issue assets. Besides these possibilities for digitization, exploitation could be further enhanced by providing functionality for recruiters to upload job profiles and carry out matchmaking.

LD as Common Ground to Share Assets with Third Parties. Especially sharing engagement assets outside of the iVOLUNTEER ecosystem requires a mechanism of information manifestation, wrapping a volunteer's engagement assets in a machine-readable format, without any loss of semantics. LD serves as valuable cornerstone for volunteers to exploit their engagement assets not only within iVOLUNTEER but also for external parties like job recruiters.

LD as a basis for "full integration" of External Assets. Importing externally earned assets is currently, as already mentioned, supported by a light-weight, i.e., link-based approach, only. Although this allows the creation of a volunteer's global view on all earned assets, the potential typing to a different T-Box hinders further internal processing, e.g., to employ this data for semantic matchmaking when looking for suitable new tasks. Thus, it would be beneficial to provide some kind of "full integration" of external assets by migrating the external data to our engagement asset ontology, which would enable their further internal processing.

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