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Dariusz Dymek
*Cracow University of Economics*, dymekd@uek.krakow.pl

Paweł Konkol
*Cracow University of Economics*, konkolp@uek.krakow.pl

Dariusz Put
*Cracow University of Economics*, putd@uek.krakow.pl

Janusz Stal
*Cracow University of Economics*, stalj@uek.krakow.pl

Jan Trąbka
*Cracow University of Economics*, jan.trabka@uek.krakow.pl

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# Conceptual Model of Personal Competence Integrator Based on Blockchain Technology

*Completed Research*

**Dariusz Dymek**
Cracow University of Economics
dymekd@uek.krakow.pl

**Paweł Konkol**
Cracow University of Economics
konkolp@uek.krakow.pl

**Dariusz Put**
Cracow University of Economics
putd@uek.krakow.pl

**Janusz Stal**
Cracow University of Economics
stalj@uek.krakow.pl

**Jan Trąbka**
Cracow University of Economics
trabkaj@uek.krakow.pl

## Abstract

Employee competences play a significant role in the labor market, influencing the development of the global economy. Previous studies have largely focused on the management of documents confirming the competence and credibility of these documents. Carrying out an in-depth analysis of acts, vocational regulations, and government reports, a conceptual model was developed that integrates competencies and skills data description, documents and all other forms of confirmation of competence acquisition. Application of blockchain technology allows integration all data into one autonomous system while using exiting competencies ledgers. The developed IT conceptual model meets the requirements of all interested parties: employees, employers and organizations issuing such documents. The findings are of great importance for improving the effectiveness of managing information on individual competencies.

### Keywords

Soft skills, hard skills, skills management, competencies, blockchain.

## Introduction

In knowledge-based economies, the development of enterprises and, consequently, the development of the entire economy depends on the knowledge, skills and competencies of employees. Hence, one of the key factors that plays an important role in the recruitment process is the set of required competencies, precisely defined by employers (Stal & Paliwoda-Pękosz, 2018). As experience shows, competencies are certified mainly by means of documents. Previous research has been largely focused on IT systems ensuring documents reliability (document-centric systems), reducing significantly the possibilities of effective competence management. It seems that creating a register of individual competencies (a competence-centric system) can provide significant support in the employment process of finding and selecting employees with the desired competencies, and, as a result, enable the automation of this process. Therefore, we have formulated a research question: (RQ1) Will effective access to a set of data on individual competencies contribute to the improvement of the process of recruiting employees on the labor market?

It should be considered that the management of competence information requires the administration of numerous types of documents, their structures, content, as well as information about the issuing institutions. Therefore, an IT system supporting such a register must meet a number of requirements in terms of efficiency, reliability and security. The requirements could be met by the exploitation of blockchain technology, being an example of Distributed Ledger Technology (DLT) (Peplow, 2016; Al-Jaroodi & Mohamed, 2019; Clohessy et al., 2019). Hence, in addition to the main research question, we formulated a specific question: (RQ2) Can (and by what means) the distributed ledger technology contribute to improving the effectiveness of managing information on individual competencies?

# Research Background

Previous research on competency refers mainly to the issue of definition of competencies and competence management and modeling, particularly, in relation to the requirements of Industry 4.0. Rezgui, Mhiri & Ghédira (2012) state that competency-based learning and training has known a growing interest, especially in conjunction with proliferation of the terms "knowledge society," "citizen mobility," or "globalization." Competency modeling becomes an important concept in many domains, especially in human resource development. Lassnigg & Mayer (2018) analyze salient discourses, strategies and steps found at the national level for the definition of key competencies as the desired outputs of the educational system or as a basis for assessment. One of the key activities, they mention, is the development of a new mandatory competency notion in the sense of a complementarity between subject-matter competence and self-competence/social competence. Merchant, Klinger & Love (2018) identify "non-cognitive skills" and analyze how these skills are reported. They state that substantial variability has been found in the labelling of these skills across provinces in Canada although they identified only a few commonly appearing. Rezgui & Mhiri (2018) emphasize the importance of competency modeling for individuals and organizations. They propose a cartography illustrating relationships between some important solutions modeling, intended learning outcomes, learning opportunities, achieved learning outcome profiles of learners and competency maps.

The competence performance approach suggests human competencies to be formalized. A considerable number of proposed solutions are based on using ontologies for competence description (Sicilia, 2005; Rezgui, Mhiri & Ghédira, 2014). Some researchers have proposed competency models. Prifti et al. (2017) develop an Industry 4.0 competency model based on a behavior oriented approach. It contributes to practice as the provided competency model can be applied to Industry 4.0 job descriptions. Kusmin, Ley & Normak (2017) propose a unified competency management platform that serves as a communication layer for the stakeholders interested in retraining and upskilling of the workforce. Ley et al. (2008) specify competencies by applying the competence performance approach. Proposed Workplace Learning Context Model specifies an integrative view on knowledge workers' work environment by connecting learning, work and knowledge spaces. Rosa et al. (2015) define a multi-temporal context awareness system that may be used by workers in present and past contexts to assist them in the development of their competencies. Barbosa et al. (2015) propose a model of a context-aware system, called DeCom, to support competence management. The model considers the profiles of employees in organizations and the contexts in which they are involved, looking for opportunities to help them to develop their competencies.

## *The problem of concept ambiguity*

Contemporary definitions of competence relate to human knowledge, skills and experience (Serafin, 2016). Competence is the knowledge, skills, predispositions and employees' attitudes which in the process of work are targeted at implementing a strategy of an organization (Juchnowicz, 2014). Other approaches associate the concept of competence to the personal features of employees. As Becket indicates (2018), skills refer to drilled ways of acting, whereas competencies include skills but have a broader scope as they incorporate knowledge, predisposition and abilities and provide the possibility to meet the requirements basing on psycho-social resources, covering skills, predispositions and attitudes (OECD, 2005).

The existing approaches to competence classification point to particularly behavioral and technical competence (Armstrong & Taylor, 2014). The competence relating to acts affecting the achievement of results can be associated with soft skills as they regard such areas as: group work, communication, leadership, and decision-making. The second type includes technical competencies, which demonstrate what should be known and done (knowledge and skills) by an employee in order to perform tasks. That perspective makes it possible to link technical competence with hard skills. Competence classification proposed by Armstrong & Taylor (2014) divides them into: (1) general and specific (they refer to all people working in a given profession, without taking into account their organization or roles), (2) threshold and related to action (the first group involves requirements concerning a given position, which are not connected with the division of workers into the ones who achieve better or worse results, whereas action-related competencies take such a division into account), (3) distinctive (regard behavioral features, providing the possibility to identify people on the basis of the results they achieve).

### *Typologies of soft skills*

The study carried out on a group of Robles managers (2012) indicates that, when it comes to soft skills, they attach the greatest importance to integrity, communicativeness, courtesy and responsibility. Higson & Andrews (2008) point out to soft skills affecting the growth of chances for job finding: professionalism, reliability, the ability to cope with uncertainty, the ability to work under pressure, the ability to plan and think strategically, the capability to communicate and interact with others, either in teams or through networking, good written and verbal communication skills, information and communication technology skills, creativity and self-confidence, good self-management and time-management skills, and a willingness to learn and accept responsibility. The U.S. Department of Labor identifies six basic areas of soft skills development (Skills to Pay the Bills, n.a.): communication, enthusiasm and attitude, teamwork, networking, problem-solving and critical thinking, and professionalism. Witak (2013) points out that in the IT industry, although it is perceived as requiring strict and analytical skills, soft skills, without which obtaining and maintaining a job often becomes difficult, are gaining in importance.

### *The evolution of the competence classification system in Poland*

Conceptual ambiguity makes it difficult for labor market participants to match offers with the expected and offered competencies. The aforementioned problem should be solved at the state level or even at the group of states level. The non-uniformity of classification and certification in particular countries handicaps the mobility of European workers. It is at the EU level that the initiatives to create a uniform system of classification of qualifications started. The ECVET (European Credit System for Vocational Education and Training) is an initiative, which is intended to provide citizens with an easier opportunity to obtain vocational qualifications (certificates, diplomas), and thus promote professional mobility. Poland, as a Member of the EU only since the 1 May 2004, has been in arrears in the field of competence management. In 2013, the Educational Research Institute conducted research on legislation with respect to the uniformity of the process of establishing, verifying and certifying qualifications in ten branches of the Polish economy (Sławiński, 2017). The main finding of the indicated research was that a large number of regulations could be found in various sections of professional law, governing verification and certification. However, the indicated regulations are nonhomogeneous and inconsistent. No common terminology and nomenclature, different references to learning outcomes, different and sometimes incomplete mechanisms for validation and certification of qualifications are cited as reasons for the described situation.

The situation began to change after the introduction of the ECVET recommendations (18 June 2009) and the creation and implementation of the common qualification system for lifelong learning in the EU Member States – EQF (the European Qualifications Framework). Poland started to adapt the Polish Qualifications Framework (PQF) to the EQF. An element of the qualification system organization in Poland was the adoption of the Act on the Integrated Qualifications System in 2015 (IQS). It defines the conceptual system of qualifications, standards of description, assignment of qualifications to the PQF levels, institutions creating and maintaining IQS, operational processes of validation and certification of persons, and the system of quality assurance of institutions participating in the learning and certification process. An important IQS element is the public Integrated Qualification Register (IQR) constituting a database regarding the qualifications included in IQS. IQR acts as a link between the qualification systems functioning autonomously so far. The register includes information on, among other things, specific requirements needed to obtain a particular qualification and the name of the institutions that are authorized to give it. This information is important in case of qualifications obtained outside school and university, i.e. those obtained either during work or as part of courses and trainings. Thanks to this, information on qualifications is available in one place for the interested persons and institutions that cooperate within the IQS. Soon, Polish qualifications will be included in a wider area of European qualifications through IQR. The information will be exported through the register to such European portals as LOQ (Learning Opportunities and Qualifications) and ESCO (European Skills, Competencies, Qualifications and Occupations). The work on the system of identification and classification of qualifications has begun in Poland. IQS, and in particular its computerized part, IQR, is gradually complemented with qualifications that operate on the labor market. Currently, IQR describes 10252 qualifications and 1813 institutions that issue certificates. Certificates are provided in paper form and are registered in certification units. There is no place to store the qualifications acquired by a given person throughout his or her school and professional life. Undoubtedly, access to such a register of individual qualifications would enable support for

employment processes and would be a key element in ensuring mobility of employees in the European Union.

## Research Methodology

To develop a conceptual model of competencies, we used a qualitative research approach (qualitative case study methodology), which provides tools to study complex phenomena in a full environmental context (Baxter & Jack, 2008). Detailed and rigorous (formalized, methodologically conducted) qualitative case studies give researchers an opportunity to investigate or describe a phenomenon in its environmental context using various data sources. Qualitative case study methodology provides a possibility to investigate individuals or organizations through complex interventions (sets of human activities), relationships, communities or programs and supports the deconstruction and subsequent reconstruction of different phenomena (Yin, 2003). A characteristic feature of this kind of research is the exploitation of multiple data sources, which also enhances data reliability (Patton, 1990). Potential data sources may include, among others: documentation, archival records, interviews, physical artifacts, direct observations and participant observations (Baxter & Jack, 2008).

First, acts and regulations of the Polish Ministry of National Education, the Ministry of Higher Education and regulations on vocational education in the period 2013-2020 have been examined. Additionally, government reports of research institutions (e.g. Educational Research Institute) were used to analyze Polish legislation in relation to the EU recommendations. Next, to develop a conceptual document model which includes non-formal competencies, not covered by government regulations, the job offers available on the "pracuj.pl" internet portal and the statements of labor market experts have been studied. Then, to classify documents containing information on qualifications, the official templates have been used or, in case of their unavailability, interviews have been conducted among representatives issuing certificates (e.g. selected universities, primary and secondary schools, as well as companies offering accredited IT trainings). Finally, the IQR system was thoroughly evaluated.

The research was conducted in the second half of 2019. At the beginning, an analysis was made of historical and current legal acts concerning the rules of issuing, storing and making available of documents confirming the competencies held. The analysis covered templates of documents used in practice by educational, industry and market institutions as well as personnel documentation of enterprises. In the next step, the methods of competence description regulated in the systems of classification and competence description were identified: EQF, PQF, and the most important element of the current Polish competence management policy, IQS. Subsequently, the database of job offers was reviewed for the possibility of using the terms contained therein to describe and classify competencies. In this context, a conceptual model of competencies was developed and discussed, categories of documents confirming competencies were defined and their structure was proposed, the choice of technology to represent the model was justified, types of users and their roles were discussed and the construction and operation of the system based on the proposed model was described.

## Research Results

### *The proposed conceptual model*

Bearing in mind the problems of conceptual and classification inconsistency, the solution proposed in IQS was adopted for the purposes of the paper. At the same time, they were extended to include elements of soft skills not covered by the system. The conceptual model of vocational competencies is presented in Figure 1. Competencies relate to knowledge, skills, experience and attitudes can be divided into hard and soft. Hard skills are associated with obtaining appropriate certificates. The act on IQS defines them as a set of learning outcomes regarding knowledge, skills and social competencies acquired through formal or non-formal education following the requirements set for a given qualification, the achievement of which has officially been certified by an authorized certification body. The division of qualifications under the IQS framework is shaped on the basis of the type of a learning cycle, and thus the institutions validating the educational output and issuing certificates, and it distinguishes:
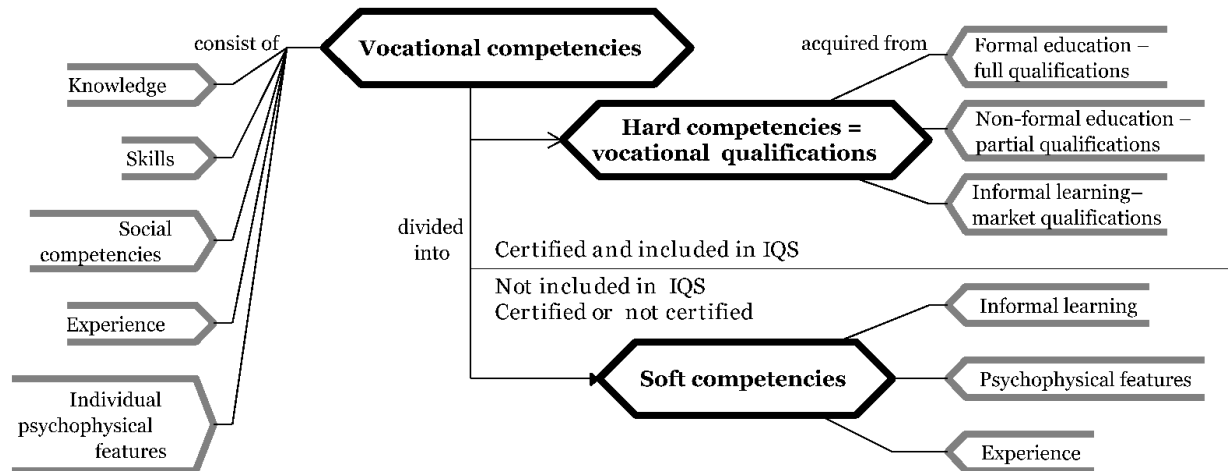
**Figure 1. Conceptual model of the competence area**

- Full qualifications, obtained within the framework of formal education, are awarded upon completion of education at first, second and third degree qualifications within the meaning of the Polish law on education. For example: a university diploma: faculty, school, institute;

- Partial qualifications can be awarded by educational institutions but also by other entities. These are qualifications confirmed by diplomas and certificates issued after exams taken in professions, further education and training courses, and other forms of teaching. For example: Confectioner – a master's diploma awarded by the Chamber of Crafts;

- Market qualifications are not legally regulated. They are awarded during the business activity. For example: the woodwork installation qualification awarded by the VCC Foundation (an example from IQR: https://rejestr.kwalifikacje.gov.pl/);

- IQR constitutes a central database of information about qualifications. However, the recording and archiving of people's certificates is handled by the units that issue them. The lawmaker assumed combining particular types of physically issued certificates with the IQR database by placing a qualification identifier from IQR on the source document and the level from PQF.

## *Document characteristics*

On the basis of the proposed conceptual model, we conducted a survey of the documents currently functioning in Poland confirming the qualifications and skills. We have also classified them, distinguishing five basic categories, presented in Table 1. The functioning of each category of documents is based on separate principles. For documents required by the law (categories 1 and 2), the issuing bodies must be accredited by supervising institutions (e.g. for primary and secondary education these are the bodies of the Ministry of Education). In case of documents certifying vocational training (category 3 and 4), the issuing bodies are either the holders of the rights to the certificate in question or the ones that act on the basis of the rights granted by the holder of such rights (for example vocational certificates from the sphere of IT of the companies such as: Microsoft, Oracle, IBM, etc.), except that there is no formal verification of the learning outcomes in case of category 4, i.e. either only the participation in the training is certified or personal information is nor verified (e.g. on-line courses). The significance of such certificates rests on the market position (prestige) of the right holder to issue them. When it comes to documents providing evidence of experience and/or skills (category 5), the issuer of the document for a given person is the institution for which that person worked, which means that there is no other entity specifying the requirements with regard to the content of the aforementioned documents.

| | Category | Certification bodies | Types of certificates |
|---|---|---|---|
| 1 | Formal education | Documents issued by educational system institutions on the basis of legal regulations | Certificates, university diplomas, degree diplomas |
| 2 | Vocational entitlements | Documents issued by institutions that are not part of the education system, but which have the status of legally required documents | Vocational entitlements requiring passing state exams (architects, electricians, drivers, etc.) |
| 3 | Formal vocational training | Documents issued by institutions whose educational status is not regulated by law, providing training within the courses | Professional certificates in various areas and ranges, e.g. issued by companies and branch organizations |
| 4 | Informal vocational training | Documents issued by organizations with not regulated educational status by law, not verifying learning outcomes or personal data (e.g. online courses without verification of personal data) | Certificates of participation or course completion issued by different organizations |
| 5 | Certification of experience and/or skills | Documents of a formal character (e.g. employment certificate) or of an informal nature (e.g. letters of recommendation) issued by employers or other organizations (employers who employed the worker receiving the certificate) | Certificate of employment combined with the employer's opinion (positions, skills, training), certificates of employment in structures of organizations of a social nature, etc. |

**Table 1. The categories of documents certifying the possessed qualifications**

## Discussion

Basing on the identified categories of documents we propose a document representation model presented in Figure 2. The model assumes that the documents of the same type issued at the same time by the same institution have identical characteristics. The flexibility of the model allows to reproduce in it a document from any category. Based on the identified categories of documents, we divided them into three groups:

- Formal Document Characteristic (FDC) (formal characteristics) – specifies the categorization of the document and indicates the supervisory authority or right holder, the issuing institution, the name of the document, the person to whom it was issued, and the date of issue (and its validity);

- General Competence Characteristic (GCC) (general competence range) – defines competencies on the basis of their scope (determined, inter alia, on the basis of hard and soft competence models, terms used in curricula, etc.). GCC is a partially closed set, i.e. the changes in it can only be made by the supervisory authorities in an update mode;

- Detail Competence Characteristic (DCC) (detailed scope of competence) – constitutes a detailed specification of GCC using concepts and terms describing the scope of competence. DCC is created on the basis of the analysis of the curriculum in conjunction with the analysis of the market offer of employment, in a mode similar to the functioning of the so-called keywords and has a dynamic character, i.e. each of the document issuers can introduce new terms. In this section, the issuer may include additional information about the scope of competencies in the form of indicating (reference to) external descriptions (e.g. the study program, the scope of training, etc.).

On the basis of the developed model of document representation, as a personal competence integrator we propose an Integrated Personal Competence Ledger (IPeCoL) to collect and provide access to information certifying the possession of specific competencies. IPeCoL would act as an integrator of existing registers of the certificates issued, and in some cases (some issuers may keep their own registers) it could replace them over time. Each issuer of a certificate, within the scope of the rights stemming from the category of documents, shall include information about this fact in the system. Each issuing entity has access to all the documents issued by it. Entities supervising types of documents (to the extent specified by law or agreement) would also have access to the indicated information. The person to whom the collected information relates has access to it as well and may grant access (e.g. temporary, full or limited) to other entities (e.g. potential employer). Including all information in one system allows all its users to economize on maintaining, confirming and verifying their qualifications.

## *The conditioning and the choice of technology*

The minimum requirements for an IT system to support IPeCoL operation include: (1) ensuring data security, including, inter alia: traceability and incontestability of the institution issuing the documents, the impossibility for unauthorized parties to upload documents, the impossibility to modify the recorded documents, and the possibility to trace the history of access to the documents, (2) accessibility for all document issuers, (3) accessibility for all persons concerned by the documents and (4) possibility to verify individual documents.
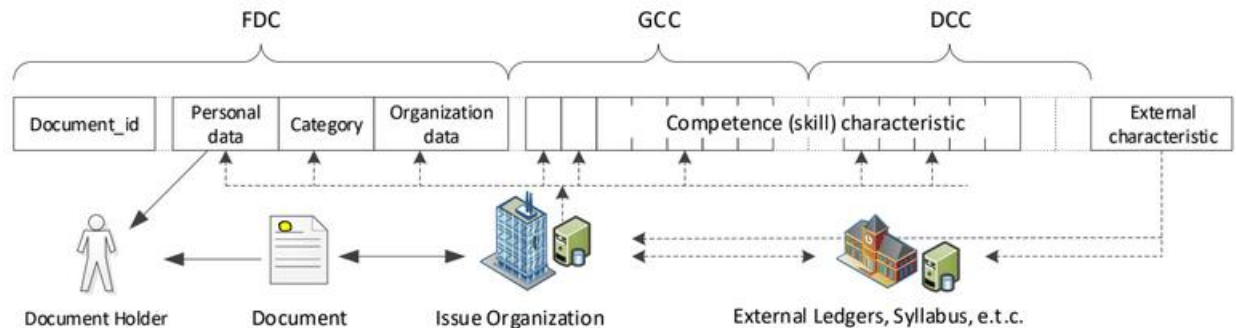


**Figure 2. Document representation model**

Despite the possibility to build a central database with such functionality, it would require considerable computing power and would have to be managed by one institution. An alternative concept of IPeCoL implementation is the use of distributed ledger technology (DLT) represented by the blockchain technology. Three basic types of systems can be distinguished in the aforementioned technology (Casino et al, 2019, pp. 57-58): public, private and federal (hybrid). In public systems, the role of full nodes can be played by any user, as they all have the same rights. In private systems, the full nodes belong to a single organization, which can provide more control but also limited trust. An indirect solution is found by means of federated (hybrid) systems, in which the list of full nodes is limited and remains under the control of unrelated organizations. This independence is one of the guarantees of security. The presented concept of IPeCoL implementation uses the federation variant.

The proposed model describes the document by attributes from three sections. An attribute can be treated as a column in a table and a section is a set of such columns. In this sense, the document characteristics is a vector composed of attributes, most of which contain a logical yes/no attribute to the document and the other attributes contain information unique to the document (e.g. personal data, date of issue, etc.). An important part of the document characteristics is the Detail Competence Characteristic (DCC), in particular references to external documents describing the scope of competence (e.g. training program). Although it is possible to store such documents in a database, from a performance point of view, it is better to limit oneself to storing a link to external registers such as IQS or the websites of competent organizations. Only with regard to documents of category 5 it can be appropriate to store electronic versions of documents.

## *Stakeholders and their roles in the system*

Eight types of users can be distinguished in the proposed system (Table 2). Accreditation bodies are responsible for managing the attributes from the FDC and GCC sections, by, inter alia, granting rights to subordinate entities to use them. The CA (1) and CA (2) are free to use the DCC attributes and additionally, complete the information (links) on descriptions stored outside the scheme. CA (3) and CA (4) complete the list of roles of active users, i.e. those who can include documents in the scheme or influence their characteristics. The users of all types of AA and CA categories have access to (can preview) certificates issued by themselves or by accredited bodies, following the legal restrictions. The role of the full node in the system is played by organizations included in AA(1), AA(2), CA(1) and CA(2) categories. They store the database, are responsible for its management, including the authorization of changes, and provide access to the system to other users. Their legal authority and market authority constitute a guarantee of the correct functioning of the system.

### *Structure and the system operation*

Figure 3 shows a general working scheme of the proposed IPeCoL system. AA(1-2) and CA(1-2) category users act as full nodes and are responsible for the operation of the system, including storing and sharing data, managing active users (including accreditation, confer entitlements to use FDC attributes), validating and accepting new entries.

| User | Symbol | Characteristics |
|---|---|---|
| Accreditation Authority type 1 | AA(1) | Supervising institutions and the ones that provide others with entitlement to issue certificates, whose nature is regulated by law (category 1 and 2). These bodies occasionally issue certificates. They usually delegate these powers to other units. |
| Accreditation Authority type 2 | AA(2) | Accreditation bodies, operating without formal legal regulations. These are organizations that provide training and/or certify qualifications based on their own requirements (category 3). They can delegate (accredit) qualifications to other entities, but they also issue certificates themselves. |
| Certifying Authority type 1 | CA(1) | Certification bodies operating in the education system on the basis of AA(1) accreditation. They may issue certificates (category 1 and 2) in accordance with their authorization, supplementing them with the General Competence Characteristic (GCC) and the Detail Competence Characteristic (DCC). |
| Certifying Authority type 2 | CA(2) | Certification bodies operating in the education system on the basis of AA(2) accreditation. They may issue certificates (category 3) in accordance with their authorization, supplementing them with the General Competence Characteristic (GCC) and the Detail Competence Characteristic (DCC). |
| Certifying Authority type 3 | CA(3) | Training institutions issuing category 4 certificates. They are not accredited. Their authority to create a certificate characterization is limited within the scope of the FDC (e.g. in terms of the type of document for 'course completion certification'). They are free to choose the characteristics for GCC and DCC. |
| Certifying Authority type 4 | CA(4) | Entities issuing category 5 documents. They are not subject to accreditation. This group includes any organization which employ staff. They have freedom in terms of GCC and DCC, with the mandatory inclusion of electronic copies of source documents. |
| Verifying Organization | VO | Verifying authorities. The entities verifying the reliability of the documents submitted, in the framework of for example the recruitment of new staff. Users in this group can verify the certificates after providing the required information (based, for example, on the content of certificates in paper form). |
| Document Holder | DH | Natural persons concerned by the certificates issued. Each person shall have access to the certificates relating to him/her and may grant such access under the rules defined by the system (scope, time, etc.). |

**Table 2. Stakeholders and their roles in the system**

Depending on the category of documents and accreditations held, active CA(1-4) users can attach information about the certificates they issue, they also have access to the data they upload (in read mode, blockchain properties do not allow to change them). By attaching documents they can supplement the information with links to external sources with more detailed information (except CA(4) which places the full document). When attaching subsequent documents, a unique code is generated for each of them, providing a possibility to verify it directly in the system.

Passive users (DH) are persons to whom documents refer and the entities willing to verify documents (VO) submitted to them. They have access to all documents that concern them (in read mode) based on the combination of digital signature and selected personal data (PESEL - Personal Identification Number). A user of DH class may grant access to his/her own documents (e.g. to future employer) in the modes defined by the system. VO users can verify documents based on their unique code or after providing the required range of data corresponding to the content of documents in a traditional paper form. The indicated access mode allows e.g. future employer to credibly verify documents certifying their qualifications submitted by candidates directly to IPeCoL, while at the same time not posing a risk of violating legal rules, e.g. in the area of personal data protection.
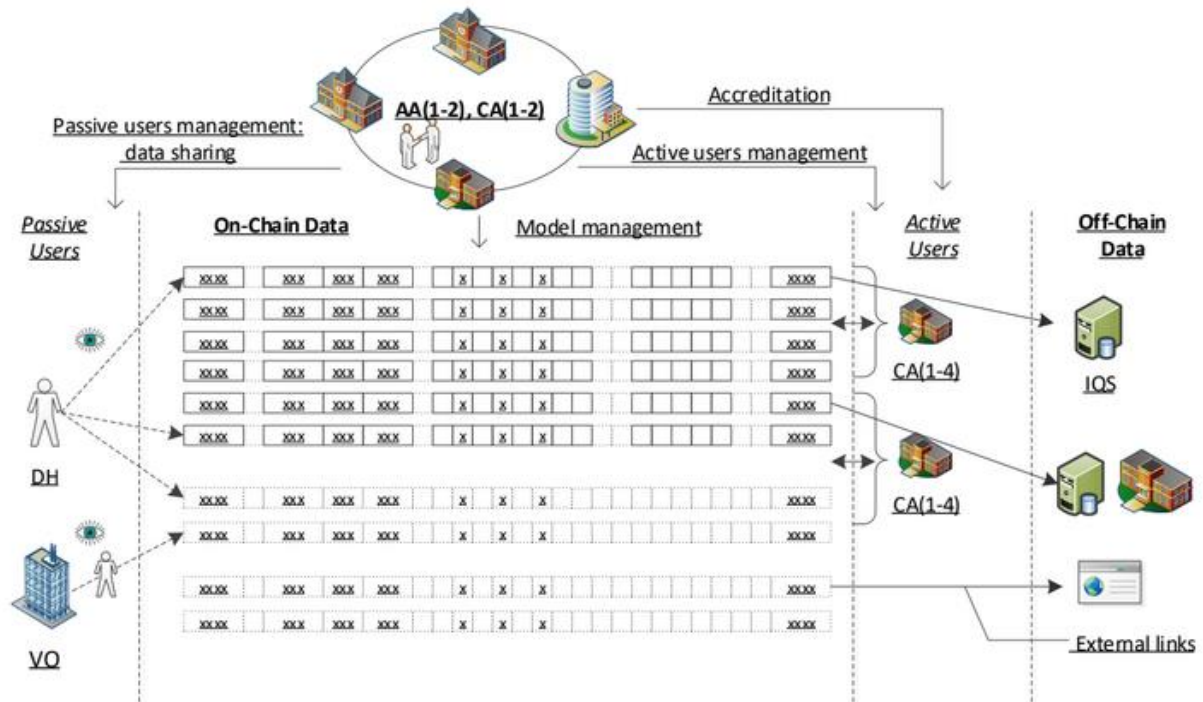
**Figure 3. The scheme of the IPeCoL system structure**

The roles of users are not exclusive in nature, e.g. an organization of AA(2) category can issue certificates, i.e. act as CA(2) and at the same time verify candidates (VO role). The mechanisms of cryptography used in blockchain technology ensure the security and integrity of data, maintaining their privacy.

## Conclusion

The possibility to verify competencies and skills in a reliable way is an important issue for both employees and employers in the modern labor market. The proposed model ensures the unification of the way in which documents confirming the possessed qualifications are represented and thus may constitute the basis for building a system intended to verify their credibility.

The described concept of the IPeCoL system, based on blockchain technology, is a starting point for building an IT system in order to prove the credibility of documents while keeping them confidential and private. It is important that proposed IPeCoL architecture does not force to replace other existing systems and ledgers but plays the role of their integrator, linking the on-chain and off-chain data in one consistent system. We plan to introduce the proposed system first in Poland. However, we are going to use only universal solutions which may be easily accepted by other EU members as well as third countries.

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