SSI EduWallets

Contents

Introduction

The Self-Sovereign Identity (SSI) EduWallets project aims to revolutionize the way we manage our personal information and privacy in the digital age of the Web 3.0. By harnessing the power of decentralized and distributed technologies such as blockchain, verifiable credentials (VCs) and self-sovereign identity, this project seeks to give users complete control over their data, freeing it from the silos of third-party storage and therefore build a more transparent and trustworthy digital ecosystem.
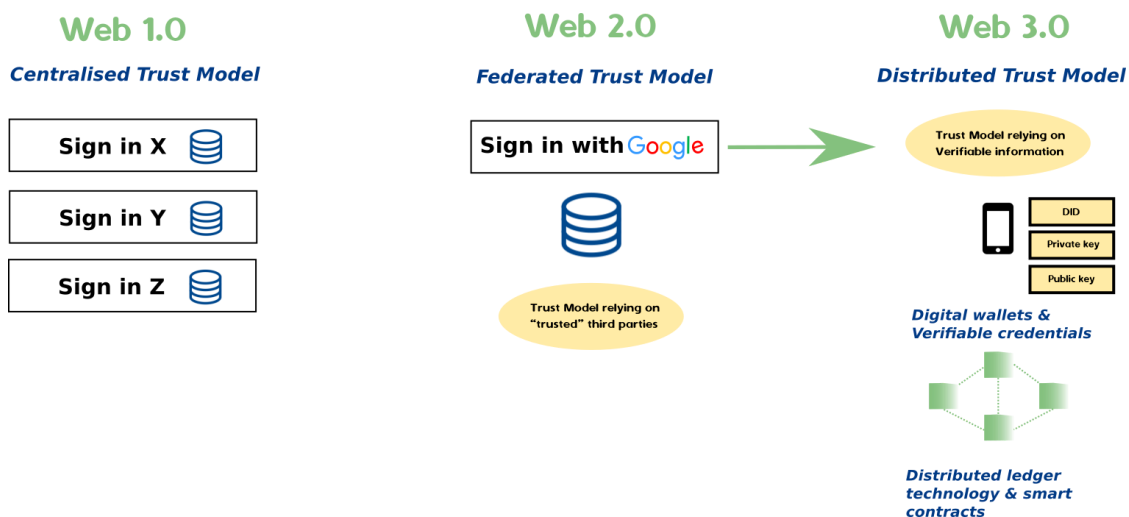
[1]

The SSI EduWallets project focuses on the implementation of a user management system for online platforms. Users are allowed to interact with the platforms that implement this system and perform the issuance of educational verifiable credentials once they complete a course or

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[1] European Commission. *Different data paradigms along the web generations*, *EBSI*. Available at (Page 3):
https://ec.europa.eu/digital-building-blocks/wikis/download/attachments/597952490/Chapter%200%20-%20Verifiable%20Credentials%20An%20introduction.pdf?version=1&modificationDate=1676459051355&api=v2

assessment through the use of [European digital identity (EUDI)][2] wallets. The presentation of verifiable credentials that are stored in the user's wallet help to enhance the platform's "learning experiences" by verifying learning histories and using this data to provide a better overall experience on the platform.

This approach, based on SSI, [W3C Decentralized identifiers (DIDs)][3], [W3C Verifiable Credentials Data Model (VCs)][4] and EUDI/ [European Self-Sovereign Identity Framework (ESSIF)][5] standards, ensures interoperability and security between different systems within the European Union.

Once a user receives a verifiable credential it will be stored in the user's wallet for future verification. By digitally signing each verifiable credential and ensuring standardization of formats, the project seeks to end the problems of interoperability, forgery and inconsistency that plague traditional educational certificate systems.

Project description

Goals and benefits

The main goal of this project is the implementation of a "proof-of-concept" capable of being integrated in educational platforms so third parties can make profit of the new Web 3.0/SSI paradigm and leverage the features of user privacy and the issuance of educational verifiable credentials to the users. Verifiable credentials are a representation of an accreditation of

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[2] European Commission *The European Digital Identity Wallet Architecture and Reference Framework*, *Shaping Europe's digital future*. Available at: https://digital-strategy.ec.europa.eu/en/library/european-digital-identity-wallet-architecture-and-reference-framework (last accessed: 08 August 2023).

[3] Sporny, M. *et al. Decentralized identifiers (DIDs) v1.0*, *W3C*. Available at: https://www.w3.org/TR/did-core/ (last accessed: 08 August 2023).

[4] Sporny , M., Longley , D. and Chadwick , D. *Verifiable credentials data model V1.1*, *W3C*. Available at: https://www.w3.org/TR/vc-data-model/#abstract (last accessed: 08 August 2023).

[5] Pastor Matut, C. and Du Seuil, D. *Understanding the European self-sovereign identity framework (ESSIF)*, *PPT*. Available at: https://www.slideshare.net/SSIMeetup/understanding-the-european-selfsovereign-identity-framework-essif (last accessed: 08 August 2023).

knowledge achieved under a qualification framework like the [Qualification Metadata Schemata (QMS)](#)[6]. This schemata are used to classify the learning outcomes in a detailed specification and also make use of the [European Skills, Competences, Qualifications and Occupations (ESCO)](#)[7] taxonomy.

Once a user finishes a course or assessment he/she can share verifiable presentations (VPs) for verification and validation of learning achievements via wallet and a platform. The main benefits of the implementation are the capabilities of a platform to issue a digital, cryptographically secure, semantically rich credential that specifies qualifications, skills and occupations under a common framework and, furthermore, to enhance interoperability between independent systems. Certificates which are issued as educational verifiable credentials are easy to verify and difficult to manipulate.

The SSI EduWallets implementation seeks to eliminate the problems of the user data handling, the forgery of traditional credentials, and the non-interoperability between systems. It streamlines the process of the issuance of a secure educational credential and the verification of the credentials saving time and costs.

Target group

The SSI EduWallets project is intended for platform operators (SMEs, corporates, governmental, non-governmental) or platform providers (LMS reseller, Learning App provider) which want to extend their platforms with the new paradigm of SSI, eliminating data privacy & security issues related to the management of users' personal/private data.

Once integrated, they allow their users to perform secure identification using EUDI/ESSIF compliant wallets via verifiable presentations (VPs) of learning achievements or issuance of educational verifiable credentials to streamline accreditations & certificates (and leverage the use of DIDs and VCs).

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[6] European Commission (2020) 'Publishing of Qualification and Learning Opportunity Data Documentation'.
[7] ESCO *About Esco*, *ESCO*. Edited by European Commission. Available at: https://esco.ec.europa.eu/en/about-esco (Accessed: 08 August 2023).

Content overview

SSI EduWallets provide a series of software components that create a stack needed to implement the new paradigm of SSI and the use of educational verifiable credentials within learning platforms.

Through the components of **EUDI wallets**, **issuer API**, **verifier API, wallet kit API**, **issuance and verifier user interface** the implementation contains following user journeys:

- Users can use EUDI wallet applications within the platforms that implement SSI EduWallets to exchange data. Those wallets store and manage the users' data instead of third parties, **enhancing the users' privacy**.

- Platforms that implement SSI EduWallets can **issue digital, cryptographically secure education diplomas** called "educational verifiable credentials" that represent an accreditation of the achievements that a user receives once he/she completes a course or assessment. These verifiable credentials will be stored and managed inside the user's wallets.

- The educational verifiable credentials issued consist of the data of the user (holder), the data of the platform (issuer), the data of the course or assessment and the issuer's signature. The information about the course or assessment follows the Qualification Metadata Schemata and ESCO in order to provide **useful information about the skills, qualifications and experiences** that the user achieves through a learning experience in order to **obtain new learning opportunities and occupations**.

- Platforms implementing SSI EduWallets can receive verifiable presentations from users' wallets to **verify and validate shared verifiable credential data** and use within platforms to **streamline some internal processes**.

- The verifiable credentials are **interoperable between different systems** because they are defined under a common data schema. Independent/external systems can recognize and then parse the structure and constraints of the specific type of verifiable credentials.

- The management processes of the interoperability, issuance and verification of the credentials are **more simple and faster improving the user experience, saving costs and time** because the intermediary parties usually in charge of performing those tasks are removed.

- Verifiable credentials are **secure because they use asymmetric cryptography technologies and digital signatures** to make them tamper-proof, easy to verify and difficult to forge.
- The data of the issuers like DIDs, public keys and transactions are **redundant, highly available and secure** if the system uses the blockchain infrastructure of [European Blockchain Services Infrastructure (EBSI)](#)[8] in order to verify a verifiable credential.

System architecture

Technologies and concepts

Self-Sovereign Identity (SSI)

SSI is a digital identity concept that gives individuals **control over the information they use to identify themselves** to websites by managing their identity data directly, **without the need for intermediaries or central authorities**, services, and applications on the Internet.

Through the SSI EduWallets implementation it is possible to leverage the features of this new paradigm and provide a new way to **exchange data in a secure, agile and interoperable way.**

European Digital Identity wallets (EUDI)

EUDI wallets are applications that allow you to manage the digital identity of a citizen of a country of the European Union, this applications are part of the [electronic IDentification, Authentication and trust Services 2 (eIDAS 2.0)](#)[9] proposal which provides a single **european digital identity** and allows to perform transactions both at a public and private level with greater security and control of information.

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[8] European Commission *European Blockchain Services Infrastructure*, *Home - EBSI -*. Available at: https://ec.europa.eu/digital-building-blocks/wikis/display/EBSI/Home (last accessed: 09 August 2023).

[9] Electronic Identification (2022) *Electronic identification*, *Electronic IDentification - IDentity Verification Solutions*. Available at: https://www.electronicid.eu/en/blog/post/eidas-2-0-what-can-companies-expect-from-it/en (last accessed: 02 August 2023).

Since there is currently no digital identity provider under eIDAS 2.0 proposal, it is not possible to obtain verifiable identity credentials at the moment, so these credentials cannot currently be used in the implementation of the project. Therefore, the use of these wallets within the platforms implementing the SSI EduWallets is dependent on the use of the DIDs as unique identifiers for each user.

European Self-Sovereign Identity Framework (ESSIF)

ESSIF is an initiative and framework developed by the European Commission to promote and support the **implementation of self-sovereign identity** (SSI) solutions across Europe. It seeks to build a **more user-centric and privacy-preserving approach to digital identity**, supporting the broader goal of a **trusted and secure digital society** in Europe.

SSI EduWallets leverage this framework to perform all the activities related to SSI and the management of verifiable credentials.

Decentralized Identifiers (DID)

Decentralized identifiers (DIDs) are a new type of identifier that enables verifiable, **decentralized digital identifiers**. "A DID refers to any subject (e.g., a person, organization, thing, data model, abstract entity, etc.)"[10][11]

SSI EduWallets use DIDs in both "issuer" and "holder": In the case of the "issuer" within EBSI, the DID and the public key are stored on the **blockchain** to be verified by third parties. In the case of the "holder", the DID is generated and stored by the user's wallet.

In case the DIDs are created with the method "key", then none of them are stored on the blockchain. This method allows **to work with DIDs and VCs without any decentralized service** (no blockchain service needed!).

Verifiable Credentials Data Model (VC)

Verifiable credentials with DIDs are the core of SSI paradigm. The verifiable credentials provides a **mechanism to express all sorts of credentials digitally on the Web** normally in the format of

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[10] Sporny, M. *et al. Decentralized identifiers (DIDs) v1.0, W3C*. Available at: https://www.w3.org/TR/did-core/ (Accessed: 08 August 2023).
[11] Decentralized Identifier parts

JSON-LD or JWT in a way that is **cryptographically secure, privacy respecting, and machine-verifiable**.

In the SSI EduWallets implementation it is used as an **educational verifiable credential**; this is a type of digital credential that represents an **individual's educational achievements**, qualifications, or accomplishments in a verifiable and tamper-resistant manner. It serves as a secure and portable proof of the person's educational history and can be shared with third parties.

Verifiable Credential schemas

Verifiable credentials schemas[12] are a standardized format or **data model** normally in a JSON-LD format used to **describe**, **define the constraints and structure of any verifiable credential type**.

SSI EduWallets define their own schema for the **user learning outcome verifiable credential** that was created, this schema is **based on the EBSI verifiable diploma schema[13]** in a simplified way, because none of the current definitions are standardized yet. So interoperability will be possible once the issuer is onboard on the EBSI ecosystem and the schema is published.

Verifiable Presentation (VP)

Verifiable presentations are **mechanisms like the verifiable credentials** (they are based on JSON-LD or JWT as well) in which the definition about the presentation, the **verifiable credentials** that will be verified, and the **sign and encryption** of the user will be stored.

The SSI EduWallets use verifiable presentations to **exchange verifiable credentials** from the user's wallets to the third parties. The verification of the verifiable credentials is out of the blockchain due the fact that EBSI is not publicly available yet.

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[12] Cohen, G. and Steele, O. (2023) *Verifiable credentials JSON schema specification*, *W3C*. Available at: https://www.w3.org/TR/vc-json-schema/ (last accessed: 09 August 2023)

[13] European Commission *Verifiable diploma schema*, *Verifiable Diploma Schema - EBSI Specifications -*. Available at: https://ec.europa.eu/digital-building-blocks/wikis/display/EBSIDOC/Verifiable+Diploma+Schema (last accessed: 09 August 2023).

European Blockchain Services Infrastructure (EBSI)

EBSI is an initiative of the European Union (EU) aimed at developing a **service infrastructure** based on **blockchain technology** to enhance and strengthen the delivery of public services throughout Europe.

SSI EduWallets seeks to leverage the EBSI ecosystem to perform all the operations related with the SSI paradigm.

European Learning Model[14] (ELM)

ELM is a **multilingual data model** providing a single vocabulary for the description of learning in Europe for Interoperability of Learning Opportunities, Qualifications, Accreditation and Credentials in Europe, developed by the European Commission.

Even though the ELM was created for the Europass Digital Credentials Infrastructure (EDCI)[15] use cases, SSI EduWallets, by defining the verifiable user learning outcomes and the schema that defines this VC, use a portion of **ELM v3**[16] (which was created based on the W3C standards for verifiable credentials to be interoperable) rather than the entire definition of attributes and properties to provide and describe the key data within the verifiable credential once a user has completed a course or exam.

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[14] European Commission (no date b) *Introduction to the european learning model (ELM)*, *ELM Browser*. Available at:
https://europa.eu/europass/elm-browser/index.html#introduction-to-the-european-learning-model-elm (last accessed: 09 August 2023).

[15] European Commission, *Europass Digital Credentials Infrastructure (EDCI),* Available at:
https://ec.europa.eu/futurium/en/system/files/ged/edci_presentation.pdf.

[16] Europass Learning Model *Upcoming launch of the European Learning Model V3: Europass*, *Upcoming launch of the European Learning Model v3 | Europass*. Edited by the European Commission. Available at:
https://europa.eu/europass/tr/news/upcoming-launch-european-learning-model-v3 (Accessed: 08 August 2023).

Qualification Metadata Schemata (QMS)

[Qualification Metadata Schemata (QMS)](#)[17] refers to a **standard structure** used to describe and represent **detailed information about a specific qualification**. This schema is commonly used in the context of Verifiable Credentials and other qualification management systems to provide additional details about a given qualification or competency. Within the QMS it is possible to use [European Skills, Competences, Qualifications and Occupations (ESCO)](#)[18] to describe what the user achieves once he/she completes a certain assessment.

The SSI EduWallets try to adapt and make use of this metadata schema in order to define a standard structure for classification of qualifications.

European Skills, Competences, Qualifications and Occupations (ESCO)

ESCO is the European multilingual classification of **Skills**, **Competences** and **Occupations**. ESCO works as a **dictionary,** describing, identifying and classifying professional occupations and skills relevant for the EU labor market and education and training.

The SSI EduWallets make use of the ESCO classifications in order to provide the skills and occupations that the users achieve once a course or assessment completion happens.

System components

SSI EduWallets is built by several software components, standards and protocols that allow the implementation of Web 3.0 features such as the SSI and the use of DIDs and VCs. The project stack is build upon the following components:

Wallets

Wallets are one of the three cornerstones of the SSI paradigm, these are applications that allow users to perform the **exchange of verifiable credentials** with the issuers and verifiers and **store** their verifiable digital credentials and decentralized identifiers that users must use to be

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[17] European Commission (2020) 'Publishing of Qualification and Learning Opportunity Data Documentation'.

[18] ESCO *About Esco, ESCO*. Edited by the European Commission. Available at: https://esco.ec.europa.eu/en/about-esco (last accessed: 08 August 2023).

compliant with the SSI EduWallets implementation. Those wallets are i.e. developed by third parties following European standards. The implementation of SSI EduWallets provides a web wallet that acts as a demo. It was also tested with another compliant wallet provider "ValidatedID[19]" for a "proof-of-concept" of a cross-device flow. Both use cases could be tested successfully, so that it was possible to perform the issuance flow.

Demo web wallet

It is a **demo** wallet application that simulates a real wallet workflow and runs based on the wallet kit API[20]. It was configured to perform a web wallet flow for performing the issuance and verification.

User Interface

The user interface is the part of the software that is responsible for graphically presenting an abstraction of the logic behind the implementation to users on the learning platforms that implement SSI EduWallets, and where users can interact directly with the implementation. The user interface is implemented based on several views in the frontend that **display the steps of issuing verifiable credentials and verify verifiable presentations**. This graphical framework makes requests to the different APIs to interact and exchange data.

Wallet Kit API

The Wallet Kit API is a third-party integration that is connected with the issuance & verifier APIs and it **is the core of the Web 3.0 & SSI stack** to perform all the operations related to the SSI paradigm and VCs. This API is responsible for DIDs creation, verifiable credential issuance, verifiable presentations, verifiable credential security, the exchange of verifiable credentials, and the demo web wallet.

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[19] ValidatedId *Validated ID - electronic signature and digital identity providers*, *Validated ID - Electronic Signature and Digital Identity Providers*. Available at: https://www.validatedid.com/en (last accessed: 08 August 2023).

[20] Walt.id, *Walt.id Wallet Kit*, *walt.id*. Available at: https://github.com/walt-id/waltid-walletkit (last accessed: 08 August 2023).

Issuer API

The issuer API is one of the three cornerstones of the SSI paradigm. This is the main component in charge of handling the user requests to start the verifiable credentials issuance flow and the communication with the wallet kit API (which performs the issuance process). This component must be implemented in each platform to **enable the issuance of verifiable credentials** to users using a compliant wallet. Once the issuer API is integrated in a platform, it can interact directly with the users' wallets and it interacts with the wallet kit API to issue an educational verifiable credential to the users of the platform, e.g. once they complete a course.

Verifier API

The verifier API is one of the three cornerstones of the SSI paradigm. This is the main component in charge of handling the user requests to create a verifiable presentation triggering the start of the verification flow and further on communicating with the wallet kit that performs the verification process. This component must be implemented within any platform to **allow the verification and validation of verifiable credentials** from the users using a compliant wallet. Once the verifier API is integrated in a platform, it can interact directly with the users and connects with the wallet kit API in order to verify if a verifiable credential is valid or not. As soon as the verification process is successful, the platform can use the released data of the verifiable credentials to perform further actions.

Implementation architecture

The implementation of SSI EduWallets is based on the integration of 5 key components.
WalletKIT API, Issuer API, Verifier API, issuance / verification UI & demo Web Wallet within a client's infrastructure such as an e-learning platform. These components are in charge of allowing a platform to **issue verifiable credentials & verify verifiable credentials** to/from users who use compatible wallets or within the demo web wallet. Once these software components are integrated, they will communicate and exchange information with the users' wallets through the OIDC4VC and SIOP protocols[21]. To integrate these components into an e-learning platform, a

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[21] Kristina Yasuda, Dr. Torsten Lodderstedt ,*OpenID Connect for SSI,* Available at: https://openid.net/wordpress-content/uploads/2021/09/OIDF_OIDC4SSI-Update_Kristina-Yasuda -Torsten-Lodderstedt.pdf

microservices-based architecture is provided to run and deploy these components using Kubernetes and Helm Chart.

The **issuance and verification UI** components can be integrated as a plugin into the front end of the client, from where platform users can interact with the SSI EduWallets implementation to graphically perform the operations associated with issuing and verifying verifiable credentials. These components make API calls to initiate the operations and establish communication between the platform and the user's wallet.

The **demo web wallet** is integrated into the client's platform by cloning the repository, deploying and running the front-end container that runs this web app. From this user interface, any user can use this demo as a custom web wallet that acts as a real web wallet to simulate the workflow of a web wallet with which it is possible to request verifiable credentials, create verifiable presentations, receive, store and manage verifiable credentials. This frontend makes API calls to perform all the operations related to the issuance, verification and storage of the verifiable credentials.

The integration of the **issuer and verifier APIs** into the client's platform is done by cloning the repositories and running the Kubernetes pod. These APIs are responsible for handling the user requests they enter through the issuance /verification UI to process and forward them to the wallet kit API.

The **wallet kit API** integration into the client's platform is performed by cloning the wallet kit repository, deploying and running the kubernetes pod, which is in charge of performing all the tasks related to the SSI and VCs workflow features like the DID generation, cryptography of the VCs, the exchange of VCs, the communication with EBSI ecosystem, issuance of VCs, reading the VPs, and the verification of VPs.

Since the issuance and verification processes can be implemented without any decentralized blockchain system, an **issuer and a user can generate their own DIDs, public and private keys through their wallets**. In case of using a blockchain ecosystem like EBSI, DIDs and key will need to be issued by the blockchain provider. For a "proof-of-concept" the method followed for the creation of DIDs is the "key"-method, which encodes the public key in the DID for the verification.

VPs are signed with the private key of both, the issuers of the VCs and the holder or presenter of the VP. Using the public key from the issuers and holder, the verifier is able to fully validate the custody chain for the hole VP.

In the SSI EduWallets implementation currently it is using the "key"-method because the EBSI ecosystem is not publicly available yet.

Work packages

Work package 1 - *<Project start>*

- **Start of the project.**

- **Assessment of the project** to begin planning & define the tasks to be carried out.

- **Development of a website to inform about the project.**

- **Creation of a blog** to summarize the creation process/objectives and the phases of the project.

This work package was developed without any deviations, the major achievements are the decomposition of the project into defined tasks.

Work package 2 - *<Requirements analysis, concept & design>*

- **Research about the Self-Sovereign Identity (SSI) paradigm in the context of web technologies.** How it works, Why to use SSI paradigm, advantages over the issuance of verifiable credentials.

- **Research about European Digital Identity wallets (EUDI) programme** and their current status & use cases for them. Future of the conformant wallets with the EU standards, review the scope of the project to unify different daily tasks in a single app following defined standards from the EU, focus on the issuance of verifiable diplomas to replace current titles.

- **Research about the European Self-Sovereign Identity Framework (ESSIF).** How ESSIF works, how to be conformant with the framework, which advantages ESSIF has, review the interoperability with other systems that follow this framework, privacy concerns.

- **Research about European Blockchain Service Infrastructure (EBSI) ecosystem,** How EBSI is implemented, which standards EBSI follow, how blockchain or Distributed Ledger Technologies (DLT) works out, how to be compliant with EBSI ecosystem, current status of EBSI, how EBSI is integrated to be use in a SSI wallet, why to use the EBSI ecosystem.

- **Research about the Decentralized Identifiers (DIDs) & Verifiable Credentials (VCs)** Standards that they follow from the W3C, How DIDs are generated, which different methods we have to create a DID, how DIDs are store and where, why the DIDs are essential in SSI, how DIDs can be resolve, which information the DID contains, which types of VCs exist, which standards the VCs follow, how VCs are generated, how VCs are secure & how VCs are signed to be tamper-proof, where VCs are store, how the VCs are shared.

- **Research about the current wallets** that are compliant with the ESSIF/EBSI ecosystem to implement a solution that leverages on them.

- **Research about the verifiable credential schemas** that exist or are defined by an authority, which types are defined in EBSI ecosystem, which fields are mandatory, how to create own schemas, how to use schemas to verify that the verifiable credentials are compliant with the chosen schema.

- **Research about pre-build wallet solutions** that follow ESSIF/EBSI ecosystem to make a test pilot and check if its possible to leverage on them.

- **Research the implementation of the SSI wallet** that allows verifiable credentials issuance, planning & design the architecture of the implementation.

The achievement on this work package was to gain knowledge about how the new paradigm of Web 3.0 fits in the current context to the status of the EUDI wallets program, how its implementation works and the architectural details behind it.

The major challenge of this work package was to research about a lot of different approaches and new concepts and unify them to understand how SSI and the architecture that composes it works. This work package was developed without any deviations from the initial planning.

Work package 3 - *<Infrastructure & setup>*

- **Setup of the SSI EduWallets architecture** Definition of the architecture that the project will follow, how the project will be implemented, which approach we follow (microservices or other).

- **Testing some use cases** for our proof of concept, what will be needed to perform verifiable credentials issuance, how the users are signed up in the platforms through an SSI wallet, how the platform can verify the verifiable credentials that the users send to / share with the platform.

- **Issue Verifiable Credentials** How it'll be issued, which steps are needed to issue a verifiable credential to a user, which fields are essential within verifiable credentials.

- **Verify Verifiable Credentials** How the verifiable credentials that the users share with the platform are verified, which steps are needed to verify a VC, what happens after the verification process finishes.

- **Setup a basic web interface** to create a test pilot of a real user claiming a verifiable credential to the platform.

- **Implementation of the endpoints** for the registration/login using a SSI wallet, issuance request, issuance of a verifiable credential, verifiable credential request, verification of verifiable credentials.

- **Setup of the hardware,** which hardware is needed and how it'll hold the API, how many resources are needed, which budget is needed, how it'll be configured.

The major challenge was to read and understand the documentation about how to implement the workflows with the SSI wallets to issue a signed credential and verify it. We were also trying to get access to the EBSI ecosystem to implement a holistic solution based on the EU infrastructure to be fully compliant with European Commission standards and ensure interoperability.

This work package was developed with some deviations to become compliant with the EBSI ecosystem. However, our request to the EU/EBSI team was not answered till project end.

Work package 4 - *<Prototype development>*

- **Implementation of writing the verifiable credentials** to the user's wallet, once the verifiable credential is created: how the exchange between platform (issuer) and the user (holder) is performed, how the user stores its verifiable credential in his/her wallet.

- **Implementation of the reading a verifiable credential** from a user's wallet, How the exchange process between user (holder) and the platform (issuer) is created, how the issuer API verify the verifiable credentials that the user share with the platforms, how the data of the verifiable credentials are manage inside the platforms

- **Documentation of the code** that we're implementing, how the wallet kit needs to be implemented in our ecosystem (PoC), which API calls are defined in the application, instructions on how to integrate the project in ecosystems.

- **Implementation of open API** to serve as an intermediary to communicate the user request with the platform and the issuer wallet.

- ~~**Implementation of authentication system** that allows users to signup and sign in on the platforms, integration of an IDP kit to allow users to perform those actions using an SSI wallet.~~ *Trustable Issuer needed to generate verifiableIDs (see "Suggestions for further developments by third parties")*

- **Build and link the whole SSI ecosystem** via open API and integrate the IDP API and SSI wallet API.

- ~~**Implementation of the EBSI onboarding** integrating the project with the EBSI ecosystem.~~ *No response from EBSI-team to take part in beta-wave (see "Suggestions for further developments by third parties")*

- **Implementation of UI components** to perform the actions of sign up / sign in, verifiable credentials issuance, and verification of verifiable credentials.

This work package was developed with some deviations while trying to integrate and obtain access to the pilot testing within the EBSI.

The major achievement was to perform the issuance and verification through an open API between the user and the issuer.

Work package 5 - *<Project management & documentation>*

- **Documentation and final report of the project.** Creation of a general documentation about the project and their features.

- **User documentation.** Creation of a user manual to introduce this target audience to the project, this documentation is an abstraction of the technical architecture of the project.

- **Developer documentation.** Creation of a developer manual to introduce this target audience to the implementation and integration of the project to convey details to be enabled to reuse the SSI approach.

- **Summarize report** creation of a short document to summarize the whole project.

- **QMS integration.** How to reuse the Qualification Metadata Schemata in context with wallets.

- **ESCO integration**. How to reuse the European Skills, Competency & Occupations Taxonomy in context with wallets.

- **Public relation report.** Creation of a public relation report.

- **Marketing.** Creation of a marketing report.

This work package was developed without any deviation.

Work package 6 - *<Quality management, IT compliance & data protection (guidelines)>*

- ~~**EBSI assessment.** Onboard to the EBSI ecosystem into the project and validate the data on the European Blockchain Services Infrastructure, compliance to their rules, regulations and standards.~~ *No response from EBSI-team to take part in beta-wave (see "Suggestions for further developments by third parties")*

- **Check the compliance of SSI & GDPR.** Review the compliance of the SSI paradigm and the GDPR to fulfill the current data protection laws in the scope of the European Union.

- **Evaluation of the European Learning Model (ELM)** Matching different data formats to be ELM and wallet kit compliant, compare differences between LOM (IEEE1484.12.1) with

Learning Opportunities Metadata Schema (LOMS), importance of EQR/QDR[22], compliance & structure of EU diplomas.

- **Evaluation of license models** to distribute the project under certain restrictions & requirements.

This work package was developed with some deviations while trying to integrate and obtain access to the pilot testing within the EBSI.

The major achievement was the successful assessment of the architecture & technical details of the EBSI ecosystem & its impact on GDPR compliance, as well as, identifying relevant ELM data models and their schemata in terms of compatibility.

Work package 7 - *<Documentation and formalities at the end of the project>*

- **Reports submission** of the project when it's finally finished.
- **Submission of all reports**
- **Bill/invoices submission**

This work package was developed without any deviation.

List of final project results

1	Interim Report	CC BY-SA 4.0	Interim report of the project in which the main functionalities and implementation are described.	https://www.netidee.at/ssi-eduwallets
2	Final Report	CC BY-SA 4.0	Final report of the project in which all the components, architecture and functionalities of the project are described.	https://www.netidee.at/ssi-eduwallets

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[22] European Commission (2020) 'Publishing of Qualification and Learning Opportunity Data Documentation'.

3	Developer Documentation	CC BY-SA 4.0	Technical documentation for developers.	https://www.netidee.at/ssi-eduwallets
4	User Manual	CC BY-SA 4.0	Non-technical documentation for end users.	https://www.netidee.at/ssi-eduwallets
5	One Pager	CC BY-SA 4.0	Project summary.	https://www.netidee.at/ssi-eduwallets
6	External Communication	see Final Report	Stakeholder communications.	https://www.netidee.at/ssi-eduwallets
7	SW project result part_1: Demo Application	MIT	Back-end and front-end for the issuer and verifier demo application.	https://gitlab.com/ssi-edu-wallets/demo-application
8	SW project result part_2: Wallet Proof of Concept	Apache License 2.0	An SSI web wallet front-end, leveraging the backend API	https://gitlab.com/ssi-edu-wallets/wallet-proof-of-concept
9	Verifiable Credentials, QMS & ELM	CC BY-SA 4.0	Documentation about Verifiable Credentials in context of the European Learning Model (ELM) and the Qualification Metadata Schemata (QMS).	https://www.netidee.at/ssi-eduwallets
10	ESCO API	CC BY-SA 4.0	Documentation about API integration of ESCO taxonomy provided by the European Commission.	https://www.netidee.at/ssi-eduwallets

Application of the project results in practice

The project results are intended to be used in the context of Learning Management Systems (LMS) or educational online platforms or environments (i.e. Learning Ecosystems). Documentations as well as public repositories provide a general introduction on how to set up a wallet architecture

based on the concepts of Self-Sovereign Identity (SSI). Our research also contains schemata layouts to be compliant to

- the European Learning Model (Europass / ELM) via Verifiable Credentials as well as
- the European Self Sovereign Identity Framework (ESSIF) and European Blockchain Service Infrastructure (EBSI)

Public Relations/ Networking

- We introduced parts of our research to the public at the LearnTec Congress in June 2023 in Karlsruhe for the first time (speaker slot).
- Our future goal is to spread the technology approach throughout Europe and to establish close links with government agencies - a process we have already started.

Own project website

- Website: https://join.courseticket.com/wallet

Planned activities after the end of the netidee project

- We plan to reach out to commercial partners & customers which are interested in integrating the EduWallet approach with us.
- Together with existing clients (e.g. Universities) we want to establish "best-practice" use cases to promote the EduWallet approach to the public.
- We will work on our main landing page (https://join.courseticket.com/wallet) and make more details & main code repositories available.
- We plan to advertise the landing page (https://join.courseticket.com/wallet) via SEM (Google Ads).

Suggestions for further developments by third parties

- EBSI integration: EBSI was not integrated due to lack of responsiveness from the EBSI group team providing any answer to our application (beta test, wave 3). The system should

be compatible with EBSI and integration should not be complex.

Prerequisite: EBSI is publicly available

● Signup authentication system: An OIDC workflow to exchange credentials between the wallets and 3rd party platforms was implemented. However, direct signup and sign-in of new users into 3rd party platforms using information from the wallet still needs to be developed. This implementation should be straightforward in a very similar way to the use cases already implemented within the project.

Prerequisite: It could be done as soon as there are trustable issuers, such as identity providers from different EU countries, that generate VerifiableIDs containing basic user data.