A Modular and Flexible Identity Management Architecture for National eID Solutions

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Abstract: Identification and authentication are essential processes in various areas of application where access to sensitive data needs to be protected and regulated. To achieve this, usually identity-management systems are put into place, where an identity provider manages digital identities and handles the identification and authentication process for a service provider, which hosts the protected data. Identity management is no new topic and hence several identity management systems have evolved over time. However, new rising requirements also demand modifications and improvements in the field of identity management. In particular, the need for exchanging or federating identities across domains or even borders requires new interoperable solutions and flexible identity management architectures. In this paper we present a flexible and modular identity management architecture which focuses on federation and interoperability capabilities based on plug-able components. Due to that, new arising requirements such as the support of different authentication protocols can be easily fulfilled by implementing appropriate plug-ins. Hence, our proposed architecture is especially applicable for high qualified identification systems such as national eIDs and their federation across borders. We further illustrate the applicability of our architecture by implementing it to be used as an identity provider for Austrian eGovernment applications, on the one side being applicable for national authentications and, on the other side, in a cross-border context.

1 INTRODUCTION

Electronic identity (eID) is indispensable for a variety of Internet services and online applications. Once the identity of communication entities is established with a level of certainty matching the value associated with the service, the communication partners can gain the confidence and trust needed for mutual transactions. Such transactions can include social network interactions, but also more security-sensitive services such as a tax declaration or an eHealth application that protects personal medical data. In each case, besides using an electronic identity authentication is additionally required to prove a claimed identity to be authentic. Consequently, this authentication step link the identity information to a person, which uses a PIN or password to proved that he or she is the owner of that identity information.

The more transactions are performed by using online applications processing sensitive data, the higher is the importance for a high level of assurance by secure means of authentication linked to qualified identity. eGovernment is such an area, where high assurance in the citizen's identity is needed. With respect to eGovernement, several countries have already developed and deployed electronic identity systems since the beginning of the 21st century. Given these identity systems were deployed about more than a decade ago and since they are still in operation, it is not too hard to guess that requirements on identity management solutions have changed over time and new technologies have emerged. Such technologies and requirements are not only things like new authentication protocols, which support a higher level of security, or new identification and authentication mechanisms, but moreover are requirements targeting usability, interoperability, or identity-management federations.

Particularly, identity-management federations such as nationally federated eID solutions or even cross-boarder eID federations became more and more important in the last couple of years. In the case of cross-boarder eID, the European Commission has recently published the EU regulation on Internal Market electronic identification and trust services (eIDAS)(European Union, 2014), which builds the

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legal framework for cross-border eID acceptance within the EU. However, the eIDAS regulation is currently only the latest step towards the implementation of a pan-European eID federation. The aim on cross-border eID recognition dates already back to 2005, as the aim was mentioned in the Manchester Ministerial Declaration(European Union, 2005), followed by the EU Service Directive (European Union, 2006) in 2006 and the eID large scale pilot projects STORK [1] and STORK 2.0[2], which is still running.

National eID systems have been deployed since nearly a decade. In order to meet these new or changed requirements on e.g. cross-border federation, an improved and enhanced architecture for identity-management systems is inevitable for meeting those requirements. Therefore, we present an improved identity-management architecture in this paper, which will meet current requirements and which is open to future extensions.

This paper is structured as follows. In Section 2 general requirements for identity-management solutions are defined. In Section 3, we describe related work and discuss it with respect to the defined requirements of Section 2. In Section 4, we propose an enhanced architecture of an identity-management system which is capable of meeting all the requirements. Afterwards, in Section 5 we demonstrate the practical applicability of our proposed identity-management architecture by implementing an identity provider for Austrian eGovernment applications supporting three main identity-management use cases. Finally, conclusions are drawn in Section 6.

2 REQUIREMENTS

Identification and authentication are by far no new issues, thus several different identity-management systems have already evolved (Bauer et al., 2005). In most of these identity-management systems, user identification and authentication are handled by an identity provider, which finally transfers the user information and authentication data to the service provider. Based on these information and data, the service provider is able to decide whether to grant or deny access to its protected resources. Consequently, the identity provider constitutes a very important entity within an identity-management system. Especially if the service provider is a public-sector application providing eHealth or eGovernment services, the support of qualified citizen identification and secure authentication by the identity provider is essential. Hence, such an identity provider needs to fulfill certain requirements to meet the high level of assurance and security required by public-sector applications. For that reason, the following requirements should be fulfilled and kept in mind, if an identity provider for public-sector applications is designed.

- **Security:** An identity provider for public-sector applications is typically used in a security-sensitive area, which handles with highly personal date, like medical information. Public-sector applications require a highly secure identification and authentication process to protect these confidential and sensitive data against unauthorized access. Furthermore, a public-sector identity provider needs to be resistant against attacks that threaten to illegally influence the identification or authentication result.
- **Reliability and Testability:** Service providers that make use of the identity provider must be able to rely on the results of the identification and authentication processes carried out by the identity provider. In addition, it should be possible for the service provider to test and validate the authentication information to check if the information was provided from a trusted identity provider and not from a attacker.
- **Flexibility:** From a service provider's point of view, an identity provider should be able to provide different standardized interfaces for service-provider communication, to offer a wide range of possible connection scenarios. Therefore, flexibility with respect to service providers can reduce the deployment costs for them. From a citizen's point of view, an identity provider should provide different identification and authentication methods, in order to being able to support a large number of users and to enable a simple usage of different secure tokens.
- **Interoperability:** An identity provider should be work interoperable with other architectures, e.g. if the communication with other identity-management systems is necessary. The requirement of interoperability increases because the interconnection of heterogeneous identity management systems is important for identity federation. Especially, this requirement is important for cross-border acceptance of identity-management solutions and to interconnect national eID systems, like a pan-European eID federation.
- **Adaptability:** In many countries national legal requirements or eID solutions serving domestic

[1] https://www.eid-stork.eu/

[2] https://www.eid-stork2.eu/

needs exist, which an identity provider has to comply with. Such solutions – which cannot be implemented by generic standards – could be a special secure token or a proprietary national infrastructure. Therefore, an identity provider supporting public-sector applications needs to build on an adaptable framework to fulfill national characteristics and to support proprietary protocols or architectures.

- **Easy-to-Use Technology:** The usage of an secure identification and authentication process should not impede usability and accessibility for both citizens and service providers. Therefore, an identity provider should provide a recognizable user interface and enable a safe and known usage with this security-relevant application. Furthermore, this requirement covers several more aspects such as hiding complexity for service providers or platform independence to reduce deployment costs.
- **Modularity:** An identity provider should have a modular architecture, because modularity is in line with flexibility and interoperability. Therefore, a modular architecture facilitates the implementation of new functionalities to meet new requirements with respect to interoperability, standardized interfaces, or new identification or authentication methods.

There exists some other works, which handles with requirements for identity management systems (Kölsch et al., 2011; Ferdous and Poet, 2012). Therefore, we use requirements of this related work in combination with our own experience to defined a non-exhaustive enumeration of requirements. This defined requirements are rather generic to be not bound to a special national identity-management system. In the next section, available identity-management systems are surveyed and their capabilities to meet the above defined requirements are assessed.

3 RELATED WORK

Numerous identity-management initiatives and systems exist, therefore we will briefly introduce a couple of systems that gained importance either due to their broad use, or as they established relevant standards.

First systems used simple directory based solutions, like LDAP (Lightweight Directory Access Protocol), to perform identity management for single organisations. Since the borders between organisations decrease, interoperable identity-management becomes more and more important. In order to manage this, identity management has to be dynamic and adaptable in different and more complex situations to handle more then one specific context. This resulted in more adaptable solutions, like Kerberos (Neuman et al., 2005), which is one of the earliest systems that allows secure authentication in unsecure TCP/IP networks.

With the increasing popularity of the World Wide Web, more sophisticated identity-management solutions, which allow secure authentication on application level, became popular. Therefore, within the Web new identity-management systems emerged, such as Shibboleth[3] or the Kantara initiative[4] (formerly the Liberty Alliance Project). Both projects influenced the development of the current version of the Security Assertion Markup Language (SAML 2.0) (Lockhart and Campbell, 2008). SAML has been developed by OASIS and defines one of the most important standards dealing with Single Sign-On or identity federation. A similar framework constitutes WS-Federation (Kaler and McIntosh, 2009), being part of the WS-Security (Nadalin et al., 2006) framework. Another decentralized authentication system on the Web defines OpenID[5].

All above mentioned identity-management solutions could be used to perform a secure identification and authentication process, but most of them are limited to a single or few authentication protocols or standardized interfaces, which are used for service provider communication. Another issue is that they may not meet national legal requirements for qualified identification or authentication in security-sensitive areas of application as those identity-management systems have been designed generic. For instance, several countries use proprietary protocols or special eID infrastructures, like electronic mandate services for example, which can be used to add additional information to an authentication process. Furthermore, interoperability and federation with other eID solutions gains importance. While some of the previously described identity-management systems support federation, this is only possible when interconnecting systems with the same basic architecture or underlying protocol. However, currently used national eID systems have a heterogeneous structure, which means that different communication and variegated implementations are in use which hinder interoperability and identity federation.

In summary, there is currently no perfect solution available, which directly is able to fulfill all requirements stated in Section 2. To overcome this problem,

[3] http://shibboleth.net/

[4] http://kantarainitiative.org/

[5] http://openid.net/

we propose an enhanced and flexible architecture for identity-management systems using the example of an Austrian identity provider. The architectural design of the proposed solution is presented in the next section.

4 ARCHITECTURAL DESIGN

The proposed solution of an advanced identity provider is based on a sophisticated modular architecture to satisfy the identified requirements. Figure 1 illustrates our proposal for a modular and adaptable architecture for an Austrian identity provider, which can be used for public and private sector applications authentication. Therefore, our architectural solution could not only be used in eGovernment applications (public sector), but also are for a highly secure authentication on commercial applications (private sector), like a social network or an online shop.

The key component of the solution is the *Core Logic*, which coordinates the different steps of an identification and authentication process. An identification and authentication process can be divided into different phases. To better illustrate the features of the architecture, we will describe it using the example of a generic identification and authentication process. This generic identification and authentication process describes the components and modules of our proposed solution on architecture level, but does not include every single communication step between the user's browser and the identity provider, service provider or other involved entities.

In the first phase, the authentication process is initiated by a communication between the application and the identity provider via a well defined authentication protocol. This communication task is accomplished by the *Protocol Adapter Engine*. For each supported authentication protocol, an appropriate *Protocol Plug-in* can be implemented. This modular Protocol Plug-in approach allows the usage of protocols which are concerted to every single application with respect to protocol security and the required scope of operation. Such protocols could be SAML 2.0, which is widely in use, OpenID Connect (Sakimura et al., 2014), SAML 1.1 (Maler et al., 2003) or a national protocol, like the Austrian PVP 2.1 protocol (Rainer et al., 2014), for example.

In the second phase, a user could select the authentication method, which he or she wants to use, if the identity provider supports more the one identification and authentication solutions. This task is carried out by a *Template Generator*, which generates a specific HTML Web interface providing the appropriate user interface depending on the selected authentication method. Every Web interface is generated dynamically depending on actually supported Authentication Plug-ins and application-specific information. This dynamically generated Web interface satisfies the requirement of an Easy-to-Use technology, because it provides a uniform interface to enable a safe and known usage of this security-relevant process step.

The third phase performs the technical identification and authentication operations. Our solution supports different high secure identification and authentication methods, which are collected and handled by an *Authentication Source Engine*. An identification or authentication step is realized as a single Plug-in. Such Plug-ins implement the communication with a secure token, like a smart-card, a hardware security-module (HSM), or the communication with another identity-management system, by using a well-defined interface, like STORK for example. A *Process Flow Engine* combines the single Plug-ins and these functionality to a well defined identification and authentication process flow. Every process flow, which is offered by the Process Flow Engine, is specified in a XML based configuration file by using an expression language. This expression language can be used to define single identification or authentication task, transactions between single tasks, and conditions for every transaction.

An additional *Attribute Engine* can be used in a fourth phase. This Attribute Engine manages *Attribute Provider Plug-ins*, which can be used to collect additional authentication attributes. Such attributes could be an electronic mandate in case of an authentication on behalf of somebody or other information collected from a national register, like the Austrian *Source-Pin Register*, which could be used to receive an additional unique identifier for this user.

In the last phase, the collected authentication information is processed to generate an authentication protocol specific authentication token, which is transmitted to the application by using a Protocol Plug-in. This modular approach allows the definition of various slightly different identification and authentication processes which satisfy the requirement of every application.

An additional feature of our architecture is a generic interface, which can be used to add new functionality to the Core Logic. The generic interface also uses Plug-ins to add new features to the core functionality. Such Plug-ins could implement features like Single Sign-On methods, monitoring and testing functionality, or a plug-in, which collects anonymised statistics information for quality assurance. To ful-

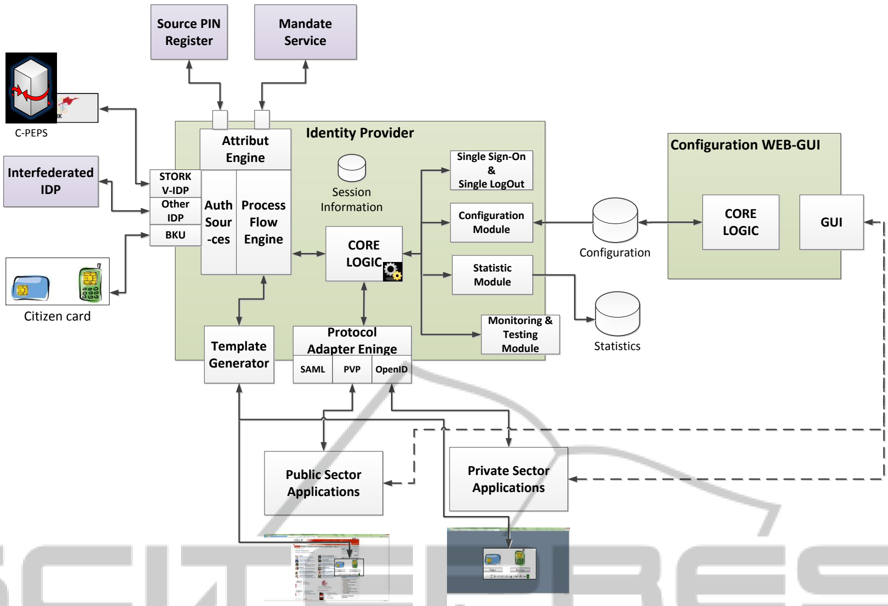


Figure 1: Enhanced architecture of the Austrian public sector identity provider.

fill the requirement of an Easy-to-Use technology, a Web based management application, which provides a graphical interface to application administrators, can be used to configure the identity provider.

5 IMPLEMENTATION

The practical applicability of the proposed architectural design has been evaluated by realizing and implementing an identity provider in practice. To illustrate that, we have implemented an identity provider for Austrian eGovernment applications. Our implementation is based on Java, thus achieving platform independence and an easy deployment on heterogeneous server infrastructures. The next sub-sections discuss three practical use cases and their implementation by using our architecture in more detail.

5.1 Use Case 1: Austrian Citizen Authenticating at an Austrian Service Provider

In Austria, unique citizen identification and secure authentication is based on the technology-neutral concept of the Austria citizen card (Leitold et al., 2002). Currently, the Austrian citizen card is implemented as a client-side approach using smart cards and as a server-side approach involving the citizen's cell phone. Unique identification of a citizen is done by using a special XML data structure which is stored on the citizen card. Authentication is based by the creation of a qualified electronic signature. Since the Austrian citizen card is the official eID in Austria, a basic functional requirement of an Austrian identity provider is the support of the Austrian citizen card. Figure 2 illustrates the involved entities and their interactions in case of an identification and authentication process.

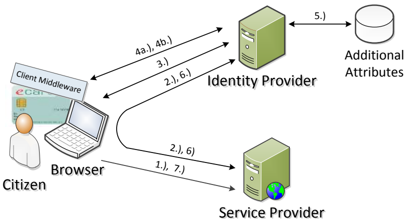


Figure 2: Involved entities in an identification and authentication process in Austria.

According to Figure 2, the process of identification and authentication involves the following steps:

1. A citizen wants to access a protected area on a service provider, by using a HTTP GET or HTTP POST request. This area requires citizen card authentication.
2. Therefore, the service provider starts an authentication process by triggering the identity provider. The identity provider is triggered by the service provider, which sending an authentication request via a specified authentication protocol. Most authentication protocols use HTTP POST or an HTTP Redirect with GET parameters to send an

authentication request from service provider to identity provider via the user's browser. To fulfill the requirements of flexibility and interoperability and to support service providers, which use a diversified set of software implementations, our practical solution implements different authentication protocol plug-ins and hence is able to receive authentication request using different protocol formats. Actually, we implemented four protocol plug-ins to support SAML 2.0, OpenID Connect (Sakimura et al., 2014), the Austrian-specific PVP 2.1 S-Profile (Rainer et al., 2014) and SAML 1.0[6] (Maler et al., 2003)

3. After the authentication request has been processed by the identity provider, the identity provider asks the citizen to select her preferred authentication method. Therefore, the Template Generator module, which is part of the identity provider, generates a web form to illustrate the different authentication solutions, which are supported by the identity provider. For Austria as example, a smart card based solution and a mobile phone based solution exists. After the citizen has selected the preferred solution, the identification and authentication process is started.
4. The proper identification and authentication process is performed by the Process Flow Engine in combination with the Authentication plug-ins. We have implemented different Authentication plug-ins to realize different processes for citizen identification and authentication. In the following two sub-steps, we describe the process, which uses the Austrian citizen card for this purpose, as an example. Therefore, a client middleware, which is just a piece of software (either installed on the citizen's PC or hosted on a server), facilitating access to the underlying citizen card implementation. In this example, a server hosted solution is used to deploy a JAVA Applet based client middleware in the citizens browser (Orthacker and Zefferer, 2011).
   (a) First, the identity provider identifies the citizen by using the XML data structure from the citizen card through the client middleware. This corresponds to the identification step. The corresponding plug-in implements the communication with the middleware and verification of the XML data structure, which comprises citizen identification information.
   (b) Second, the identity provider requests the citizen, via the client middleware, to create a qualified electronic signature for authentication. This task is also realized as a plug-in which implements the task specific communication and validation operations. Especially, validation is important to comply with the high security requirements for eGovnernment applications. Therefore, the electronic signature must be verified by the plug-in involving appropriate certificate revocation mechanisms, for example.
5. After identification and authentication are completed, the identity provider could use the Attribute Engine to collect additional authentication information of the citizen. Such additional information could be electronic mandates, for example, which are often used in Austria (Rössler et al., 2006). In our architecture, such additional information can be easily added to the authentication process by realization of an Attribute Engine plug-in. Therefore, we implement the communication with the Austrian electronic mandate service by using the Attribute Engine functionality.
6. If all authentication information is collected properly, the identity provider generates a protocol specific data structure. This data structure includes all authentication information that the service provider has requested and is transferred to the service provider.
7. Based on the received authentication information, the service provider is able to provide the protected resource to the citizen.

5.2 Use Case 2: Identity Federation

This scenario covers the case, where authentication information should be transferred from one identity provider to another identity provider. Such functionality brings considerable advantages to heterogeneous service models, in which service providers are linked to differed identity providers. Such advantages, for example are federated single sign-on (SSO) or interaction of identity providers which implements different identification and authentication methods. Figure 3 illustrates the actors and their relations in a federated service model. In this use case, every service provider is registered at a specific identity provider, similar to Use Case 1 described in Section 5.1, but in this use case there is the possibility of an authentication data transfer between the individual identity providers. To transfer the authentication data between the concerned identity providers, a secure and trusted communication channel has to be established. We use the SAML 2.0 protocol to establish a trustworthy

[6] In Austria, SAML 1.0 is widely used as legacy protocol by existing service providers.

communication channel by using the SAML2 Web-SSO Profile (Hughes et al., 2005) and an exchange of SAML2 metadata (Cantor et al., 2005). An advantage of this solution is a high interoperability with other identity-management systems or identity provider implementations, because SAML2 is supported by almost all identity management solutions.

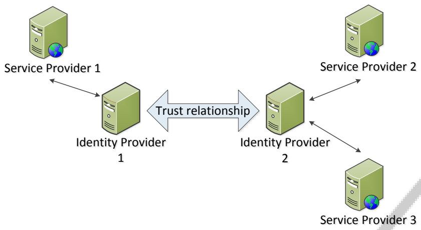


Figure 3: Overview - Identity federation.

This functionality brings a lot of advantages for citizens and service providers. In the Austrian eGovernment, there actually exists practical applications for such an identity federation. We will present two of these applications next, one for citizens and one for employees of a public authority.

5.2.1 Federated Single Sign-On (SSO)

eGovernment applications in Austria use a decentralized identity management approach, which means that service providers deploy there own identity provider for authentication locally in their service provider domain. This decentralized approach has advantages in case of availability and scalability but it is difficult to provide modern user-friendly functionality, like single sign-on for example. To overcome this disadvantage, we implement a single sign-on federation mechanism. Figure 4 illustrates such an application scenario graphically.

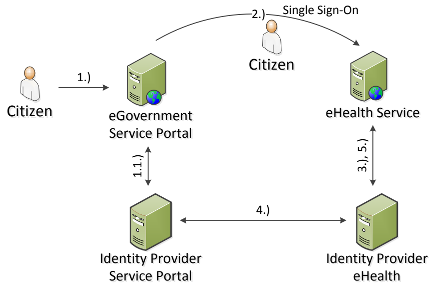

2.)
Single Sign-On
Citizen
1.)
Citizen
eGovernment Service Portal
eHealth Service
1.1.)
3.), 5.)
4.)
Identity Provider Service Portal
Identity Provider eHealth

Figure 4: Federated Single Sign-On for citizens

According to Figure 4, the login process for federated single sign-on involves the following steps:

1. The citizen authenticates a single sign-on session on an *eGovernment Service Portal* by using the identity provider, which is dedicated to this application. This service portal could be a One-Stop-Shop for different eGovernmant applications, like an *eHealth Service* for example.
2. Second, the citizen wants to use an eHealth Service, which operates as a self-contained web application. For this purpose, the citizen clicks a link in the service portal which starts an identification and authentication process on the eHealth Service. This link URL include the information of a possible active SSO session on the service portal IDP as a HTTP GET parameter, which contains a unique identifier for the service provider IDP.
3. The eHealth Service requests authentication from its dedicated identity provider, but in contrast to Use Case 5.1 the information of an active SSO session at the Service Portal identity provider is provided.
4. If an active SSO session information is received, the identity provider starts an authentication process at the declared identity provider and requests all information, which the eHealth service needs. The SAML2 WebSSO Profile is used to transfer authentication data between the identity providers in an encrypted way. The encryption keys are shared by using the information in SAML2 metadata, which are provided from each IDP. After successful authentication at the declared identity provider, the authentication information is transmitted to the eHealth identity provider.
5. At last, the eHealth identity provider could generate an eHealth Service specific authentication protocol response and transmit it to the eHealth Service.

By using our federated solution, it is possible to combine the user-friendliness of single sign-on solutions with the availability of decentralized services. Additionally, this solution requires no service-provider modifications because all functionality can be implemented on identity provider side.

5.2.2 Public-Authority Network Gateway

eGovernment services are not only used by citizens, they are also used by public officials during there occupation in public administrations. Such public administrations are carried out from a private government network on public eGovernment services. However, such administrative operations often require extensive privileges or additional attributes for security reasons. Figure 5 shows this use case in a graphical example. In this example, a public official would use an eHealth Service as part of his work as a civil servant. Here, the public official could be identified and authenticated in the secure private network area and maybe some additional information attributes could be collected. After this, he could be authenticated as a civil servant at the eHealth service without full re-authentication on the eHealth identity provider, by using identity federation. An advantage of this solution is that there is no adjustment at the eHealth service necessary because the functionality for public officials is encapsulated in the identity provider functionality and can be also used for other services providers.

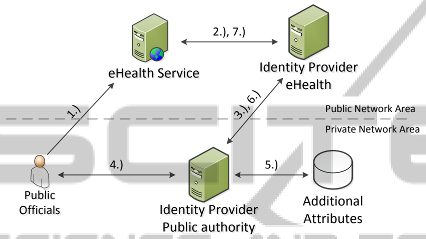


Figure 5: Authentication of public officials on public eGovernment applications.

Both application scenarios can be implemented easily by using our architectural design and actually there is a trial period for establishment in Austrian eGovernement applications.

5.3 Use Case 3: European Citizen with European Service Provider

The third use case tackles the requirement of a secure and seamless cross-border electronic identification, which is part of the European eIDAS regulation or the STORK 2.0 large scale pilot (Leitold et al., 2014). Due the mobility of citizens, cross-border interoperability of national electronic identity systems in the European eID landscape has become more and more important in the last couple of years. Actually, every EU member state has implemented its own identity management service infrastructure. This circumstance leads to a heterogeneous environment when these individual solutions should be coupled to a cross-border electronic identification solution. The STORK large scale pilots treated with an interoperability framework, which can be used to couple different national eID solutions.

The STORK interoperability framework defines two different models, which can be used to build up an interoperability layer between national eID solutions. These models are the Pan European Proxy Service (PEPS) model, which is shown in Figure 6(a) and the middleware (MW) model illustrated in Figure 6(b) (Zwattendorfer et al., 2013).

The PEPS model uses a proxy-based approach to encapsulate specifics of the national eID infrastructure. In this model, a PEPS is a national gateway and a single point of service for other countries, which implements the cross-border authentication functionality. In contrast to the PEPS model, in the middleware model citizens are directly authenticated at the service provider. Therefore, the service provider has to deploy a so-called V-IDP in the service provider infrastructure. This V-IDP is the server-side middleware, which provides all necessary functionality for citizen identification and authentication. Actually, STORK implements both models and all possible combinations between them because there are advantages and drawbacks in both interoperability framework models. (Zwattendorfer et al., 2013).

Therefore, we implement a solution for our Austrian identity provider, which can be used in both models in order to enable the widest possible utilisation. From a national point of view, the implemented functionality can be separated into two process flows.

5.3.1 European eID to National Service Provider Flow

This process flow covers the case in which a European citizen, which does not have an Austrian eID, should be identified and authenticated to use an Austrian service provider. Therefore, we implement an authentication plug-in, which offers all functionality for PEPS communication to support the PEPS model, and functionality to identify and authenticate foreign citizens directly, which is identical to the middleware model. This direct identification and authentication is actually implemented for some European member states. Additionally, a mapping from European authentication information to national authentication information is required to fulfill Austrian legal requirements and to provide all necessary information to Austrian service providers (Stranacher, 2010).

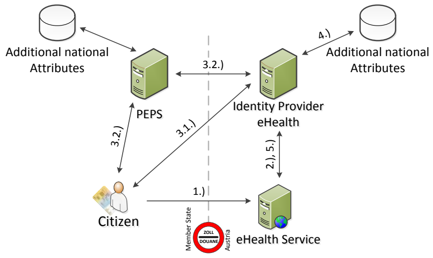
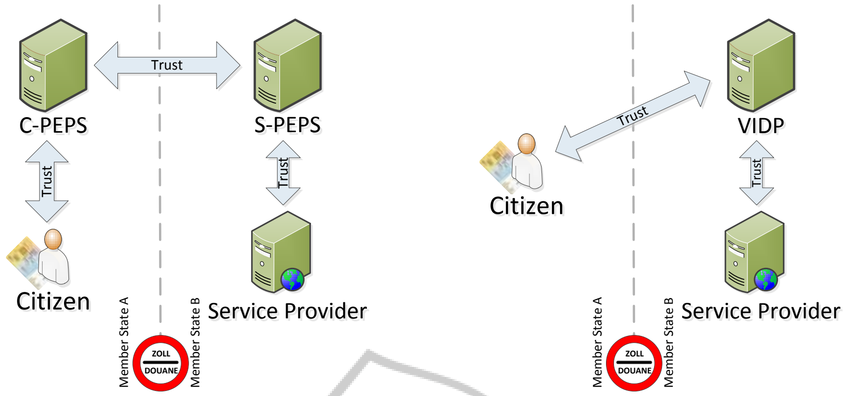


Figure 7: Process flow to authenticate an European citizen at an Austrian service provider.

Figure 7 illustrates this inbound process flow.



(a) STORK - PEPS Model. (b) STORK - Middleware Model.

Figure 6: STORK interoperability framework models

1. A citizen of a member state wants to access a protected area at an Austrian service provider.

2. The citizen is redirected to the identity provider and there the citizen has to select the his or her favourite identification and authentication model.

3. After selection, one of the following solutions is performed.

   (a) **Middleware Model:** In this case, the identification and authentication process is performed at the Austrian identity provider by using the citizen's secure token directly. Consequently, only information that can be provided by the secure token can be used for identification and authentication.

   (b) **PEPS Model:** In this case, the citizen is redirected to the PEPS in the citizen's member state and there the identification and authentication process is performed. By using this model, some additional attributes could also be provided by using member state attribute infrastructure, which is connected to the PEPS. Afterwards, the authentication information is returned by using the STORK communication protocol.

4. To fulfill Austrian legal and technical requirements, the authentication data has to be processed by the Austrian identity provider. Therefore, we use the attribute plug-in functionality of our architecture to implement a register query plug-in, which uses the Austrian attribute mapping service to fulfill these legal and technical requirements.

5. At last, the authentication information is transmitted to the Austrian service provider and the citizen can access the protected resource.

5.3.2 National eID to European Service Provider Flow

The second process flow characterises the identification and authentication of an Austrian citizen to access protected resources at a European service provider. To perform this assignment, we implemented a new protocol plug-in, according to our architecture, which implements the STORK communication protocol for service provider communication. Therefore, this protocol plug-in can be used to authenticate an Austrian citizen by using his secure token.

If our solution is deployed as a single point of contact in Austria (C-PEPS) according to the PEPS model (see 6(a)), then the member state service provider and the intermediate service provider PEPS (S-PEPS) can use the functionality of our identity provider just like an Austrian service provider can do. In this case all national legal requirements for additional attribute consuming, like the usage of electronic mandates, can be easily fulfilled.

The situation is different if the middleware model is used and our identity provider is deployed as a V-IDP which operates in the service provider infrastructure outside of Austria, because some national legal requirements cannot be achieved directly in this deployment situation. This circumstances affect mainly the attribute plug-ins, which are used to provide additional information after identification and authentication steps. In order to solve this problem, we benefit from our modular architecture design because the affected plug-ins can be easily replaced by a modified implementation, which are used in case of V-IDP deployment.

Figure 8 illustrates this deployment, in which a modified attribute plug-in for electronic mandate collection is used, as example. In contrast to the PEPS

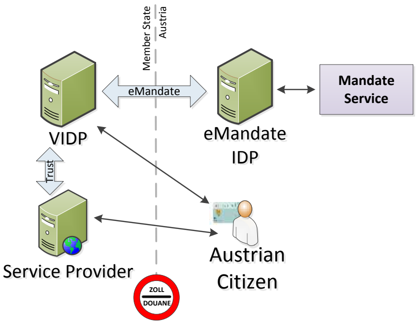


Figure 8: Our IDP solution used as V-IDP with modified attribute plug-in.

deployment, a request to the Austrian infrastructure is only necessary if requested authentication information cannot be provided by the V-IDP directly. The advantage of this solution is obtained by combining the benefits of the middleware model with the entire functionality of an Austrian identity provider.

By combining the inbound and outbound process flow, our solution can also be used to authenticate an European citizen to an European service provider. According to this, our implemented solution is also directly usable in other European states and not only in the Austrian national eID infrastructure.

6 CONCLUSIONS

Identification and authentication of citizens is an integral component for a variety of Internet services and online applications. The capability for secure and reliably identification and authentication according to national legal requirements is important for service providers, which process private and individual-related data, like eGovernment applications. In this paper, we have presented a new architecture for identity-management systems, to provide a flexible, interoperable and easy-to-use identity provider for service provider identification and authentication. Our solution relies on an adaptable and modular architecture that facilitates future extensions. Although the presented solution has been developed to meet special requirements of the Austrian eID infrastructure and Austrian legal requirements, its general architectural design and implementation is also applicable in other contexts.

We have demonstrated the practical applicability and flexibility of the architectural design by implementing solutions for different use cases, which need to be covered by an Austrian identity provider. These use cases cover the use of the presented solution to identify and authenticate Austrian citizens and public officials in various ways and assure interoperability of our solution in a European context. Actually, the practical implementation of use case 1 is used for productive applications in the Austrian eGovernment. The implementation of the use cases 2 and 3 are actually evaluated in different national and European pilot programs. The realization of further use cases or additional functionality, like two-factor authentication in case of single sign-on, that make use of the presented architecture is regarded as future work.

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