

An Electronic-signature Based Circular Resolution Database System

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ABSTRACT

Secure and efficient decision making processes are of particular importance especially for small and medium-sized enterprises. In this context, delocalization of responsible decision makers often leads to decision making processes relying on circular resolutions. Although circular resolutions based on written consent are usually efficiently manageable for a limited number of decision makers, involving a potential large number of persons inevitably complicates these processes in practice.

In this paper, a circular resolution database system that addresses this problem is introduced. Our solution, which is based on the Austrian citizen card concept, makes use of qualified electronic signatures that provide means for secure authentication of users as well as for electronic signing of digital documents. By enhancing decision making processes in terms of security, usability, and effectiveness while assuring auditing acceptability, the presented circular resolution database system especially contributes to the future competitiveness of small and medium-sized enterprises.

Categories and Subject Descriptors

H.4.1 [Information Systems]: Information Systems Applications
– Office Automation – *Workflow management*.

General Terms

Reliability, Security

Keywords

Qualified electronic signature, circular resolution, decision making, Austrian citizen card, business workflow, electronic document, non-repudiation, integrity

1. INTRODUCTION

In particular small and medium-sized enterprises (SMEs) benefit from carrying out decision making processes as efficiently as possible. Depending on the corporate structure and defined policies of the organization, making a decision usually requires

the written consent of several responsible decision makers. Due to common practice, organizations and companies are commonly organized in a decentralized way and are often spread over several separated locations. Therefore, responsible decision makers are regularly not able to meet face-to-face on a daily basis and decision making processes get complicated and slowed down as written consent cannot be instantly given.

Accepting the challenge of locally dispersed activity areas of responsible decision makers, circular resolutions provide efficient means to carry out decision making processes. Following the circular resolution approach, the particular decision to be made is written down in a document. This document is sequentially sent to all decision makers in order to enable them to give their written consent on the respective decision.

In this paper, an improved approach for the processing of circular resolutions based on qualified electronic signatures is presented. Relying on the Austrian citizen card concept, which has been introduced by Leitold et al. [1], the entire decision making process through circular resolutions is significantly enhanced in terms of processing time, usability, and security. Qualified electronic signatures, being the enabler technology of the proposed solution, are the digital equivalent to handwritten signatures. Legal equivalence is provided by national signature acts (e.g. the Austrian Federal Act on Electronic Signatures [16]) and the European Signature Directive [17].

The Austrian citizen card, which is used for the creation of electronic signatures, can basically be regarded as an electronic ID for use on the Internet. Although the eID is denoted “card” the underlying concept does not necessarily depend on smart cards. Any token allowing the creation of electronic signatures and providing storage for data can be set up as citizen card. The independence from certain kinds of technology is one of the greatest strength of the concept paving the way for special USB tokens as well as for cell phones and last but not least for smart cards. Although there are many conceivable types of implementations, the smart card type is very common in Austria. This is due to the fact that the national health insurance card, which has been rolled out countrywide, as well as many debit cards can be registered as citizen card. This enables each citizen to perform administrative procedures and to conduct electronic signatures over the Internet using solutions like the one proposed in this paper.

The citizen card concept basically provides two central features, namely identification and electronic signature. Identification is achieved by a special signed record called “identity link”. This record securely binds the token (e.g. the smart card) to the

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respective person by linking it with the person's unique identifier, which is issued by the Austrian Data Protection Commission. Electronic signature is based on qualified electronic certificates allowing citizens to conduct signatures that are legally regarded equal to handwritten signatures.

Applications making use of the citizen card concept for identification and signature do not need to directly address each conceivable type of implementation. For this purpose, an XML based interface has been designed. This interface, which is technologically independent from the client application, from the type of token being used, and from the cryptographic algorithms that are applied, encapsulates access to functions for identification and electronic signature. Using this approach, a maximum of interoperability is gained.

By relying on the Austrian citizen card concept, our solution benefits from the high level of security and interoperability provided by this technology and from consequent use of cryptographic functions both for authentication to the system and for signing documents.

In the remainder of this paper, the proposed electronic-signature based circular resolution database system (RDS) is introduced in detail. Section 2 illustrates basic problems being addressed by our solution and introduces core concepts of our implementation. Additionally, Section 3 gives an overview of already existing solutions and points out main differences to our approach. Subsequently, our proposed circular resolution database system is presented in Section 4 by introducing its basic building blocks and core functionality. Thereupon, practical experiences that have been gained from more than one year of productive operation are presented in Section 5. Finally, Section 6 concludes this paper by pointing out its central facts and findings.

2. CORE CONCEPTS

In order to become aware of the problem that is addressed by our solution, this section provides an illustrative example and introduces core concepts of the proposed system.

Consider the following scenario: a department of an enterprise identifies a new challenge and aims to start a respective project as soon as possible in order to be in advance of other competitors. Because of the financial volume of the planned project, the written consent of the company's executive board members is required. Since some decision makers are currently away on business trips, the executive board cannot meet face-to-face to make the required pending decision.

Therefore, following the circular resolution approach, the leader of the respective department creates an appropriate resolution document, which authorizes the start of the project. This document is sent to the first member of the executive board, for instance electronically via e-mail. Upon reception of the resolution, the respective board member signs the document and forwards it to the next designated signer, who proceeds with the obtained document in the same way. Finally, when all board members have accordingly signed the resolution, the final document is published to the leader of the department, who is thereby authorized to start the project.

Depending on the number of designated signers and the time it takes each signer to manually process the resolution the overall procedure can become very time-consuming. This, in turn, may

cause a delay of other urgent activities and finally may lead to disadvantages in terms of competitiveness.

Further problems with this commonly used approach are possible due to the lack of a central instance of the processed resolution. This may result in an impossibility to apply reliable backup mechanisms and to preserve auditing acceptability during the entire decision making process. Furthermore, the manual forwarding of documents is a potential source of errors, in case the entire procedure is not well defined or followed properly by all users.

Application of the proposed RDS eases the processing of circular resolutions. Using our solution, the leader of a company's department is able to securely log-on to the system using the personal citizen card and to dynamically create a digital document containing a resolution with all required facts. After completion of the document creation process, the resulting resolution is stored in a securely protected central database. All members of the executive board, who are required to give their written consent to the resolution, are automatically notified by e-mail. Subsequently, each executive board member is able to authenticate to the system, review the newly created resolution, and sign it using the personal citizen card. As soon as all intended recipients have processed the resolution appropriately, the document is immediately published and made available to all authorized users.

Due to the centralized approach, no local copies of the documents to be signed have to be exchanged manually between signatories any more. This allows a central maintenance and guarantees auditing acceptability of all resolutions. Furthermore, by integrating qualified electronic signatures into the decision making process, the proposed solution, which is described in the remainder of this paper in more detail, improves security, usability, and efficiency of the entire decision making process.

3. RELATED ELECTRONIC-SIGNATURE BASED SOLUTIONS

The electronic-signature based circular RDS introduced in this paper basically comprises the core features "document creation", "document processing", and "publishing of documents". Therefore, our solution can be classified as special form of a document management system (DMS). Since integration of electronic signatures into existing document management systems is not an entirely new topic, this section provides an overview of currently available DMS with integrated support for electronic signatures. It also shows how our circular RDS differs from those solutions and illustrates how users and enterprises can benefit from the proposed system.

While document management systems have a relatively long tradition and already play an important role in many companies and organizations, the use of electronic signatures is often not inherently supported by these systems. Due to the demand of electronic-signature based solutions, several vendors offer appropriate plug-in based solutions in order to integrate the functionality of electronic signatures into already existing document management systems.

For instance, E-Lock Technologies [12] offers a tool that enables users to digitally sign documents and forms within existing DMS. This way, E-Lock Technologies provides authentication of the respective documents, integrity of the underlying data, and non-

repudiation. Furthermore, E-Lock Technologies affirms to be compliant with several widely accepted legislations like the US E-Sign law or EU law.

Another plug-in based solution that extends existing document management approaches by means of electronic signatures is offered by ARX – Algorithmic Research [14]. Their tool called “CoSign” can be integrated into various existing document processing applications including Microsoft Office, Adobe Acrobat, IBM Lotus, or Oracle UCM. This way, documents being created and maintained using these applications can easily be extended by functionality provided by electronic signatures. CoSign follows a centralized approach to deploy and administrate required signature credentials by storing them on a central server.

In contrast, CEDITI [15] follows a local approach by offering a tool that allows an integration of the Belgian eID card’s functionality that has been introduced by De Cock et al. [18][19] into existing document management systems. This way, Belgian citizens are able to electronically sign documents being managed by solutions like Alfresco [20] or Documentum [21]. The required signature credentials are managed locally on the respective eID card, which is uniquely linked to the respective user.

Most available solutions have in common that they basically provide means to extend already existing applications. The additional functionality provided by application of electronic signatures is solely used to electronically sign documents in order to ensure integrity and to achieve non-repudiation. However, electronic signatures are usually not employed to improve existing user authentication processes.

Our solution tries to remove this shortcoming by following a different approach. In the presented approach, electronic signatures are not only an additional feature, but a core component of the entire solution. Relying on the Austrian citizen card concept, approved means for both, the secure smart-card based authentication [3] of users, and the electronic signing of documents are available. In contrast to most comparable products, our circular RDS provides secure user authentication and enables reliable user-, access-, and rights-management based on qualified signatures.

Platform independency is one of the most noticeable advantages of our solution. By following a web-application based approach, users of our system are not restricted to certain computer architectures or operating systems. The full functionality of the proposed circular RDS can be accessed by means of common web browsers from an arbitrary client system (e.g. personal computer) without the need to install a local instance of the system.

The main objective of our solution is to increase the security of basic operations like user authentication and the signing of digital documents. Therefore, less effort has been invested in the implementation of additional features and gimmicks. Hence, compared to other already well established document management systems, our solution features only a basic but nevertheless highly secured set of features.

The Austrian citizen card has already proven to be able to act as an enabler for the creation of secure and reliable signatures of documents [4]. While other comparable products support electronic signatures on several document formats, our solution solely relies on the popular PDF format. Although this restriction seems to be a disadvantage at a first glance, limitation to the PDF

format is beneficial in several respects: PDF is freely available among all conceivable platforms, it provides accessibility and it guarantees digital preservation.

Furthermore, PDF guarantees consistency of layout across different platforms. In consideration of the platform independent nature of our solution, this feature makes PDF perfectly suitable to be the format of choice. Finally, respective tools and frameworks to create and verify PDF signatures are already available [5], which eases the integration of support for citizen card based PDF signatures.

In the following section, basic building blocks of the proposed RDS are introduced. Benefits from integration of electronic signatures are emphasized and advantages compared to other existing solutions are identified.

4. ARCHITECTURAL DESIGN

Similar to comparable existing solutions, our circular resolution database system comprises features to create, publish, and maintain electronic documents. However, the main design objective of our solution was to leverage the application of qualified electronic signatures in order to increase the degree of provided security. The proposed RDS applies qualified electronic signatures to securely authenticate users and to electronically sign digital documents. This way, a higher degree of security compared to comparable solutions is achieved while usability and efficiency of our system are still maintained. In the remainder of this section, the proposed electronic-signature based RDS is introduced and benefits that have been achieved by the application of electronic signatures are emphasized.

In our solution users are authenticated by means of qualified electronic signatures. Additionally, each user can be dynamically assigned to one or more user groups. In total, four user groups have been defined. Users belonging to the group “Creators” are able to create new resolutions either by uploading an appropriate document or by dynamically generating a document based on user entered data. Users being part of the user group “Decision Makers” are intended to electronically sign newly created resolutions. Completely signed documents are finally published to predefined users, whereas members of the user group “Privileged Users” have unlimited access to all published documents. Users belonging to the group “Administrators” have access to several system maintenance interfaces.

In order to use given synergies and to be able to rely on already existing tools, a web-application based implementation approach has been chosen. Web-applications ensure a high degree of platform independency and facilitate the use of the application by avoiding the need for additional software installations on the client side. Thus, the developed web-application can be simply used by means of arbitrary web browsers.

In order to increase reliability and maintainability of the proposed solution, the web-application relies on several well-established frameworks. The entire web-application is based on Java Servlet technology using the open source framework Apache Struts [7], which separates model, view, and controller responsibilities and facilitates an efficient development process.

Figure 1 outlines the execution environment of our RDS and illustrates interfaces to external components. The RDS, which resides on an appropriate web server, provides means to connect

to an external mail server. This mail server is employed to deliver e-mail based notifications during productive operation. Users interact with the RDS by means of a standard web browser. Electronic signature based operations of the RDS require access to the user's citizen card, which typically resides on the client system too. In order to enable and to trigger the creation of qualified electronic signatures, the user has to prove knowledge of the secret PIN by providing it to the citizen card.

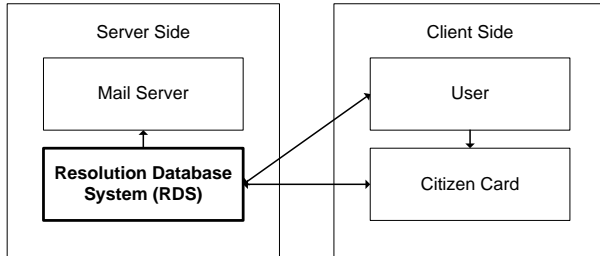


Figure 1 – System overview

The core components of the proposed resolution database system being highlighted in Figure 1 are illustrated in Figure 2. The following subsections describe the three core functionalities “Data Maintenance”, “Secure User Authentication”, and “Processing of Resolutions” in more detail.

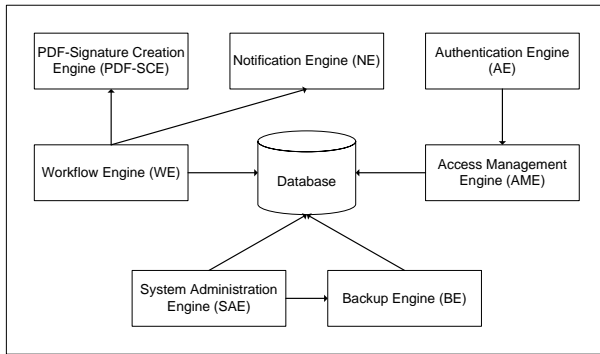


Figure 2 – Circular Resolution Database System – Core Components

4.1 Data Maintenance

All relevant data including maintained documents, resolutions, and user profiles are stored in a central database. Access to this database by other components of the RDS is abstracted by means of the open source framework Hibernate [8] that allows various types of databases to be used.

For database maintenance, our RDS features a System Administration Engine (SAE) that enables authorized users being assigned to the user group “Administrators” to review and modify data in a convenient way by using appropriate web interfaces. In addition, the SAE provides means to manage user accounts and to backup maintained documents. The latter is achieved by employing the Backup Engine (BE), which allows a systematic selection of all documents to be backed up through convenient web interfaces. Beside user triggered backup operations, the Backup Engine features automatic backup procedures too. This way, periodic backups can be configured easily in order to guarantee continuity of all maintained data.

4.2 Secure User Authentication

In general, access to data and functions of the RDS is restricted to authorized users only. In order to apply these restrictions, an Access Management Engine (AME) has been developed that protects resources of the RDS from unauthorized access. Upon requesting a certain resource of the RDS, the AME checks whether the respective user belongs to a user group that has appropriate access rights. Certainly, the reliability of the implemented AME depends heavily on the secure authentication of users. Only if user identities are forgery-proof, the AME is able to ensure that certain resources are exclusively accessible to intended users only. Because of the importance of secure and reliable user authentication, the proposed RDS integrates qualified electronic signatures into the authentication process. In the developed RDS, the Authentication Engine (AE) is responsible for handling the entire authentication process and forwards obtained authentication data to the AME on completion.

The AE itself relies on functionality provided by the publicly available framework MOA-ID [9] being part of the MOA family [2]. MOA components ease the use of the citizen card concept by taking over complex tasks like signature verification or complete workflows like user authentication for instance. Being responsible for user authentication based on the Austrian citizen card concept, the functionality of MOA-ID can be accessed through a web-service interface. If a user of the RDS initiates an authentication process, the RDS redirects to MOA-ID, which establishes a connection to the user's citizen card over the high-level XML interface mentioned in the introductory chapter. Through this interface, the user's identity link is read out from the citizen card in the first instance. Subsequently, the user is asked to create an electronic signature for authentication purposes. MOA-ID performs all verification and validation steps needed and finally returns the obtained authentication data to the RDS or to be more precisely to its Access Management Engine.

Relying on the approved web-service MOA-ID, the reliability and security of the employed user authentication process is guaranteed.

4.3 Processing of Resolutions

The Workflow Engine (WE) being one of the core components of the entire RDS is responsible for all tasks concerning the creation, signing and publishing of resolutions. For users belonging to the user group “Creators”, the WE provides means to create new resolutions. This can be accomplished either by uploading externally created PDF files or by dynamically generating PDF documents based on data being entered by the particular user. Created resolutions are securely stored in the database and made accessible to users of the group “Decision Makers” that are intended to review and sign them. The WE features a locking mechanism, which guarantees that resolutions cannot be modified in parallel by two or more decision makers. This ensures that resolutions can be signed in an arbitrary sequence avoiding the need for predefined signing orders or the assignment of user specific time slots. This increases usability and significantly speeds up the entire decision making process.

The PDF signing process itself is outsourced to the PDF-Signature Creation Engine (PDF-SCE). The PDF-SCE relies on functionality provided by the framework PDF-AS [5], which has originally been developed for the creation of official signatures in

the context of e-government applications [4]. Nevertheless, PDF-AS provides several features that make it suitable for integration in our circular RDS. Especially the inherent support of the Austrian citizen card for qualified electronic signatures on PDF documents is a substantial argument for an employment of PDF-AS within our solution.

In order to initiate a document signing process, the RDS contacts the web based interface of the PDF-AS framework. The framework makes use of the already mentioned high-level XML based interface to invoke electronic signature functionality of the underlying citizen card implementation. Upon retrieval of the resulting electronic signature PDF-AS embeds a visible and recognizable representation of the signature in the PDF documents which is finally returned to the Workflow Engine of the RDS.

When all dedicated users have successfully signed a resolution, the WE provides means to publish the respective document to all designated recipients. Furthermore, the WE offers an appropriate web interface that can be used by authorized users to view details on the respective document and to download the resolution in PDF format.

During processing of resolutions, the Workflow Engine makes use of functionality provided by the Notification Engine (NE), which handles the dynamic creation and delivery of e-mail based notifications. Whenever relevant events (e.g. creation or publishing of resolutions) occur, respective notifications are created and sent to all intended receivers, which accelerates the entire decision making process. In order to ensure an efficient information flow while avoiding unwanted e-mail receptions, each user can individually configure the NE to fit personal needs.

By combining the functionality of all introduced engines, our circular resolution database system leverages qualified electronic signatures to improve decision making processes. Due to citizen card based authentication and document signing processes, the proposed solution provides an increased degree of security. At the same time, the overall processing time of decision making processes can be reduced significantly while maintaining usability as well as auditing acceptability of all maintained resolutions.

5. LESSONS LEARNED

Our circular resolution database system has been in productive operation at the non-profit association A-SIT (Secure Information Technology Center – Austria) [10] since July 2008 and has been frequently used for the creation, signing, and maintenance of all internal resolutions. This section focuses on experiences that have been gained so far and shows how the proposed RDS has significantly enhanced the organization's entire decision making process.

The non-profit association A-SIT is distributed over two locations residing in different cities. The organization's executive board, which is involved in all decision making processes, consists of two members, one from each site. Due to the local distance between the two locations and due to frequent business trips, face-to-face meetings of the executive board members have often been impossible, which has complicated the efficient processing of internal resolutions.

Due to these circumstances, A-SIT has early started to rely on circular resolutions, as this kind of decision making process does

not require personal meetings of the executive board. However, the manual exchange of respective documents between members of the executive board has posed a serious risk to the continuity and auditing acceptability of processed resolutions. Especially the provision of relevant data to members of A-SIT's supervisory board, which has an auditing role within the organization, has been cumbersome. Therefore, A-SIT has been predestinated for application of the developed RDS in order to improve decision making processes and to ensure auditing acceptability of internal resolutions.

After more than one year of productive operation, usage of the circular RDS has substantially reduced the overall processing time of circular resolutions. While the manual handling of circular resolutions has usually taken several days, the overall processing time of resolutions has been reduced to several hours. In cases, in which all members of the executive board were online at the same time, even processing times of only a few minutes could be realized.

Due to the centralized approach and the integration of qualified electronic signatures, auditing acceptability and continuity of all processed resolutions is guaranteed during their entire lifetime. All relevant data can easily be accessed by authorized users at any time. This ensures an efficient exchange of information between employees, the executive board, and the supervisory board of the organization

Productive operation at A-SIT for more than one year has proven the proposed circular RDS' ability to significantly enhance decision making processes. Nevertheless, potential for further improvements has already been identified. For instance, the integration of secure and non-deniable electronic delivery could extend the functionality of the RDS system by ensuring that documents and notifications are verifiably delivered to intended recipients.

6. CONCLUSIONS

This paper has introduced an electronic-signature based circular resolution database system. In order to remain competitive, secure and efficient decision making processes are crucial especially for small and medium-sized enterprises. Fulfilling of this requirement is complicated by the fact that decision makers, e.g. members of a company's executive board, are often locally dispersed and thus not able to meet face-to-face. In this paper, a solution for this problem in the form of a freely available [22] electronic-signature based web-application for processing of circular resolutions has been introduced.

Relying on the Austrian citizen card concept, the proposed solution incorporates qualified electronic signatures for two purposes. On the one hand, the application of qualified electronic signatures is used to unambiguously and securely authenticate users by means of a citizen card based two-factor authentication. On the other hand, created and maintained resolutions are electronically signed in order to guarantee integrity and non-repudiation of the particular data. This way, security and efficiency of decision making processes relying on circular resolutions are enhanced while maintaining auditing acceptability and usability.

The RDS has been in productive operation at the non-profit association A-SIT for more than one year and has proven its capability to significantly improve decision making and resolution

maintenance processes. While the average processing time of decision making processes has been reduced, usability as well as the achieved level of security has been increased by integration of qualified electronic signatures.

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