CONTENT 2020

The Twelfth International Conference on Creative Content Technologies

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CONTENT 2020 Editors

Hans-Werner Sehring, Tallence AG, Hamburg, Germany

CONTENT 2020

Forward

The Twelfth International Conference on Creative Content Technologies (CONTENT 2020), held on October 25 - 29, 2020, continued a series of events targeting advanced concepts, solutions and applications in producing, transmitting and managing various forms of content and their combination. Multi-cast and uni-cast content distribution, content localization, on-demand or following customer profiles are common challenges for content producers and distributors. Special processing challenges occur when dealing with social, graphic content, animation, speech, voice, image, audio, data, or image contents. Advanced producing and managing mechanisms and methodologies are now embedded in current and soon-to-be solutions.

The conference had the following tracks:

- Data Transmission and Management
- Web content
- Domains and approaches

Similar to the previous edition, this event attracted excellent contributions and active participation from all over the world. We were very pleased to receive top quality contributions.

We take here the opportunity to warmly thank all the members of the CONTENT 2020 technical program committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and effort to contribute to CONTENT 2020. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations and sponsors. We also gratefully thank the members of the CONTENT 2020 organizing committee for their help in handling the logistics and for their work that made this professional meeting a success.

We hope CONTENT 2020 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the area of creative content technologies

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Video Teaching Materials to Train Deaf or Hard-of-Hearing Curators in Museums

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Abstract*—We aimed to improve the information accessibility of museums based on the principles of "universal design" and "design for all." Focusing on visitors who used sign language, we trained a curator to offer explanations via sign language to communicate scientific facts to visitors who were Deaf or Hard-of-Hearing (HOH). Demonstration training for hearing curators consists of observing the lecturer's movements, dialogue with visitors, and consultation of teaching materials while listening to explanations. However, if trainees are persons with hearing impairment, they cannot observe the sign language interpreter, instructor's movements, and teaching materials simultaneously. Consequently, trainees may overlook important explanations and dialogue with visitors. To address this problem, we recorded the lesson and created a video with captions for review. The materials can be operated on a tablet device, allowing trainees to study freely. We created two pieces of content, "shark eggs and sharkskin" and "human bone," which were used in the aquarium and science museum, respectively. In this report, we describe the need for contents for visitors with hearing impairment in Section I and then introduce our related content for them and presents the reason to nurture curators who are sign language users with hearing impairment. Section III presents our curator training materials designed for trainees of sign language users who are Deaf or HOH. Lastly, we describe our future work.

Keywords- science museum; training materials; Deaf or HOH curators; content design.

I. Introduction

The definition of museum adopted by the International Council of Museums states [1]: "A museum is a non-profit, permanent institution… for the purposes of study, education and enjoyment." Since the establishment of the Disability Discrimination Act in 1995 [2], advocacy for persons with disabilities has been a priority in most institutions. Museums therefore seek to reflect information in the discussion of museum research, policy, and practices. However, Atkinson [3] has warned that while exploring a museum collection constitutes a very visual experience, "deaf audiences are one of the most neglected by museums."

According to the World Health Organization [4], there are 466 million people in the world who suffer from hearing loss. The World Federation of the Deaf estimates that there are about 70 million deaf people worldwide who use sign language as their first language or mother tongue. The National Deaf Center [5] explains that persons with hearing impairment who are Deaf or HOH have different communication needs. Goss [6] advised that a wide range of multilingual communication is required for the diverse range of museum visitors who are Deaf or HOH. We therefore explored the different communication needs of Deaf and HOH individuals that must be addressed to break down both the physical and intellectual barriers they face in museums.

In this paper, we use the "uppercase D" Deaf to describe the cultural identity of people with hearing loss who share a common culture and have a shared sign language. HOH is used to indicate people with Japanese as their first language who lip-read and use hearing aids as well as sign language to help their communication. The remainder of the paper is organized as follows. Section II introduces the related works and presents the reason to nurture curators who are sign language users with hearing impairment. Section III presents our curator training materials designed for trainees of sign language users who are Deaf or HOH. Section IV compress point out the advantages of training materials using media technology for training curators with hearing impairment.

II. Previous and Related Works

Sanagustín [7] reported on the effects of Quick Response (QR) codes in museums, stating that visitors prefer direct mechanisms for obtaining information about the exhibits, such as text on a panel or videos on a screen. Consequently, Namatame [8] initially provided the Japanese sign language explanation via QR code technology at an aquarium in Japan. QR codes are a cost-effective way of providing opportunities to transform the public's experience in museum-like spaces. When visitors captured the QR codes in front of the aquarium tanks, explanations appeared that used sign language videos and superimposed captions, including KANA. This enabled us to implement a convenient system that encourages Deaf visitors to visit museums and enlighten themselves using the sign language explanations offered by QR code technology.

Deaf or HOH visitor groups who visit museums can be categorized into the following three groups: "spoken-focused," "simultaneous language," and "sign language-focused." For the convenience of Deaf visitors who are sign language-focused, we designed the tour with a sign language interpreter in the science museum. Martins [9] has reported that Deaf visitors' engagement is enhanced when tours are given by Deaf tour guides, so we tried to nurture curator sign language users who are Deaf or HOH. Doing so required that we first design teaching materials for Deaf or HOH trainees. The Deaf or HOH trainees who came forward as candidates for this project were interested in science and had to be capable of using Japanese sign language to communicate and reading written Japanese without difficulty.

The next section reports the teaching materials we designed for trainees who are Deaf or HOH.

III. Training Materials Design

In the demonstration training for curators, a hearing person can observe the lecturer's movements and dialogue with visitors, while consulting the teaching materials and listening to the explanations. However, Deaf or HOH trainees are unable to see the sign language interpreter, instructor's movements, and materials at the same time. Consequently, trainees may overlook important explanations and dialogue with visitors. We therefore recorded the lesson and created a video with captions for review. The materials can be operated on a tablet device, meaning trainees can study freely. We created two pieces of content. One was "shark eggs and shark skins," to be used in the aquarium, and the other was "human bone," to be used in the science museum.

A. *Training Materials for Curators who Provide In-Person Explanations*

The training materials were designed for the trainees to use at the space in the aquarium called the "desk." This space consists of a desk with some shark eggs and a shark skin displayed between the visitor and the curator, enabling the lecture to progress while communicating face to face (see Fig. 1). The curators in the lecture corner provide visitor experiences and in-person explanations and require conversational skills to provide visitors with new knowledge and stimulate their curiosity as well as the ability to field questions appropriately.

The training program was conducted from September 7, 2019 to December 5, 2019. The training process involved a team of four people: a Deaf curator candidate, an aquarium curator, a sign language interpreter, and an information supporter. It was designed to follow four units: individual visitor experiences, the study of knowledge about sharks using books, observation of demonstrations to learn how to interact with visitors, and a rehearsal. The individual training could be supported by both sign language interpreters and information supporters. However, the observation of demonstrations was very difficult for the trainee who was Deaf, the interpreter, and the information supporter, for several reasons: the voice conversation between the customer and the curator was fast and simultaneous. In addition, the voice conversation was conducted with the face turned down as the user touched several materials, one after the other. The time lag between the conversation and the interpreter's actions had disastrous consequences, and the trainee was unable to lip-read because the speakers' faces were turned down.

We designed two training materials based on our observation of demonstrations to help solve this problem. We used a speech recognition system to instantly transcribe the description from the curator's voice. In addition, we photographed the materials to be touched on the spot with the transcribed text that was then superimposed on the images (see Fig. 3). Moreover, the video was recorded at a fixed point, with a focus on the hand. After observing the demonstrations, these videos were captioned and provided to the trainees who were deaf to help them learn how to better interact with visitors (see Fig. 4).

B. *Training Materials for Curators who Provide Classroom-Style Lectures*

These training materials were designed for trainees working in the "school program" at the science museum that is intended for school organizations. Participants in this program are students and schoolteachers. Students are led by the schoolteachers, and they listen to the lecture in groups (see Fig. 2). The materials and lecture rooms are provided by the museum. There are fixed scenarios in the content of the lecture, and the curator leads the class accordingly. Curators must have proficient teaching skills to encourage students' spontaneous thinking and promote the joy of discovery. They must also possess the ability to keep students engaged and answer questions correctly.

We conducted the training program from November 5, 2019, to December 6, 2019, with a team that consisted of an HOH trainee, a curator, an interpreter, a supporter, and a volunteer lecturer of the science museum. The primary training concerned how to teach appropriately. This program was very difficult for the HOH trainee, interpreter, and information supporter. The scenario involved several technical terms such as "skull," "rib," and "pelvis." The trainee was unable to comprehend the instructor's voice and, thus, encourage students' awareness in real time. The trainee was also unable to hear the unspecified number of students' voices, meaning he did not know why the instructor was making such remarks. In the classroom-style lecture, it was very important to understand the situation of the students and the timing of the instructor's utterances.

We designed the video materials for the lecture, which were divided in the unit according to the scenarios. The teaching materials consisted of multiple captioned videos, the scenario, a Q & A section, a figure with bone names, and the main menu. The trainee selected the necessary units from the menu and could study freely (see Fig. 5, 6).

IV. Conclusion and Future Work

To comprehend the design and technology of suitable content that guarantees information accessibility for the Deaf or HOH trainee, we prepared the following combinations: the technical approach (automatic speech recognition and authoring), museum type (aquarium vs. science museum), and presentation scenario (face-to-face vs. classroom). In the paper's conclusion, we outline a methodology for adapting the proposed materials to other types of scenarios or different educational contexts.

This report introduced training materials for Deaf or HOH curators in a science museum and an aquarium. The training materials could be operated on a tablet device and were shown to be very good tools for enabling Deaf or HOH

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curators in the science museum and aquarium. Two technology patterns were used to create the training materials. The first approach involved using speech recognition technology to rapidly superimpose the description of the real material. The second approach was to add captions to the video using an authoring technique.

Practical research in museums has taught us that the interpreter time lag represents a barrier to understanding conversations. Moreover, the physical distance of the exhibits and showcases impedes the ability to point at displays directly.

Technologies for superimposition of descriptions and speech recognition can be used to correctly indicate exhibition points. Video teaching materials can also reproduce subtitles to solve the time lag between the speaker and the interpreter and help Deaf or HOH individuals to understand conversations. Furthermore, multimedia technology can represent the dialogue setting and teaching materials on the same screen. This research convinced us that training materials using media technology were essential for training curators with hearing impairment.

Such types of content are adaptable and flexible for use in other types of scenarios or different educational contexts. However, they serve different purposes: one is suited to real-time communication about exhibits, and the other is suited to self-learning.

Future work is needed to evaluate the effectiveness of such training materials for Deaf or HOH trainees. The addition of sign language descriptions is planned for the next version of the video training material.

ACKNOWLEDGMENT

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Figure 1. Snapshot of the face-to-face lecture

Figure 2. Snapshot of the classroom-style lecture

Figure 3. Screenshot of speech recognition text superimposed on the image

Figure 4. Screenshot of video training materials to learn how to interact with visitors

Figure 5. Main menu of the training materials implemented on a tablet PC

Figure 6. Screenshot of the training materials with instruction points and the status video of the class

Architectural Considerations for the System Landscape of the Digital Transformation

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***Abstract*—Since the advent of the World Wide Web the latest, there is a growing adoption of digital media for different purposes. It started with mere consumption through information and entertainment services, and expanded to the engagement of users with service providers in commercial and governmental affairs. As a consequence, services are extended into different directions: the communication channels used by clients, the improvement of services by including information on users and usage contexts, up to the goods or services in themselves that are being delivered. To this end, established processes, even ones at the core of a company's value adding chain, have to be thought over, optimized, or even restructured. The importance of these kind of adaptations for current enterprises led to the coining of the term *digitalization* or *digital transformation* for them. Since systems for the support of digitalized processes consist of many products and services that are assembled or coordinated, a consideration of their overall system architecture is required. In face of ready-to-use solutions that are available for specific functionality, and also of the availability of larger ecosystems that enable digitalized processes, often the architecture is dictated by the components that are available in practice. Architectural considerations that start with requirements and constraints instead have to be applied in order to achieve the engineering quality of other software solutions, and to meet non-functional requirements like maintainability. The contribution of this paper is a first step into that direction. It starts with an analysis of typical functional requirements of systems for the support of digitalized processes. From these, it presents a first approach to an integrated architecture for digitalized systems, and it maps requirements to common software components and services that typically implement parts of the architecture.**

Keywords*—*Digitization; Digitalization; Digital transformation; Software architecture; Systems architecture; Solution architecture; Enterprise architecture.

I. INTRODUCTION

Since the advent of the World Wide Web the latest, there is a growing adoption of digital media for different purposes. It started with mere consumption through information and entertainment services, and expanded to the engagement of users with service providers in commercial and governmental affairs. Services, to this end, are extended into different directions: the communication channels used by clients, the inclusion of information on users and usage contexts into service delivery, up to the goods or services in themselves that are being delivered.

Nowadays, practically every business is required to offer information, fulfillment (e.g., sold goods or delivered services), and support over the Internet through its website, specific apps for touch devices, social media appearances, etc. [1] This requirement is not limited to digital goods. In fact, it has long been extended to the real world. Companies engage with clients through digital services in ways that are oriented at the clients' needs and preferences. This includes the choice of communication channels, as well as channel changes in the course of a process, or even the process as a whole.

The increased engagement of clients with service providers in conjunction with both the fact that demands are posed by the clients and the need to rethink processes led to the coining of the term *digitalization* or *digital transformation* for the wider approach. Its importance is underlined by the facts that most parts of the IT industry are now working in the field of digitalization and that some governments devised action plans to encourage digital service improvements.

There is no rigid definition of what digital transformation is or what it includes. Sometimes, the terms *digitization*, *digitalization*, and *digital transformation* are interpreted as three aspects of the transformation of processes [2]. One attempt by Gartner for a definition is "the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." [3]

Technology is, therefore, an important driver for such business goals. In addition to its classical functions as computing machinery, data storage, and communication medium, the further employment of data and IT infrastructure forms the basis of the digital transformation [4]. With respect to systems support for client interactions, these require going beyond the mere utilization of IT infrastructure for the support of established processes. Quite the opposite, established processes, even ones at the core of a company's value adding chain, have to be thought over, optimized, or even restructured [5] in order to reach the new goals.

Since systems for the support of digitalized processes consist of many products and services that are assembled or coordinated, a consideration of the overall architecture is required. In face of the ready-to-use solutions that are available for specific functionality, and also of the availability of larger ecosystems that enable digitalized processes, often the scope and structure of applications are dictated by the components that are being used. This is an observation that can be made in practice, similar to Conway's law.

A return to old values of systems architecture seems due in order to construct systems based on requirements and with the aim of business value, not the other way round. Furthermore, taking a software engineering approach to the construction

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of systems for digitalized processes allows achieving the engineering quality of other software solutions, and it allows meeting non-functional requirements like maintainability.

The contribution of this paper is a first step into that direction. It starts with an analysis of typical functional requirements to systems for the support digitalized processes. From these, it presents a first approach of an integrated architecture for digital systems, and it maps requirements to usual software components and services that typically implement parts of the architecture.

The rest of this paper is organized as follows: The scope of the digital transformation is outlined by Section II. In Section III, we give an overview of the functionality that is expected from modern IT systems of digitalized institutions. Section IV presents a selection of software systems, services, and components that deliver such functionality. The paper closes with a summary and an outlook in Section V.

II. Digitalization of Enterprises

The introductory section already introduced characteristics of the digital transformation. Further characteristics and technological considerations follow.

A. Digital Transformation Goals

The digital transformation can no longer be handled separate from the "real world". Both physical as well as digital channels are used equally. Or, put the other way around: "Every business is now a digital business." [6]. Companies need to (actively) maintain customer relationships over all channels, processes must not be hindered by media barriers between channels, companies collect different data on product sales and on product use, etc. In essence, more and more of an enterprise's processes will be transferred to the digital domain. This is particularly important for, but not restricted to customer-facing interactions.

This paper concentrates on processes by which institutions interact with clients. In particular, it focuses on companies that interact with their customers and, therefore, on interactions and client engagement.

The paper does not, e.g., consider the digitalization of engineering processes (compare Computer-Aided Design, CAD, Computer-Aided Manufacturing, CAM, Computer-Integrated Manufacturing, CIM, and similar technologies). It does also not cover aspects of digitalization driven by recent technologies like, e.g., the Internet of Things (IOT), applications for Industry 4.0 [7], Radio-Frequency Identification (RFID), Near Field Communication (NFC), or Beacons to collect customer data through devices, and modern payment methods like crypto currencies.

An understanding of customers is derived, among other data sources, from information on *customer journeys*. They are formed by all (inter)actions of customer with respect to a current activity. For example, all web searches, web page reads, and commercial transactions connected to a purchase form the customer journey of buying a product. For a more fine-grained determination of the points of contact on a customer journey, Google proposed "micro-moments" that exhibit customers' intent, context, and immediacy [8].

On top of the technical abilities, further important factors for the ongoing transformation are the willingness of consumers to take part in a digital economy and to stay informed, even if this means putting some privacy concerns aside, as well as the recognition of potential economic benefits of digitization and the need to foster them [9].

B. Digital Transformation Technology

Since this paper focuses on interactions between companies with their customers, system support mainly consists of commerce functions like marketing, sales, and customer care.

There are many other aspects and opportunities related to the digital transformation. In particular, there are other technology-driven aspects of digitalization. Topics include, to name just two examples, big data, e.g., behavioral data (tracking, purchases, etc.) on customers, and artificial intelligence and machine learning approaches, e.g., to the analysis of big data [10].

A plethora of products and services for digitalized enterprises is emerging [11]. The "Marketing Technology Landscape Supergraphic" [12] visualizes this for 8,000 of them. Some of the products and services provide rather isolated functionality, some try to cover a larger portion of digitalization requirements such as integrated solutions like product suites or service collections (by some providers called *marketing clouds* or similar).

In concert, the partial solutions allow digitally transforming a company's processes at affordable cost. The application-specific combination of products and services allows companies to realize competitive advantages while keeping up with the state-of-the-art in communication with reasonable effort.

When the technical landscape that drives digital enterprises is realized by the composition of a range of components, there are many communication relations between them. Communication requires interfaces that ensure a coherent handling of data and its interpretations, a common understanding of customers in each of the components, etc. To this end, the architecture of such technical landscapes has to be defined.

III. High-Level Architecture Consideration

Without formally giving a definition for architecture, we start by studying functional building blocks of systems for digitalized enterprises. They are assumed to be the architectural building blocks of a logical architecture. In contrast to common practice, we do not want to start with the consideration of concrete components. We use the term *component* for both a software product and a service.

The aim is to be able to talk about requirements and solutions in general, to study functionality and dataflows. We want to avoid the premature assignment of responsibilities to services, and also the concentration on data exchange, data conversions, etc., as it is often found in practice.

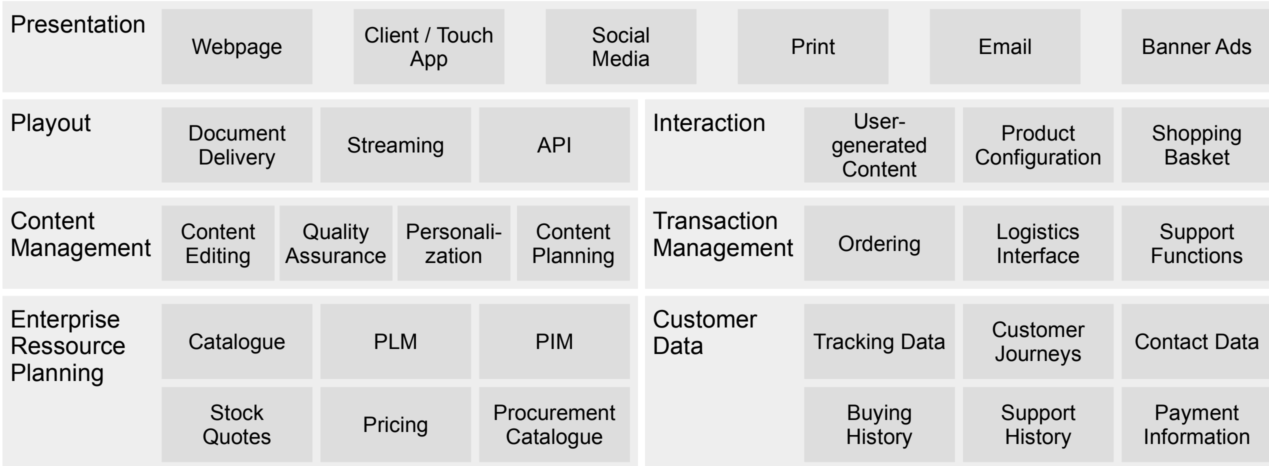

Figure 1. Functional building blocks of a high level architecture.

Figure 1 highlights some of the functional building blocks of an architecture. In the subsequent subsections, we study some of them. The outer boxes are arranged as a layered architecture in order to visualize service dependencies in general. In the vertical dimension, the lower components each offer services to the components that graphically are placed above them.

A. *Content Publishing*

Systems for digital enterprises often consider the World Wide Web (WWW) as one of their primary channels through which they communicate with their clients. Subsequently, many of these systems are centered around a *Content Management System* (*CMS*) or another web-based system. Figure 2 shows the components that contribute to a publishing process that addresses multiple channels.

A content management component primarily incorporates functionality to store and manage content. Often, structured (text and structure of text documents) and unstructured content (images, sound, moving image, etc.) are distinguished because of their different properties and the different functions associated with their management. Unstructured content is then managed by a *Digital Asset Management* (*DAM*) system.

Content management typically includes quality assurance. Some products achieve it by *content staging*. They copy content that is ready for publication to a specific component that delivers content to the playout components. Rules and workflows may be associated with quality assurance.

A *playout* component is employed to distribute documents that are created from content.

The receiver of such documents is a client that serves for their presentation. Interactive applications can also be found on this layer, e.g., JavaScript apps embedded in webpages or touch apps for mobile devices. For those, an API may be provided on the playout level that gives access to different services of the other components.

B. *Personalization*

By means of *personalization*, the documents and services that are delivered are individualized for specific users. *Targeting* is the approach to this that is found is practice most often. The component interplay for general personalization is shown in Figure 3.

Personalization can be applied on the level of content, as well as on the level of content representations. Content personalization is built into some CMS products. The personalization

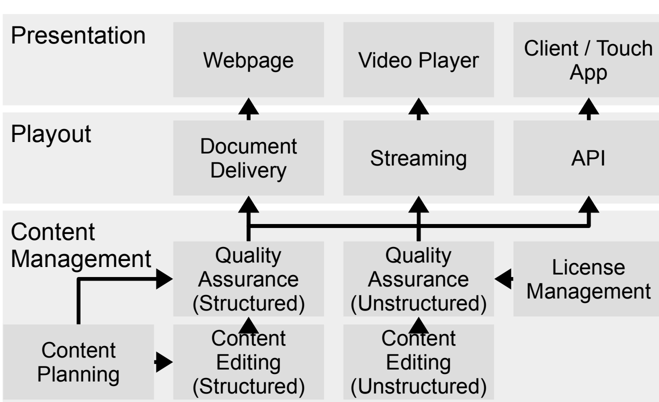

Figure 2. Content management components.

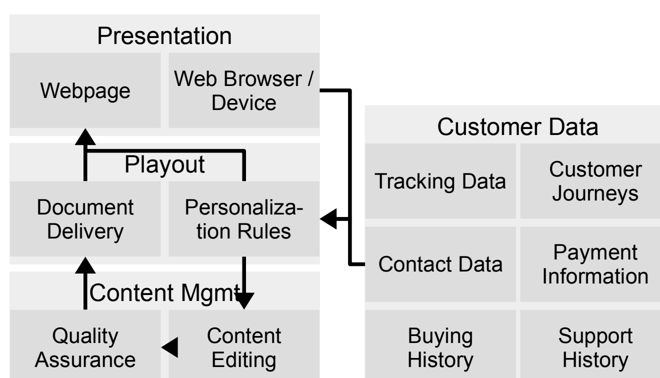

Figure 3. Components involved in personalized document delivery.

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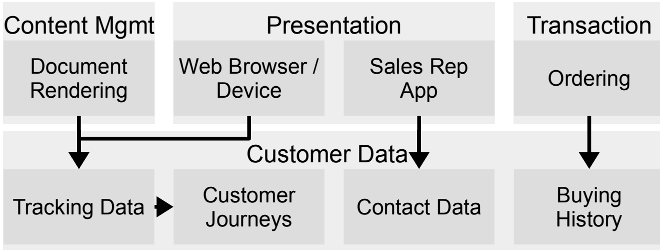

Figure 4. Components for the management of customer data.

of representations can also be fulfilled by a service that is provided outside the CMS.

On both levels, personalization is normally performed by evaluating rules on the basis on a classification of customers that is derived from their behavior [13].

Tracking is the most basic way to observe users' behavior. For content personalization, the utilization of pieces of content during document rendering is monitored. Accesses to web pages are typically recorded for document personalization. Tracking is performed by some (web) tracking or *tag management* service.

C. Consumer Data Management

One of the pillars of the digital transformation is the involvement of clients. Therefore, it is obvious that a company needs to know its customers and, therefore, collect data on them. This is done for two reasons: Firstly, the data is of value in itself, e.g., to be able to identify customers and prospects that might be interested in offers. Secondly, the data is used to fulfill services better.

An excerpt of an architecture for the management of customer data is shown in Figure 4.

There are multiple components available that collect information on users. The previous subsection already named tracking services as a source of data on customer behavior. Also, the commerce functions allow to access historical data, e.g., on past purchases. *Customer Relationship Management* (*CRM*) systems are the primary class of systems for customer data. These allow to structure customer information in order to record contact information, purchases and other interactions, the communication history, etc. A CRM is typically maintained by sales personnel.

In a digitalization scenario, a CRM system needs to be extended with the other sources of data about customers, and in particular the collection of information that originates from all channels the customers use. The increased user database is also called a *Customer Data Platform* (*CDP*).

The *sales rep app* depicted in Figure 4 represents a typical client-side software application that is used in sales talks, product presentations, etc. It uses material that is delivered by, e.g., a CMS, and it is typically used to create and update records in a CRM.

Another potential use of customer information lies in the extension of personalization and recommendations, often called *Customer Journey Orchestration*. It relies on the aggregated

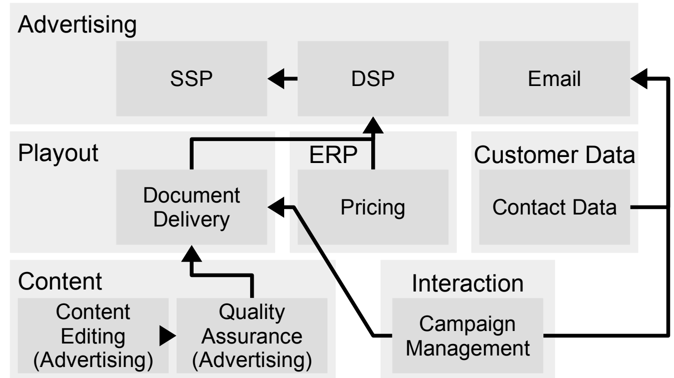

Figure 5. Retargeting components.

information collected on different channels, and it is used to personalize whole customer journeys, i.e., series of interactions at different touchpoints.

D. Retargeting

A customer journey may lead a user away from the digital touchpoints of a company (or some other institution), for example, to get information from somewhere else. Companies want to keep the users' focus user on their customer journey and to encourage the users to return to one of their touchpoints once they feel informed. The process of re-attracting customers is called *retargeting*.

One common means for retargeting on the web are adverts on foreign websites. For example, when a customer leaves a company's website and visits another one, a banner ad placed on that other one leads the user back to the company's website. In the best case, the ad is personalized for the customer [14]. The URL underlying the ad might, e.g., direct the user to a landing page for recurring users that displays a personalized offer.

Components and data flows for retargeting are shown in Figure 5. Ad servers choose an ad to be displayed on a webpage that offers ad space. They operate on a marketplace for ads on which companies register ads, and from which websites fetch one.

A service for the management of registered ads is called a *Demand Side Platform* (*DSP*). A company might use its content management systems (CMS and DAM) to manage publicity material and to hand it over to the DSP. Further information might include, also indicated in the figure, a rebated price for a personalized offer to be made by an ad, and a campaign key, so that the campaign management tool can measure the success of a retargeting campaign.

Websites that include ads retrieve them from a *Supply Side Platform* (*SSP*) service that chooses and delivers ads on demand. The SSP retrieves the ads from the DSP.

Another common tool for retargeting is email. This is also sketched in Figure 5. The campaign management tool triggers email delivery when retargeting is appropriate. The email body may come from a CMS, the recipient's email address from the customer data management system.

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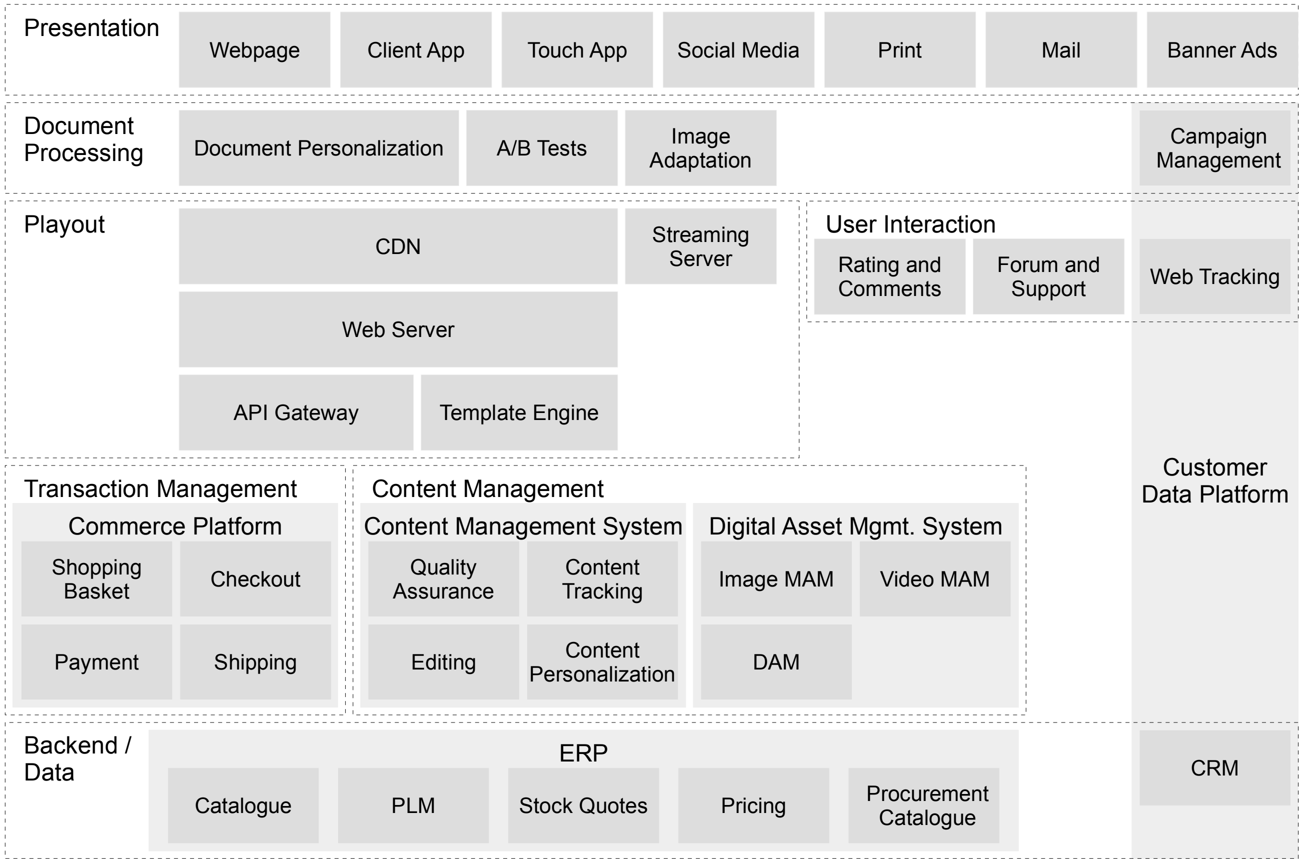

Figure 6. An exemplary system configuration for a digitalized enterprise.

IV. Architecture Building Blocks

A logical architecture that describes functionality as outlined in the preceding subsection is mapped to concrete components for implementation. In order to distinguish the logical view on the architecture from a component view that describes system implementation, we call the implementation model a *system configuration*.

A system configuration mainly consists of a selection of components and services, parameterizations and customizations of the components, the communication between the components, as well as interfaces to the environment.

Figure 6 gives outlines the structure of a high-level system configuration. The dotted lines outline functional units as they have been considered in the preceding section. The outer gray boxes depict software products and services that are employed to implement functionality. This way, we relate the two architecture views – abstract functionality and concrete implementations – in the figure.

Each implementation unit may be delivered by a single component, an assembly of components, or separate components that work in concert. Therefore, there are lots of integration tasks for a configuration. This may be one strong argument in favor of marketing/sales clouds that offer integration out of the box. Alternative approaches are an integration platform and a central integration bus. But these solutions are rarely found.

Instead, a lot of point-to-point integrations are found in practice. These may be implemented in different ways. Through tight coupling, the systems may use the same data by sharing storage, by exchanging data, or by one using the other as its storage. With loose coupling, one component offers services to another.

There are well-established principles that guide the assignment of functionality to components and the choice of the integration approach. A prominent example are the principles of high coherence and low coupling. High coherence is important to avoid redundancy as much as possible, of both functionality and data. Low coupling supports non-functional properties so that, for example, services of a certain kind can be chosen dynamically, and components can (horizontally) be scaled.

As an example for implementation alternatives, the integration of a CMS with a DAM has thoroughly been studied in an earlier publication [15]. In this case, content management functionality like quality assurance and content transformations are offered by both kinds of components. Therefore, the responsibility for the according tasks has to be distributed. The (independent, but related) lifecycles of structured and unstructured content are another factor for the choice of the integration approach.

The CDP is another relevant example. There exist dedicated products and services for this component that may import data from the other components that collect data about customers.

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A CDP may as well be realized by, e.g., importing web tracking and campaign tracking data into a CRM, or by an orchestration of the components.

Many systems have a notion of customers: the CMS through tracking and personalization, the campaign management through address lists, a commerce system through commercial transactions, the CRM system by keeping contact information, *Enterprise Resource Planning* (*ERP*) systems for accounts receivable accounting, etc. All these different perceptions of a customer need to be related to each other. If the related information is materialized in one aggregated record, this one is sometimes called a *golden record*. The records are handled through so-called *master data management*.

The same holds for the products or services a company offers. While product data are hosted by a *Product Information Management* (*PIM*) system, prices are calculated by a pricing engine based on data from the PIM, the ERP, or the commerce system. Additional product descriptions that are maintained for marketing reasons may reside in a CMS. Therefore, master data management is also required at this point.

V. Conclusion

The paper concludes with a summary and an outlook.

A. Summary

This paper presents the main requirements to system support for digitalized institutions. It focuses on commercial interactions between companies and their customers.

Current IT landscapes for digitalized enterprises are typically assembled from readily available software products and services. The architecture of the resulting systems often seems to be motivated by the selected components, not by established architecture principles. In particular, requirements are often formulated after the functionality of available components, and responsibilities are solely assigned on the basis of given functionality and the characteristics of available components.

This paper constitutes the starting point for a discussion on architectures for digital systems through which companies interact with their customers. In order to do so, we enumerate typical tasks to be performed by such systems, and we take an architectural view on such systems. By first designing the logical architecture, the system design follows requirements, not technical constraints. Such architectural considerations allow discussing different implementations of the requirements. Furthermore, non-functional requirements can be covered by system design.

B. Outlook

This paper presents insights gained from various digital transformation projects. As a next step, existing reference architectures have to be analyzed for further input on requirements, product and service categories, and solution patterns.

One future result would be an approach to architecture definition for systems for digital enterprises. It may be supported by checklists, templates for requirements and constraints, as well as solution patterns.

There are many well-understood cases from which it seems possible to create a generic pattern library for system constellations that have proven beneficial. This would include architectural building blocks, architecture principles, guidelines for the selection of products and services, etc. Such pattern libraries are at least within reach for specific cases or domains.

Acknowledgment

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QRCode DOOR Project:
Access Control Application using QR Code Image

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***Abstract*—This research proposes a novel technology for access control, creating a smartphone embedded key making use of two types of cryptography to generate a QR Code image, all this combined with a WebCam attached to an electric lock on a door. This paper introduces an architectural model of the access device, the creation of a QR Code image using encrypted users' data, the encryption process, and the elaboration of the QR Code reading device using a microprocessor Raspberry Pi 2.**

Keywords–QR Code Image; Smart Door; Access Control; Internet of Things; Computer Vision.

I. INTRODUCTION

The evolution of society requires new ways of smart access. This can be seen in home offices, apartment complexes, enterprises, schools, and private events, where identity verification and access validation is necessary. The present paper approaches the use of mobile technologies to figure out this typical problem practically and securely.

One of the main challenges in managing physical access is the administration of the access keys, which can be lost, stolen, or even given away. Also, these keys do not ensure rules about access such as scheduling access, specific locations (sub-locations), or limit of capacity. Given these reasons, the creation of smart doors, which can be managed remotely and have a simple and modern activation interface is justified [1].

As technology use rises, the smartphone has been incorporated into everyday life, hence the loss of a physical key is justified [1]. An embedded virtual key allows creating complex access rules, as encryption and one-time access token. A physical key can be used by anyone who has it or finds it, while a smartphone possesses security engines such as fingerprint lock and/or private passwords, restricting its use to only its owner. Another characteristic is that one single Smartphone can be used to access different profiles, depending on the password used to unlock it [2].

As the digital revolution happens, several daily tasks have become virtual, while the physical access method remained the same. It is more convenient to carry a smartphone holding several access keys than carrying a lot of keys as seen in [1]. It is more inexpensive and practical to manage the access virtually than by using a physical device. This device can control access tries and record user identification, date, and time of admission as well as generates statistics over the accesses.

This paper's objective is to propose and develop access management, web-client aligned with the current mobile and virtual technologies, as for example QR Code, which provides security and ease of use.

Section II describes the proposed approach. Section III presents verification and validation of the system proposed. Finally, conclusions are given in Section IV.

II. PROPOSED METHODOLOGY

This research methodology is built up in four steps of development. The first step is to develop the web-client and the prototype of the mobile layout. The second step consists on the creation of the access device, which involves the QR Code capture definition by the WebCam as seen in [3] and the conceiving of how the captured image is validated and decrypted in the backend, allowing the access by the user. Later on, there will be the conceiving of the concept as well as the system's architecture which incorporates both platforms (hardware and software). The last step is the codification of all system modules, with validation and integration tests with a physical access device.

A. Access Control Device Conception

The access control system (Figure 1) is composed by an electric lock attached to a door and to a Webcam that reads the QR Code from the smartphone's screen. These devices work-integrated through a Raspberry Pi 2 microcontroller.

B. QR Code Image Conception

The QR Code is a two-dimensional barcode (Figure 2) which specifications state is used to encode any set of characters mapped by ISO4 8859-1. Widely diffused in mobile technologies, it is versatile and easy to implement. Besides all this, it is free to use.

According to the literature, two-dimensional barcodes are simple and cheap ways to represent commercial data, but it

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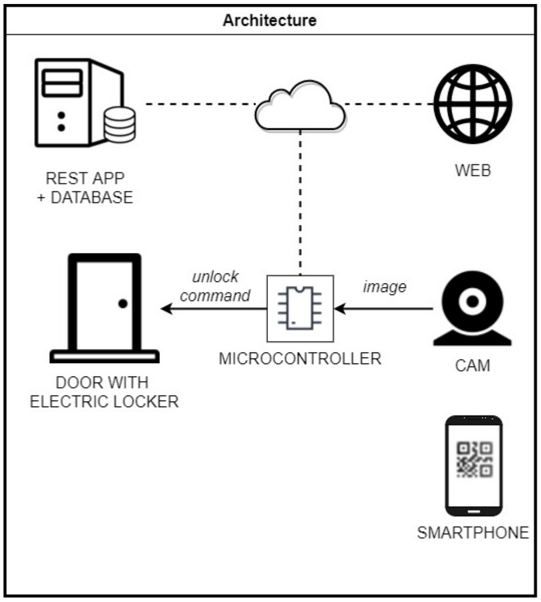

Figure 1. System's architecture proposed.

also improves mobile user experience by reducing the amount of manually input data [4].

The QR Code was developed by Denso Corporation in 1994, and it was acknowledged later as a usable standard. QR Code has been approved as a standard by ISO, JIS e AIM protocols as seen in [5] [6]. This standard has been widely used in a large variety of applications as the manufacture, logistics and sales applications. There are over 40 different QR Code versions, four levels of error correction and its maximum symbol size can encode 7089 numeric data or 4296 alphanumeric data. The QR Code images are captured by the cell phone camera. In most smartphones the images are captured in RGB 24 bit [7], but the QR Code symbol is a set of dark and light pixels, therefore it is needless to deal with color information making its reading and calculation quick [4].

Figure 2. QR Code image.

In this research, the QR Code is used to transmit the access information from the smartphone to the access control system. This information contains the following items: the unique device identification; user's access password; a system generated key; the date and time of the QR Code generation; and a hash [8] MD5 [9] in order to avoid access information corruption. In overview mode, all this information is encrypted using RSA [10] algorithm so that no QR Code reader or other application is able to interpret this information (see Figure 3).

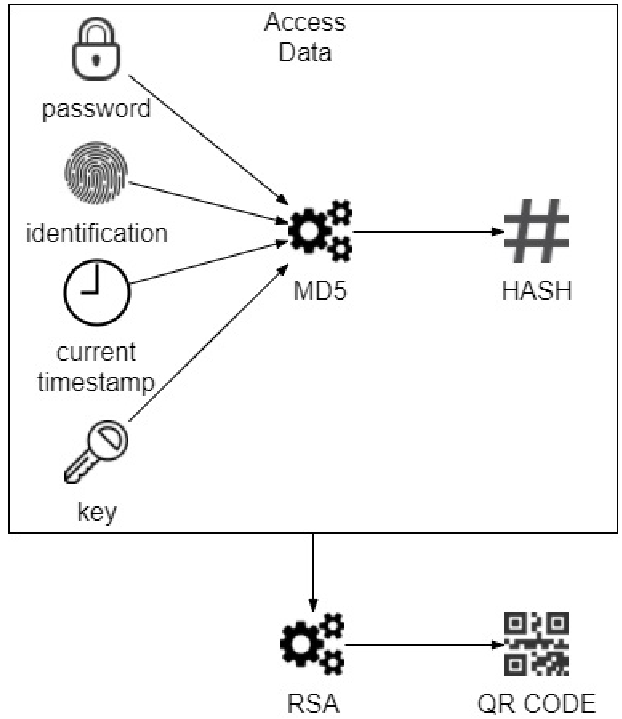

Figure 3. QR Code image generation.

C. Conceiving the Integrated System

The goal of this session is to define what components are necessary for the proper functioning of the systems, as well as the interaction between them. Five artefacts, at least, were identified in the validation and access liberation process: an access key, a sensor, a client, authentication service and a physical access device. The key is generated by the smartphone which generates the QR Code according to the previously mentioned procedure. The sensor is a WebCam positioned at the door disposed at any user's arm's range. At this point, it is important to consider any physical limitation that the user may have, such as: reduced hight, wheelchair or crutches also considering any possible motor disability in order to manage the QR Code reading. The WebCam is connected to the client and it is responsible for the reading of the QR Code on the mobile. The client is responsible for creating and maintaining this connection with the authentication service and door lock activation. On the authentication service module there are all the access rules and answers to the clients resulting in an allowed access or not.

The physical access device can either be an electric door lock, a vault, a ticket gate, a gate, or any other advice that has been already used as long as it allows electronic activation. According to Figure 4, the authentication process is configured in six steps, which are:

1 The application installed on the user's smartphone is responsible for creating and rendering the QR Code on its screen with the access information,

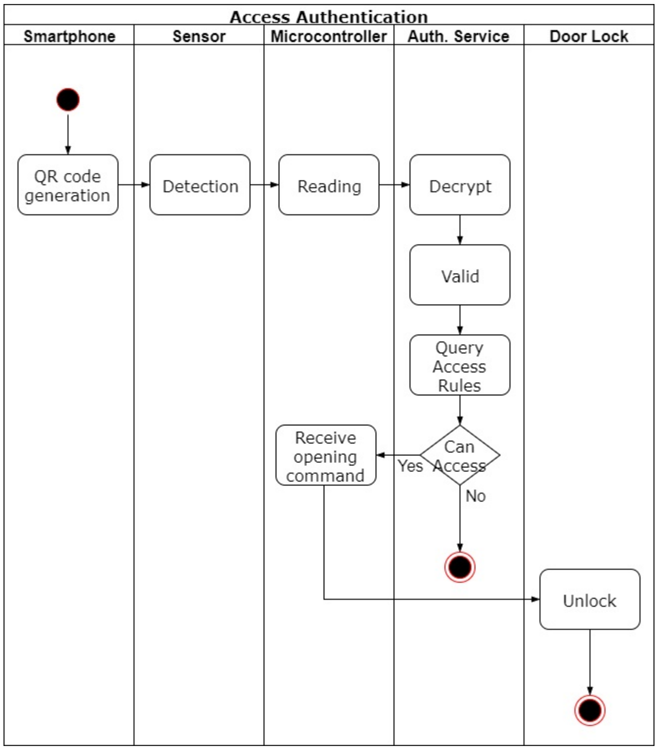

Figure 4. Access authentication flowchart.

2 The user's QR Code is then captured by the camera that transmits the image to the microcontroller.

3 Using image processing techniques on the user's QR Code, the microcontroller identifies the QR Code, reads its containing access information, and sends them to the authentication service.

4 The authentication service decodes the access information, validates the authenticity of the data, and checks within the access rules if the door must be opened or not.

5 In case the service identifies that the door must be opened, it sends the liberation request to the microcontroller attached to the door lock.

6 The microcontroller activates the door lock in order to open it.

III. Verification and Validation

After the conceived system a verification procedure is done in order to answer the question: "Are we building this system correctly?". In software engineering, this question is answered through tests at different levels, and with different techniques. The choice of the procedure was verified and based on its relevance inside the project as a way to soften the risks [11].

Firstly, this procedure verifies if it is viable to generate the QR Code with all the access data in a safe and reliable way. Next, it tests the microcontroller functioning, verifying if it complies with the project requirements, which are: working with a WebCam, QR Code reading, activation of electric devices, and establishing a connection with authentication services. And lastly, it runs the integration tests in order to validate the system functioning in its core parts.

Most importantly, it creates a simple server that implements login authentication and the WebSocket [12]. Then, it is built on a client on the camera's microcontroller. The QR Code is generated. And lastly, the integrated system is tested.

A. *QR Code Image Generation*

Concerning the verification of the QR Code generation it is used an unit test technique [11] validating the system input and output. We seek to find if it is possible to generate the QR Code inside the predefined security parameters:

1 Containing the basic authentication data, composed by device identification and password;

2 Containing date and time of QR Code generation;

3 Containing hash-based data to validate the information authenticity;

4 Encrypting all the data before the QR Code generation.

The access data encoding process is shown in Figure 5. The test input is an 8 digit identification code and a 10 digit password. This means that with the same pattern, it is possible to generate E+18 different combinations. The date and time of generation have minute precision, which means that it is possible to create a maximum tolerance between the QR Code generation and the authentication of up to one minute. After the input data is encoded, the MD5 algorithm is applied on the generation of a hash. Then, the first two bytes of the hash are concatenated at the end of the previously encoded data. This step is fundamental to the authentication service to verify if the access data hasn't been changed.

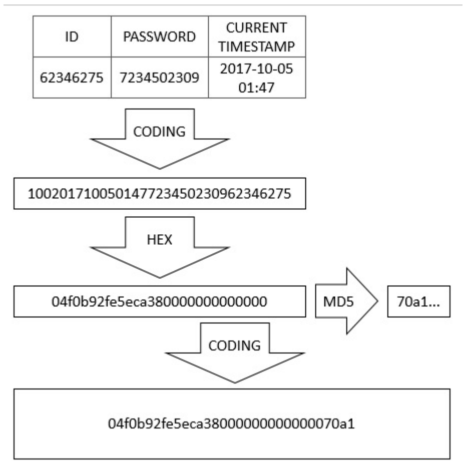

Figure 5. Access authentication flowchart.

Lastly, the data is encrypted with the RSA algorithm and encoded in base64 (Figure 6). The encryption is necessary so that no other QR Code is able to interpret its containing information. The base64 encoding is necessary because the RSA output is a set of bytes and the QR Code is generated from a text, as shown on Figure 7.

Thus, the output is a QR Code image (Figure 7) that can be easily read by the access control device and owns all the needed security characteristics of the project.

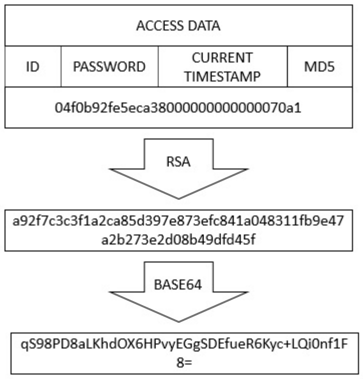

Figure 6. Access data encryption.

Figure 7. QR Code image generation.

B. Hardware to Access Control

The hardware engineering process can be seen in three phases: planning and specification; project and prototyping; production, distribution, and service field [11]. The first two phases are executed in this project.

The hardware requirement analysis is made in order to specify the functionality, interface, and performance requirements, for all the hardware components. The component validated in this step of the project is the access control device.

In prototyping, it is assembled a device to meet the requirements (Figure 8). It is possible to identify the following components:

- CC Power cable, 5 Volts and 2 Amperes with micro USB 2.0 type B connector (see Figure 8-1);
- Ethernet cable with RJ-45 connector, connected to the same network as the authentication service (see Figure 8-2);
- Microcontroller Raspberry Pi 2, with 900MHz processor, 2GB of RAM, e 8GB of ROM (see Figure 8-3);
- LEDs to indicate the system status of the door lock simulation system on a breadboard (see Figure 8-4) and
- Digital camera with 5 Megapixels resolution connected via USB (see Figure 8-5).

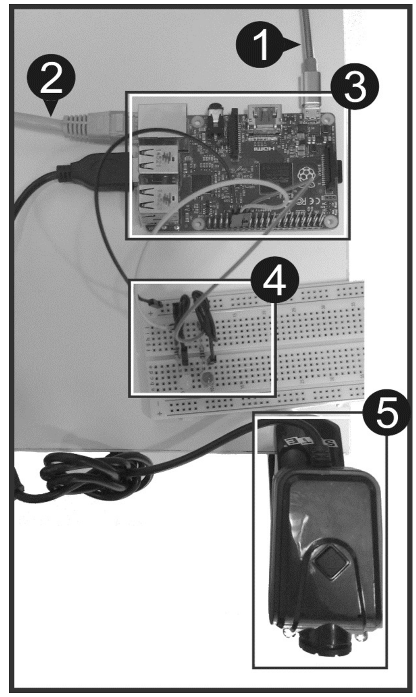

Figure 8. Assembled Device for testing.

After the prototype assembly, the function of each device part is verified through software executions. The camera functioning and QR Code reading competence are checked by Zbar Barcode Reader [13] as seen in Figure 9, it highlights the captured QR Code image inside a light green rectangular area. The configuration and network connectivity with the authentication service is done by a shell Telnet command that verifies not only the network layer but also the application layer.

And finally, a logical port microcontroller verification is done by an embedded programming that connects LEDs on microcontroller ports and executes a written script in Python language [14] using RPi, GPIO library, as seen in Figures 10 and 11. As a result, it is possible to see that the hardware requirements are met by the assembled device.

C. Integration Test

The integration tests aim to verify if the individual system modules work properly when running combined [11]. It also tests if the interfaces that interconnect the components work with an error level below allowed. So, all the components created in the previous sections are used in this test. The QR code generated is rendered on the smartphone screen in front of the device's camera.

The access data is then captured and sent to the server who decodes and validates if the access is allowed and returns an authorization message to the door lock, or in this experiment case, activating the LED. All these tests data are obtained through the logs shown in the screen connected to the microcontroller.

It is possible to see all microcontrollers processing through the logs sent to the client screen in Figure 10. Firstly, the device logins the server sending user data and password. Afterward, it

Figure 9. The camera capture the QR Code image.

```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
```

Figure 10. Python script to verify the logic port.

```
GPIO.setup(18, GPIO.OUT)
print("LED on")
GPIO.output(18, GPIO.HIGH)
time.sleep(1)
print("LED off")
GPIO.output(18, GPIO.LOW)
```

Figure 11. Python script python to verify the logic port.

```
qrcdoor-embedded/src $ python3 main.py
Connecting to server by websocket
Creating session
URL: "http://192.168.1.3:8070/login"
PAYLOAD: "{'password': 'user1', 'username'
Sending data to server
Server's response
URL: "http://192.168.1.3:8070/login"
RESPONSE: "<Response [200]>"
Cheking session
URL: "http://192.168.1.3:8070"
RESPONSE: "<Response [200]>"
Session valid
COOKIES: "{'SESSION': '41341f27-4c60-41db-
URL: "ws://192.168.1.3:8070/open/websocket
COOKIE: "SESSION=41341f27-4c60-41db-9019-3
WS connection has been opened
Sending QR code:
QR-Code:Bzhshsjsjjdhhddjdjhdhdjdjxj
A message has been received:
Hello, QR-Code:Bzhshsjsjjdhhddjdjhdhdjdjxj
```

Figure 12. View from Microcontroller logs.

opens a WebSocket connection to exchange messages referring to the door lock (Figure 12). As soon as it detects and extracts the access data from the QR Code, the system sends information to the server. And lastly, after the server decrypt and validates the data, it notifies the client that the door lock must be activated. Finally, it is certified that the component integration has been well succeeded.

Considering the problems encountered during the development of this project, there were many implementation difficulties in programming the communication of the door microcontroller with the server. And this was solved, with the improvement and refinements of the embedded system algorithms, in a stable direction.

This project was established quickly, and it is part of a larger project, entitled Smart Door [15], which has as relevance the proposed web system that manages doors and users, the use of RFID technology to access the door with use of key tags and also the use of Android technology resources to establish a communication to the door. Finally, the combination of all these technologies is not yet available on the marketplace, making out of this project a very relevant one.

IV. CONCLUSION

As the access to mobile technologies is becoming more and more common, and the regular locks need physical keys (which can be lost or stolen), digital locks offer more safety and simplicity. In this paper, we propose using simpler, cheaper, and consolidated technologies, creating virtual embedded keys in smartphones. Using this gadget that is already inserted in daily life to perform one or more tasks, replacing physical keys. The Raspberry Pi 2 has entry for one single camera, or via USB, making this project's assembly more accessible.

The QRCDoor project consists of the creation of a web client and a mobile application, conceiving the door access device, which involves the definition and capture of the QR Code image by the mobile camera. The elaboration of the system architecture, integrating all proposed platforms were validated. Finally, we have the coding of all system modules, with validation tests, and integrating with the physical access control device. Thus, all goals of this research have been reached.

Controlling access is a present-day problem. The access control available depends on a human direct intervention, where the user is registered in a system and receives a physical card that grants him the access, this card can be easily lost or stolen. The QRCDoor innovates it by making the control digital and embedding the access keys and cards in a smartphone. Making it possible to create complex access rules to places with specific date and time and also allows an easy identification and access key control. Therefore, another relevance for this research is that the proposed system makes daily life more practical for home and professional environments.

In the future, with the new QRCDoor modules, the intention is to make everyday life, even simpler, by also making access to private events digital, eliminating the use of traditional keys and cards.

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