

Tobias Baumgärtner

A Software Framework for Mobile Apps in the Museum Application Domain

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Tobias Baumgärtner

A Software Framework for Mobile Apps in the Museum Application Domain

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Preface

This section ties together the particular structures surrounding the overall research project. It summarizes the intent of the ViSIT project, the relevance of the overall undertaking, and the transposition between the practical and scientific perspectives. The stage for the dissertation is set by highlighting the contiguity between the domains and communities involved.

Domains and Communities

The inevitable influence of information technology and digital devices has reached most sectors of today's society. When researching the impact of such systems, the perspective needs to be adjusted for the characteristics of a specific field's contextual environment and its stakeholders. This has led to multiple transdisciplinary actors trying to absorb the emerging possibilities and their dependencies into their own domain knowledge.

Putting the focus on the context at hand—museums—Marty and Burton Jones (2008) describe the field of *Museums Informatics* to examine the “socio-technical interactions of people, information, and technology in museums” (Marty and Burton Jones, p. 274, 2008). In doing that, they try to capture the complexity and govern the flow of information at the juncture between experts and visitors on both theoretical and practical levels. The relevant aspects are representation, organization, and access to information as well as the enabling technologies.

Those insights were connected to only the individual data layer for a long time. However, that drastically changed with the introduction of the internet. It was no longer possible to conceal those considerations to just one singular institution. The aspects of sharing and interaction became inevitable. That makes it

mandatory to build strong communities and to develop ways to enable automated exchange between their members.

The progress on this end is already quite far advanced from the technical perspective, as data models, platforms, and task-specific systems are available. Advances in standards in the data persistence and exchange layer may help to incorporate smarter systems, but that does not account for institutions on the strategic or operational level. The transfer of the lessons learned, extracting existing best practices, and accessing available knowledge should be more of a concern to making them widely available for as many members within the domain as possible (Marty & Burton Jones, 2008).

Similarly, the focus of *Digital Humanities* initially has been pointed toward incorporating digital tools and archives as well as advanced analytical methods to the increasing demand of their respective fields. However, the scope opened up by the rapid advances in technology and its general availability. Now “it can at times be difficult to determine with any specificity what, precisely, digital humanities work entails” (Gold & Klein, 2016). That leads to the construct referred to as the “big tent” accounting for the interdisciplinary influence and the growing emphasis on information and communication technology in practice, outside of archives (Warwick, et al., 2011).

With the further evolution of technology, ubiquitous user-centered systems and applications need to get even more attention. The conception, development, and implementation of these are core components of *Information System Research*. Knowledge and process management are advanced in this field alongside human-computer interaction. Supplying users and technical systems with information by incorporating application programming and graphical user interfaces, this field tries to develop and connect the economic questions to their technological solutions (Mertens, et al., 2001) (Stormer, Meier, & Lehner, 2005).

Information Systems Research, therefore, provides the ideal methodological foundation if the goal is to design a holistic and sustainable Software Framework for Mobile Apps in the Museum Application Domain (Stein, Galliers, & Whitley, 2016).

This dissertation has been accompanied by four paper publications and one demonstration, highlighting the practical relevance and scientific foundation of the conducted research. In that regard, both the intrinsic entity of the scientific domain within Information Systems Research and the practical community of museum professionals surrounding the online presence of cultural heritage institutions have been included:

- ‘Museums and the Web’ (MW) is the largest international conference devoted to the exploration of art, science, and natural and cultural heritage online. It was founded by ‘Archives & Museum Informatics’ in 1997 and is still hosted annually by the ‘MuseWeb Foundation’ an offshoot of the ‘Museum and the Web LLC.’ with the goal of transforming the business of culture.
- The European Conference on Information Systems (ECIS) is considered the premier Information Systems event in the European region. It is affiliated with the Association for Information Systems (AIS) and has been held annually since 1993.

Preceding Publications and Presentations

The following publications were accepted by their peers, and each has been presented to the respective audiences of the practical and/or scientific community. The results of these manuscripts are, in part, included within this dissertation.

The Technical Aspects of Museum Information vs. the Museum Professional’s Point of View: A Conceptual Change of Perspective on Data Processing.

Baumgaertner, T. & Lehner F. (2017).
Proceedings of the 21st Museums and the Web conference (MW17),
Cleveland, Ohio, USA, April 19–22, 2017.
Published February 16, 2017.



Entwicklung mobiler Applikationen im Anwendungsbereich von Museen— Customer Experience Value Chain.

Baumgärtner, T. & Lehner, F., (2017).
HMD Praxis der Wirtschaftsinformatik: Vol. 54,
No. 5.
Springer Fachmedien Wiesbaden. (S. 808-820).
<https://doi.org/10.1365/s40702-017-0350-1>



**Introducing Socio-Technical Changes through
“Mobile First” in the Museum Application
Domain.**

Baumgaertner, T. (2018).
Proceedings of the 22nd Museums and the Web
conference (MW18),
Vancouver, British Columbia, Canada, April
18-21, 2018.
Published February 15, 2018.



**A Software Framework for Mobile Apps
within the Museum Application Domain.**

Baumgaertner, T. (2019).
Demonstration at the 23rd Museums and the Web
conference (MW19),
Boston, Massachusetts, USA, April 2–6, 2019.



**Conceptualizing a Mobile App Framework
For the Museum Application Domain.**

Baumgärtner, Tobias. (2019).
Proceedings of the 27th European Conference on
Information Systems (ECIS), Stockholm & Uppsala,
Sweden, June 8–14, 2019.
ISBN 978-1-7336325-0-8 Research Papers.



The ViSIT Project

This dissertation has been accompanied by the project with the title ‘Virtuelle Verbund-Systeme und Informations-Technologien für die touristische Erschließung von kulturellem Erbe’ (ViSIT). The project has been funded by

the INTERREG programme ‘V-A Bayern-Österreich 2014–2020’ enabled by the ‘European Regional Development Fund’ (ERDF).

That fund focuses its investments on the ‘thematic concentration’ within these priority areas:

- Innovation and Research
- The Digital Agenda
- Support for Small and Medium-Sized Enterprises (SMEs)
- The Low-Carbon Economy

ViSIT highlights the cultural area lined out by the three rivers Inn, Salzach, and the Danube. That territory has been historically defined by the salt trade, dating back to the beginning of the 11th century, as well as the Prince-(Arch-)Bishoprics of Salzburg and Passau. Thus, the territory has a strong connection, characterized by its rich historico-cultural heritage.

Within the focal scope of ViSIT was the visitor experience to be generated, especially in alignment with the development of partnerships between institutions. Among other integral projects, the development of *A Software Framework for Mobile Apps in the Museum Application Domain* has been a pivotal element.

Tobias Baumgärtner

Executive Summary

The popularity of mobile applications has been ever-increasing since their conception in 2007. Structural changes related to digital transformation and tourism significantly impact the expectations of and toward cultural heritage institutions associated with the subject of apps. The overall role of museums has shifted from a keeper of artifacts to a provider of information.

The intention of those apps is to generate added value for the visitor, who therefore is mainly seen as the primary element of any associated reflection related to the experience that is created while interacting with that mobile application. Nevertheless, the cohesion between an application's creator, the application's content, and the consumer operating the app in a designated context needs to be appropriately examined.

Looking at the specific customer touch-point provided by mobile applications, it is not trivial to create such an integrated user experience. Those apps can be drivers for digital transformation and strategic alignment of historico-cultural institutions. However, the mandatory insights and know-how necessary to create such experiences are not at all related to the core skill set of museum professionals or the existing processes within those institutions. That makes it quite challenging to implement an overall (digital) strategy that enables institutions to provide interactive applications based on structured data in addition to their core tasks.

Especially in the context of museums, it is necessary to simultaneously cater to different perspectives to provide a coherent digital experience to both the visitor and the museum professional. Based on insights gained during this examination and under the utilization of design science research, human-centered design, and domain-driven design, *A Software Framework for Mobile Apps in the*

Museum Application Domain is created, and a prototype implementation using web technologies is developed throughout this dissertation.

The resulting Page CUBE Content Representation (PCCR) application framework intends to act as an entry point to the digital realm for museum professionals. The development of mobile applications is the anchor for digitization and acts as a starting point to further examine the properties of mobile applications, specifically within the Museum Application Domain, in the future.

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Abbreviations

ACID	Atomicity, Consistency, Isolation, and Durability
AIS	Association for Information Systems
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
AR	Augmented Reality
ARIA	Web Accessibility Initiative's Accessible Rich Internet Applications
BASE	Base Availability, Soft state, and Eventually consistent
BITA	Business-IT-Alignment
BYOD	Bring Your Own Device
CBT	Computer-Based Training
CRM	Conceptual Reference Model
CRUD	Create, Read, Update, and Delete
CUBE	Composition Ubiquity Building Element
DBMS	DataBase Management System
DDD	Domain-Driven Design
DOM	Document Object Model
DSR	Design Science Research
ECIS	European Conference on Information Systems
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HTTP	HyperText Transfer Protocol
ICOM	International Council of Museums
ICT	Information and Communication Technology
IDE	Integrated Development Environment
JSON	JavaScript Object Notation

LIDO	Lightweight Information Describing Objects
LOD	Linked Open Data
MAD	Museum Application Domain
MoMA	Museum of Modern Art
MRT	Magnetic Resonance Tomography
MV*	Model-View-Star
MVC	Model-View-Controller
MVP	Minimal Viable Prototype
MVVM	Model-View-ViewModel
MW	Museum and the Web
OLAP	OnLine Analytical Processing
OLTP	OnLine Transaction Processing
OS	Operating System
PC	Personal Computer
PDA	Personal Digital Assistant
RDF	Resource Description Framework
REST	Representational State Transfer
SDK	Software Development Kit
SEO	Search Engine Optimization
SME	Small and Medium-sized Enterprises
SOA	Service-Oriented Architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
UNESCO	United Nations Educational, Scientific and Cultural Organization
URI	Uniform Resource Identifier
UX	User Experience
ViSIT	[Project Name Recronym]
VR	Virtual Reality
W3C	World Wide Web Consortium
WHATWG	Web Hypertext Application Technology Working Group
WWW	World Wide Web
WYSIWYG	What You See Is What You Get
XML	Extensible Markup Language
XSS	cross-site scripting

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Introduction and Structure of the Thesis

1

The dissertation entails nine chapters. In this introduction, each chapter is briefly described to provide a general overview of the manuscript and its fundamental structure, presented in **Figure 1.1**. The reasoning and motivation for the investigation in the context of the Museum Application Domain (MAD) are provided. The proposed research setup is underlined along the conceptual foundation of the Software Framework for Mobile Apps in the Museum Application Domain and the resulting prototype implementation.

Across all domains, information and communication technology (ICT) exerts its influence on value-oriented institutions, on how they operate, and on the manner, they interact with their customers. The impulses involved often create a precedent to spill over demand into other domains. Like the case within cultural heritage institutions, those may initially not be equipped to adopt certain innovations. Proposals are often not reflected in their intended situation or are obstructed by other intrinsic or extrinsic restrictions, like societal implications or the capabilities accessible within the target domain.

To shape an understanding of the current landscape and possible issues, data available from German museums gathered between 2008 and 2018 has been analyzed. The greatest impacts today originate from digitization, mobile technologies, and tourism. These factors contribute to the field of tension surrounding the institutions in question (*Chapter 2—Motivation*).

The identity coined by the historic role of cultural heritage institutions and the inherently embedded collection-based processes museum professionals were primarily occupied with in the past do not reflect the modern profile established by the shift of focus within their societal tasks. While museums were able to provide technology-based aid for their visitors in the past, the increasing complexity and pace of innovation make it difficult to keep up with the state of the art. These issues weigh even greater in smaller institutions, which struggle to provide

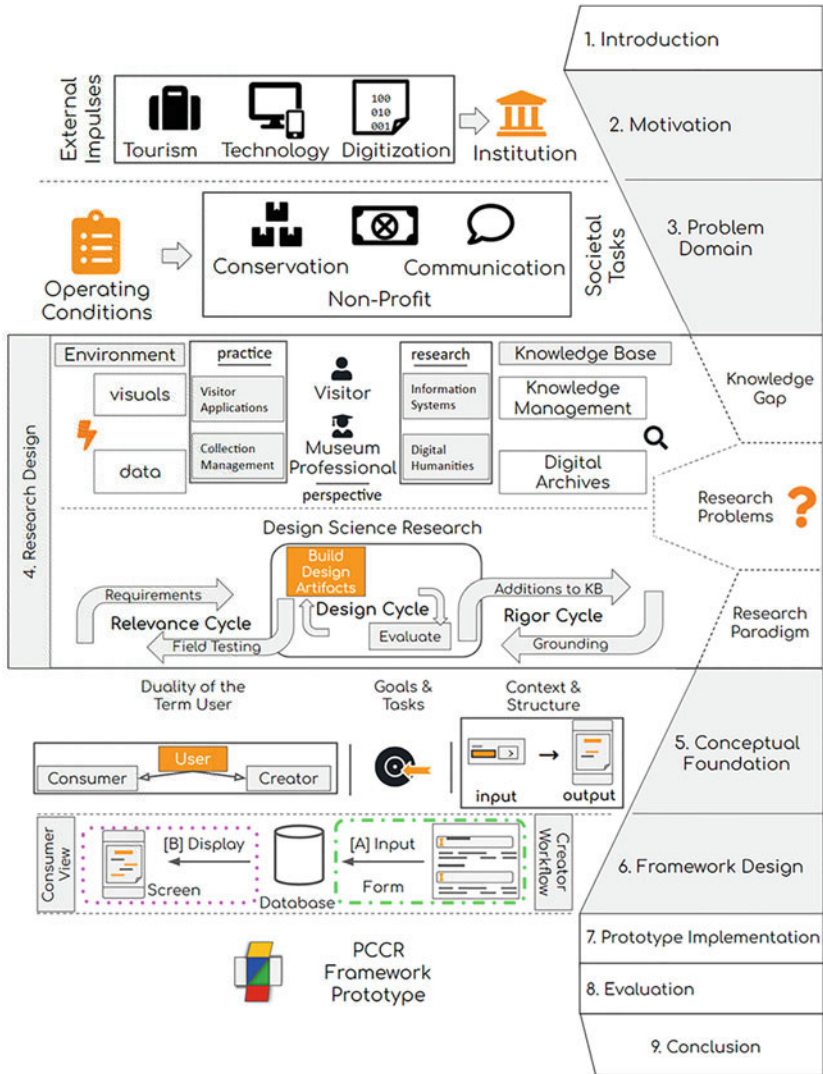


Figure 1.1 Visual Abstract

the required resources to maintain a holistic strategy because they do not have access to an entry point to introduce digital products like mobile applications, nor the required aides to access or obtain the knowledge to develop, deploy, and distribute potential solutions (*Chapter 3—The Problem Domain*).

The conflicts within the MAD are multi-dimensional. The most obvious is the usual barrier between research and practice, which might not appear to be most relevant in the application-oriented scenario, but perfectly illustrates the skew of perspective as well as the existing gaps and deficits within the domain. While the internal processes of museum professionals are primarily motivated by the conservation of knowledge and artifacts for the purpose of scholarly work, they tend to focus on tasks to fit their agenda, involving organizing their findings and archiving their existing collections. From the outside view, the museum audience, by contrast, desires to experience collections in an informative and entertaining fashion, being able to interact more directly with the artifacts decoupled from the associated scientific foundation. Thus, data must be collected in a manner to satisfy both perspectives without creating overhead on top of the processes necessary between data inquiry and presentation (*Section 4.1—Problem Areas*). Those challenges are reflected in the leading research motive:

“How to provide guidance for small cultural heritage institutions to govern digital transformation, and how to align the possibilities with the available capabilities by creating A Software Framework for Mobile Apps in the Museum Application Domain?”

This question is dissected into three separate research problems (*Section 4.2—Research Problems*) to be approached by applying a design science research approach with the intent to build a robust domain artifact (*Section 4.3—Research Paradigm*).

To instigate the process, certain important terms need to be distinguished. That includes defining the conceptual idea of a framework, how content is perceived in relation to information, which is to be presented to the consumer, and the elements of human-centered design. To further advance that holistic inspection, those conceptual components need to be extended by the psychological foundation obligatory for genuine user experience design. One of the most central postulations is the conceptual difference in how the term user is applied to the observation, which influences application design. It is crucial to understand that the needs related to information systems involved in mobile content delivery do not only include the consumer but the creator as well. The attention usually exclusively put on the consumer-facing product needs to be extended to the structure and the context of the data entry process itself, which the creator is bound to interact with initially. Facilitating the dedicated understanding of the conceptual

foundation the whole system is based upon creates immediate opportunities for the individual and produces long-term benefits for the whole organization. Finally, the essence of the presented composition is aligned with the conceptual foundation characteristic for system development (*Chapter 5—Conceptual Foundation*). This does conclude the purely theoretical inspection of the underlying issues and commences the transition toward the design and development of the Software Framework for Mobile Applications in the Museum Application Domain.

The concepts of domain-driven design are introduced to set up the framework design process. The central ideas behind the initial design iterations and the insights gained within each of those loops are summarized before the final design is introduced. The foundation for the realization of the framework is discussed based on the processes and roles involved. The architectural model chosen for the framework is used as a scaffold for introducing the fundamental concepts, which tie together the user interface and the data model. The core system design accommodates the resulting consumer app pages as an anchor for all creator tasks. That makes it possible to approach the available features from each perspective independently (*Chapter 6—Framework Design*).

The technology necessary for the prototype implementation of the framework as a web application is introduced alongside the tools and services applied and used during the entire development process (*Chapter 7—Prototype Development*).

The episodes of the evaluation process are then described, supported by the pivotal guidelines from within the research approach. The suggestions received by different users and the related improvements achieved during the trial are compiled to represent the adaptability and extensibility of the framework scope (*Chapter 8—Evaluation*).

To conclude the thesis, the main findings are summarized. Further research potential is pointed out and is encouraged based on the presented results (*Conclusion*).



This chapter presents the central impressions surrounding the subject environment of the Museum Application Domain. To warrant the investigation and provide a frame of reference, first, some longitudinal data about museum visits in Germany over the past decade is being analyzed (*Section 2.1—Museum Visits in Germany*).

The motivational setup for the thesis is provided by analyzing the three central themes between digital transformation (*Section 2.2—Digital Transformation*), mobile technologies (*Section 2.3—Mobile Technologies*), and tourism (*Section 2.4—Tourism*). These three external impulses are most relevant for the perception of the subject environment and how its assignments are being framed, approached, and processed. Those topics are presented in **Figure 2.1** and further described below.

The major impact of digital transformation does affect the inside view (*Section 3.1*), controlled by inherent domain processes (*Subsection 3.1.1*) as well as the goals and tasks of the museum professional (*Subsection 3.1.2*). Historically the museum identity has been dominated by collecting and conserving historic artifacts, while in the 20th century, the focus of the societal tasks stemming from the institutional assignments has shifted toward communication. Systemically, that does lead to a conflict today in the 21st century.

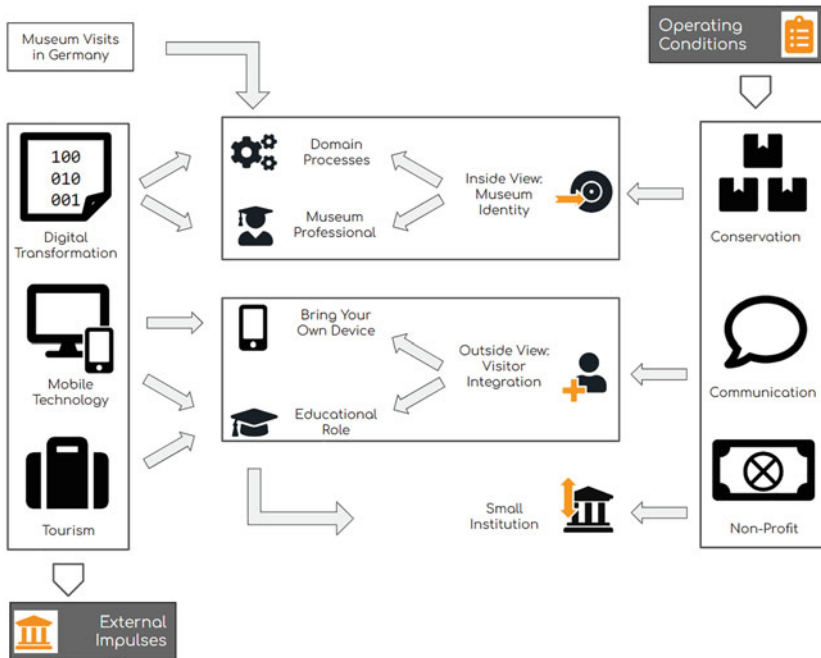


Figure 2.1 Relationship between External Impulses and Operating Conditions

On the one side, the museum professional's inside perspective and the domain processes are coined by conservation, which often translates to digitization projects being directed toward archiving and similar purposes or fully disregarded without establishing any middle ground.

Conversely, the audience structure grows increasingly heterogeneous and becomes more conscious while less centered. In general, the outside view (Section 3.2) shifted from a historically academic circle focused on scholarly work to a more casual consumer. These visitors, who approach the learning environment provided by the museum's educational role (Subsection 3.2.1) seeking entertainment, need to be integrated with the institutional context. They are still motivated by the physical museum experience. However, the shifts touristic encounters have experienced across the board as well as recent developments in mobile technology, exert immense pressure on the content authored and published by cultural heritage institutions. Visitors have developed the desire to have access