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Authoring of Multimedia Content: A Survey of 20 Years of Research

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Multimedia has been one of the buzzwords in the mid nineties. Since then, it has not decreased in interest but rather has become ubiquitous part of our environment. Thus, today high quality playback of images, audio, and video has entered numerous application domains and is available on various devices including advertisement screens at train stations, infoscreens in elevators, and mobile devices like cell phones. Authoring of multimedia content, i. e., creating content has been investigated for about two decades now. In this chapter, we investigate the different authoring support that has been developed in the past. Based on an earlier study [131], we conduct an extensive analysis and provide a classification and comparison of the existing authoring support.

This survey helps not only in better understanding the existing support and approaches for authoring personalized multimedia content but also enables assessing future work.

1.1 Introduction and Overview

The notion of multimedia is ambiguous. Basically, multimedia is considered the composition of the words “multi” (multiple) and “media”. This means that multimedia is the combination and usage of multiple media. A medium can be either discrete or continuous, determined by its medium type. While multimedia content represents the composition of different media assets into a coherent multimedia presentation, multimedia content authoring is the process in which this presentation is actually created. Todays multimedia applications need to provide personalized content that actually meets the individual users needs and requirements. This means that the multimedia content must reflect the users situation, interests, and preferences, as well as the heterogeneous network infrastructure and (mobile) end device settings. Consequently, personalization is considered as a shift from a one-size-fits-all to a very individual and personal provision of content by the application to the end users. The term personalization often appears together with the term of customization. However, the distinction between the both is not always clear, often intermixed, and sometimes considered equal or interchangeable. However, we clearly distinguish between the notion of personalization and customization and will show that this distinction is not a mere academic one but provides for defining two different application families, the customized applications and the personalized applications. This is due to the different requirements customized and personalized applications have to implement their functionality. Finally, authoring is the process of selecting and composing media assets into multimedia content, i. e., into a coherent, continuous multimedia presentation that best reflects the needs, requirements, and system environment of the individual user. Typically, the result is a multimedia presentation targeted at a certain user group in a specific technical or social context.

The book chapter provides an extensive review of todays support for authoring and personalizing multimedia content. We first present our notion of media and multimedia in Section 1.2. In Section 1.3, the notion of multimedia documents, multimedia document models, and multimedia formats are introduced. In addition, the central modeling characteristics of multimedia content are identified and presented, namely time, space, and interaction. These definitions lay the foundations for understanding the notion of multimedia content authoring introduced in Section 1.5. In Section 1.6, the different aspects of personalization are presented and our understanding of authoring personalized multimedia content is introduced. Subsequently, we review the state-of-theart in the field of multimedia content authoring and personalizing multimedia content in Section 1.8. To this end, we systematically present and analyze the existing approaches and systems for multimedia authoring. Finally, we categorize and compare the different authoring support and authoring approaches for multimedia content, before we conclude this chapter.

1.2 Notion of Media and Multimedia

Multimedia is the composition of the terms "multi" and "media" [143, 92]. It is the combination and usage of multiple media [113]. A medium can be either *discrete* or *continuous*, depending on its medium type (or medium form [77, 98]). Examples of media types for discrete media are text and image, e. g., computer graphics and pictures taken from a digital camera. They do not change in time. Discrete media types are also called time-independent [20, 143], time-invariant [71], and non-temporal [70], respectively. On the contrary, continuous media objects naturally change in time like the media types audio, video, and animation (cf. [55]). These media objects are time-dependent [20, 143], time-variant [71], and temporal [70], respectively. An instance of such a medium type is called a medium asset.

Summarizing the discussion above, multimedia can be seen as the interactive conveyance of information that includes (a seamless integration of) at least two media assets that are of two media types [77, 147]. A frequently cited, extended definition of multimedia by Steinmetz et al. [143, 78] requires the use of at least one continuous medium type and one discrete medium type. The definition also considers further aspects of multimedia with respect to storage and communication. This leads to a definition of multimedia that is characterized by the computer-controlled, integrated creation, manipulation (i. e., interaction of the user with the media), presentation, storage, and communication of independent information [143]. This independent (multimedia) information is encoded at least through one continuous medium type and one discrete medium type [143].

1.3 Multimedia Document Models and Formats

The composition of different media assets such as images, text, audio, and video in an interactive, coherent multimedia presentation is the multimedia content or multimedia document (also called multimedia object [18]). Features of such a multimedia document are the temporal arrangement of its media assets in a temporal course, the spatial arrangement of the assets, and the definition of its interaction features. A multimedia document is an instantiation of a multimedia document model. A document model provides the primitives to capture the aspects of a multimedia document as sketched above. A multimedia document that is composed in advance to its rendering is called pre-orchestrated in contrast to compositions that take place just before rendering that are called live or on-the-fly. A context-aware multimodal document model is presented by Celentano and Gaggi [43]. It allows for a rule-based approach for specifying different ways how multimodal information is presented to a user in a specific context.

A multimedia format defines the syntax for representing a multimedia document for the purpose of exchange and rendering. Since every multimedia format implicitly or explicitly follows a multimedia document model, it can also be seen as a proper means to "serialize" the multimedia document's representation for the purpose of exchange. Examples of multimedia formats are the World Wide Web Consortium (W3C) standards SMIL [40, 41], SVG [146], and HTML 5 [157], the International Organization for Standardization (ISO) standard Lightweight Applications Scene Representation (LASeR) [82, 83], and proprietary multimedia formats such as the wide spread Flash format [5]. Finally, a multimedia presentation is the rendering of a multimedia document to an end user. For a more detailed discussion and definition of the terminology, we refer to the literature such as [131].

1.4 Central Aspects of Multimedia Documents: Time, Space, and Interaction

The expressiveness of a multimedia document model, i. e., the primitives it defines, determines the degree of functionality the multimedia documents can provide. These central features or central aspects [133] are the temporal course, spatial layout, and interaction possibilities of a multimedia presentation, i. e., how users can interact with the document [23, 26, 81, 80, 86, 125, 97]. We present an overview of these central aspects. For further discussions, we refer the reader to [133, 23, 26].

- Temporal course: A temporal model describes the temporal arrangement of media assets defined in a multimedia document [26, 25, 86, 66, 106]. With the temporal model, the temporal course such as the parallel presentation of two videos or the ending of a video presentation on a mouse-click event can be described. One can find four types of temporal models: point-based temporal models, interval-based temporal models [107, 11], enhanced interval-based temporal models that can handle time intervals of unknown duration [52, 79, 158], event-based temporal models [19], and script-based implementations of temporal relations [146]. The multimedia formats we find today implement different temporal models, e. g., SMIL 1.0 [35] and Flash provide an interval-based temporal model only, while SMIL 2.0 [19] also supports an event-based time model.

- Spatial layout: Not only the temporal synchronization of the media assets is of interest in a multimedia document but also the spatial arrangement of the assets on the presentation canvas [17]. The positioning of visual media assets in the multimedia document can be expressed by the use of a spatial model. It defines the spatial organization, i. e., the spatial positioning of the visual assets [26, 25, 86]. For example, one can place an image above a caption or define the overlapping of two visual media assets. Besides the arrangement of media assets in the presentation also the spatial layout is defined in the document. In general, three approaches to spatial models can be distinguished: absolute positioning, directional relations [118, 117], and topological relations [53]. The absolute positioning of media assets with respect to the origin of the coordinate system can be found, e. g., with Flash [5] and SMIL 2.0 in the Basic Language Profile (BLP) profile [19], while relative positioning is provided, e. g., by SMIL 2.0 [19] and SVG 1.2 [146].

- Interaction possibilities: The third central aspect of a multimedia document model is the ability to specify user interactions. The interaction model allows the users to choose between different presentation paths [25]. Multimedia documents without user interaction are not very interesting as the course of their presentation is exactly known in advance and, hence, could be recorded as movie. With interaction models a user can, e. g., select or repeat parts of presentations, speed up a movie presentation, or change the visual appearance. For modeling user interaction, one can identify at least three basic types of interaction [25]: navigational interactions, scaling interactions, and movie interactions. Navigational interaction provides for control of the flow of a multimedia presentation. It allows the selection of one out of many presentation paths and is supported by all multimedia document models (cf. hyperlink in [86]). Scaling interaction and movie interaction allow the users to interactively manipulate the visible and audible layout of a presentation [23, 26]. For example, one can define if a user is allowed to change the presentation's volume or spatial dimensions. Scaling interaction and movie interaction are rarely used or not defined within today's multimedia documents. Typically, such type of interaction rely on the functionality offered by the actual multimedia player used for playback of the presentation.

Looking at the existing multimedia document models both in industry and research, one can see that these aspects of multimedia content are implemented in two ways: The standardized formats and research models typically implement time, space, and interaction in different variants in a structured fashion as can be found with SMIL 2.0, HTML+TIME [136], SVG 1.2, Madeus [88, 89], and ZYX [23] employing the Extensible Markup Language (XML) [32]. Proprietary approaches, represent or program these aspects in an internal model such as the Flash format [5]. Examples of (abstract) multimedia document models in research are Madeus [88, 89], Amsterdam Hypermedia Model [73, 75], CMIF [39], ZYX [23, 22], and MM4U [134, 133], which is based on ZYX.

1.5 Authoring of Multimedia Content

While a multimedia document represents the composition of different media assets into a coherent multimedia presentation, multimedia content authoring is the process in which the multimedia document is actually created. The process of multimedia content authoring involves parties from different fields including domain experts, media designers, and multimedia authors. Domain experts provide their specific knowledge in the field such as biology or sociology. The input from the domain expert is used by the media designers to create a storyboard of the intended multimedia document or set of multimedia documents, e. g., in form of an interactive multimedia application. Figure 1.1 depicts an example storyboard for the highly-interactive multimedia-based e-learning tool GenLab [130]. The virtual laboratory GenLab[1] allows students of genetics engineering to conduct experiments without risks using the computer and preparing themselves for a real laboratory work.

Besides creating a storyboard of a multimedia document together with the domain experts, the media designers also create, process, and edit the media assets required for the multimedia document. To this end, the storyboard is used as basis to create a list of required media assets and to plan the implementation of the multimedia content. Finally, multimedia authors compose and assemble the preprocessed and prepared media assets into the final multimedia document. This composition and assembly task is typically supported by professional multimedia development programs, so-called authoring software or authoring tools (see Section 1.8.1). Such tools allow for the manual (possibly assisted or wizard-based) composition and assembly of the media assets into an interactive multimedia document via a graphical user interface. If the multimedia document needs to be programmed using authoring tools, the media authors are often computer scientists. The implementation of the storyboard of the virtual laboratory GenLab is shown in the screenshot of Figure 1.2.

Even though we have described the authoring of multimedia content as a sequential process, it typically includes cycles. In addition, the expertise of

[1] `http://virtual-labs.org`, last accessed: 20/1/2013

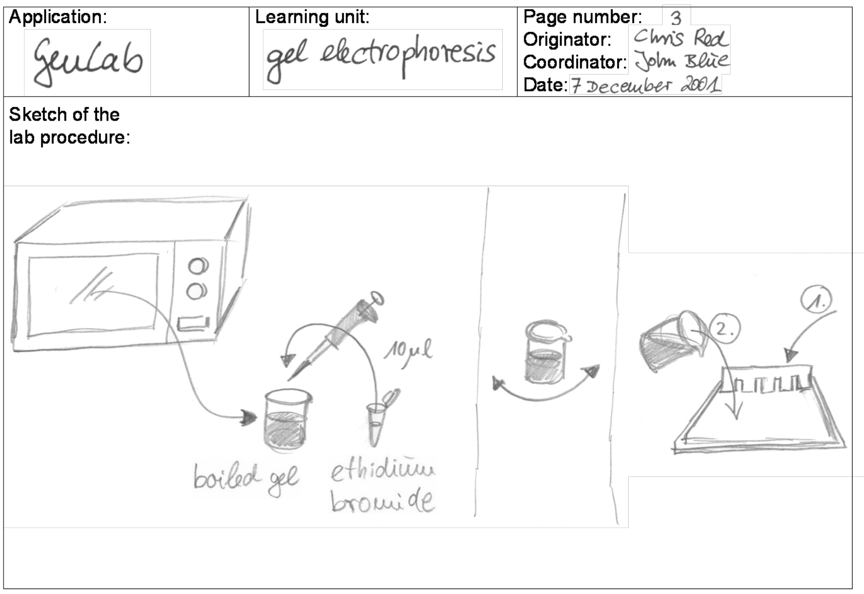

FIGURE 1.1
Example of the storyboard of the highly-interactive multimedia application GenLab (taken from [130]).

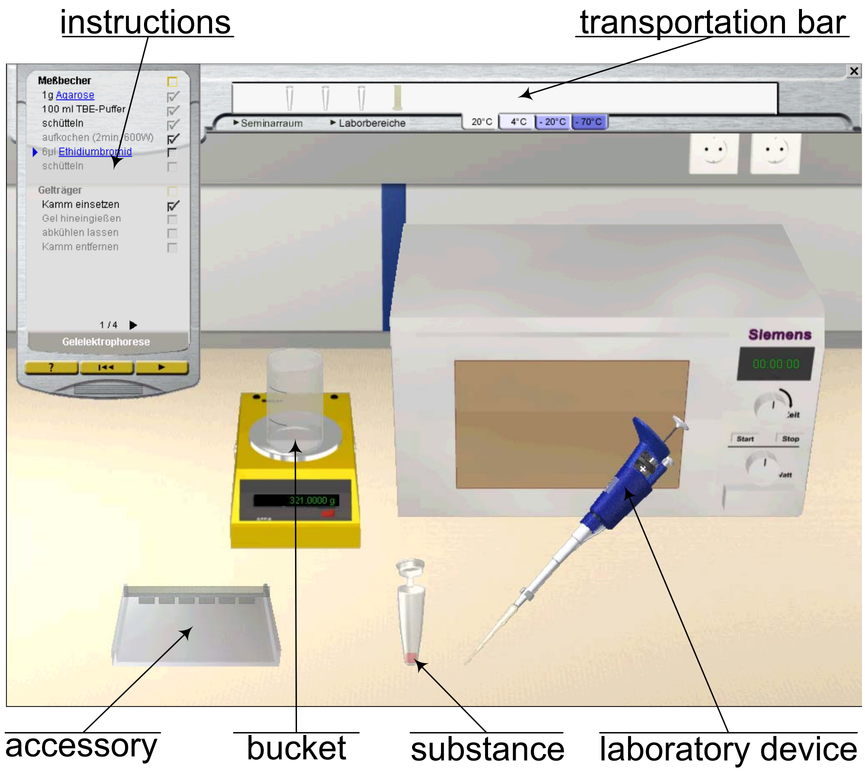

FIGURE 1.2
Screenshot of the final interactive multimedia presentation resulting from the storyboard depicted in Figure 1.1 (also taken from [130]).

some of the different roles involved in the process can be provided by a single person.

1.6 Personalization vs. Customization

The concept of personalization means different things to different people [123]. It is often intermixed and sometimes considered equal or interchangeable with customization [76, 150]. In this work, we clearly distinguish between the notion of personalization and customization as done by [10, 116]. This distinction is not a mere academic one, but provides for defining two different application families, the customized applications and the personalized applications.

Customization is an activity that is conducted and under direct control by the user [76, 116, 10]. This means that a customized application is actively adapted by their users to their individual needs and requirements. However, the customized application does not provide to adapt itself to the users. For example, users actively customize their cell phone's user interface by selecting individual content such as apps, ring tones, screensavers, and wallpapers. However, the cell phone itself does not adapt to the user (although of course some apps installed on the phone do). As customized applications do not adapt to the needs and preferences of the users, there is no need for them to provide a user model, i. e., to gather and maintain information or assumptions about the users' needs and preferences. All customization activities are carried out by the users themselves.

In contrast, personalization is considered a process driven by the application [31, 116, 10]. Here, the content provided to the individual users is adapted by the personalized application itself. Thereby, the personalized applications take, e. g., the interests, preferences, and background knowledge of the users into account [62, 10]. For example, a personalized web application aims at providing web pages to the users based on information and assumptions of his or her information needs [116]. Consequently, a personalized application must provide a user model, i. e., it must gather and manage some information or assumptions about the user's needs and requirements. The personalized application is able to adapt itself to the needs and requirements of the user, i. e., to individualize [115, 55, 114] or tailorize [115, 96] its content according to the information stored in the user model.

We support our decision to clearly distinguish between customized applications and personalized applications by the traditional distinction between adaptable systems and adaptive systems [38, 63]. While an adaptable system allows the user to change certain system parameters and adapt its behavior accordingly, an adaptive system can automatically change its behavior according to the information and assumptions about their users [38, 63]. Consequently, a personalized application is sometimes also called a user-adaptive application.

On basis of the discussion about the notions of personalization and customization, we can now provide our definition of personalization. Personalization is defined as the offer and opportunity for a special treatment in form of information, services, and products, provided by an application according to the interests, background, role, facts, requirements, needs, and any other information and assumptions about the individual. Personalization is conducted pro-actively by the personalized application and typically carried out to the user in an iterative process.

1.7 Authoring of Personalized Multimedia Content

Based on the definition of personalization and multimedia content, we consider personalized multimedia content as multimedia content targeted at a specific user or user group. It is able to adapt itself to the individual user's or user group's needs, background, interests, and knowledge, as well as the heterogeneous infrastructure of the (mobile) end device to which the content is delivered to and on which it is presented. Consequently, the authoring of personalized multimedia content is considered as process of selecting and composing media assets into personalized multimedia content, i. e., into a coherent, continuous multimedia presentation that best reflects the needs, requirements, and system environment of the individual user. A recent survey on multimedia personalization has been conducted by Lu et al. [108].

The authoring of multimedia documents described in Section 1.5 represents a manual creation of such content, often involved with high effort and cost. Typically, the result is a multimedia document targeted at a certain user group in a specific technical context. However, this one-size-fits-all fashion of the multimedia document does not necessarily satisfy the different users' information needs. Different users may have different preferences concerning the content and also may access the content in networks on different (mobile) end devices. Consequently, the authoring of personalized multimedia documents raises new requirements. For a wider applicability, the authored content needs to "carry" some alternatives or variants that can be exploited to adapt the multimedia presentation to the specific preferences of the users and their technical settings. This approach has been investigated in the past in projects such as aceMedia[2].

[2] `http://cordis.europa.eu/ist/kct/acemedia_synopsis.htm`, last accessed: 20/1/2013

1.8 Survey of Multimedia Authoring Support

We have introduced and defined the central terms in the area of multimedia content authoring and personalization. These definitions lay the foundations for the subsequent analysis of the existing authoring support for (personalized) multimedia documents and the classification of this support. With respect to authoring personalized multimedia content, there has been research conducted for almost two decades. Prove of these achievements are among others the well-known Cuypers Multimedia Transformation Engine [69, 152], the Semi-automatic Multimedia Presentation Generation Environment [57, 58], and the Standard Reference Model for Intelligent Multimedia Presentation Systems [139, 56].

In the following, we provide an extensive overview in the field of multimedia content authoring and analyze existing approaches and systems for multimedia content adaptation and multimedia content personalization. We present today's support for personalized multimedia authoring from different points of view and aspects. Following this overview and analysis of today's support for personalized multimedia content, the considered approaches and systems, families of systems, and research directions are categorized in Section 1.9.

1.8.1 Generic Authoring Tools

Multimedia authoring tools allow for the manual composition and assembly of media assets into an interactive multimedia presentation via a graphical user interface. For creating the multimedia content, the authoring tools follow different design philosophies and metaphors, respectively. Traditionally, these metaphors are roughly categorized into script-based, card/page-based, icon-based, timeline-based, and object-based authoring [122]. Examples of multimedia authoring tools are Adobe's Authorware [6], Director [7], Flash Professional [8], Toolbook [145], and the Edge Tools and Services [4] that allows for the authoring of Flash-like multimedia documents using HTML 5 [157]. Also Tumult's Hype [148] allows for an easy and interactive generation of Flash-like multimedia documents in HTML 5. These domain-independent tools let the authors create very sophisticated multimedia presentations, typically in a proprietary format or in HTML 5 in the case of Edge and Hype. In addition, the general purpose authoring tools typically require high expertise in using them and do not provide explicit support for personalizing the authored multimedia documents. Everything "personalizable" needs to be programmed or scripted within the tool's programming language. Consequently, the multimedia authors need programming skills and thus some experience in software engineering.

Adobe's icon-based authoring tool Authorware provides some support for creating personalized multimedia content [6]. It allows for a flow-chart ori-

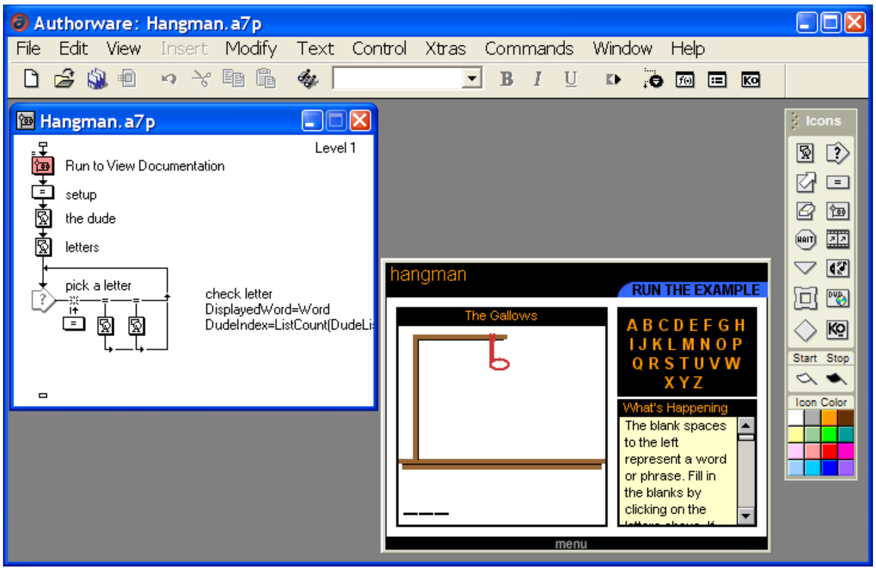

FIGURE 1.3
Screenshot of Adobe Authorware for a flow-chart oriented creation of multimedia documents (taken from a test installation of [6]). It shows the flow-chart of a simple Hangman game (top left) with the decision icons when the user provides correct and incorrect answers and the actual rendering of the game (bottom right).

ented creation of multimedia documents as shown in Figure 1.3 that supports defining the control of the presentation's flow with Decision Icons. A Decision Icon calculates the current value of a variable or expression that is attached to it and determines by this means which path of the decision structure is followed [6]. Thus, the Decision Icon can be used in principle to "personalize" the flow chart of a multimedia application developed with Authorware. However, an enhanced support for developing personalized applications is not provided.

In the field of adaptive multimedia models exist authoring tools such as the SMIL Builder [29] that allows for an incremental authoring of SMIL documents while verifying the temporal validity of the documents at any step. To this end, the authoring tool makes use of a temporal extension of petri nets. Another tool that provides for the authoring of personalized multimedia presentations is the Madeus authoring environment [88, 89]. Here, constraints are exploited to compose and assemble adaptable multimedia presentations. However, these constraints provide for a personalization support only within a limited range and do not support exchange of presentation fragments as it is supported, e. g., by SMIL's switch element (cf. Section 1.8.3). In addition, the generalized authoring tools are still tedious to handle and not practical for the domain experts, and following Bulterman in [37]: "Unfortunately, we have not seen the hoped-for uptake of authoring systems for SMIL or for any other format."

In order to provide multimedia authors a comprehensive support for personalized multimedia content, the multi-purpose authoring tools need to offer an editor that explicitly allows to define (abstract) user profiles. These user profiles need to be matched with, e. g., Authorware's Decision Icon, in order to select those paths in the flow chart that best fits the user's needs.

1.8.2 Domain-specific Authoring Tools

In order to allow domain experts for authoring personalized multimedia documents, domain-specific authoring tools hide as much as possible the technical details of the content authoring details from the authors. They let them concentrate on the actual creation of the multimedia documents. The tools we find here [162, 67, 100, 99, 64, 132, 24] are typically very specialized and target a specific domain. They are often organized in a wizard-like fashion that guide the experts through the authoring process. An example of such a domain-specific authoring tool is the page-based Cardio-OP Authoring Wizard [93]. The wizard supports the creation of personalized multimedia content in the field of cardiac surgery [93, 72, 24]. It guides the domain experts through the authoring steps in form of a digital multimedia book on cardiac surgery.

Another example is the page-based *Context-aware Smart Multimedia Authoring Tool* (*xSMART*) [132]. It is based on the MM4U document model [134] and provides different domain-specific wizards for the (semi-)automatic, context-driven generation of multimedia documents such as multimedia-based photo books [129]. During the different steps of creating the multimedia document, xSMART exploits contextual information as depicted in Figure 1.4 to guide the author through the content authoring process. For example, in the context of authoring multimedia-based photo books, the tool takes into account among others the quality of the photos, limitations such as maximum number of pages, and targeted audience like for personal memory, for family like grandparents and friends, or for professional use such as architects and exhibitors. The authoring tool xSMART is designed such that it can be extended and customized (see Section 1.6) to the requirements of a specific domain by application-specific wizards. These domain-specific wizards can be developed such that they best meet the domain-specific requirements and effectively supports the domain experts in authoring the personalized multimedia content, while at the same time fully exploiting the generic infrastructure the authoring tool provides.

Similar to xSMART, the user-centric authoring tool by Kuijk et al. [99] allows for creating stories from photos. Another photo-driven authoring tool and layouting system is by Xiao et al. for creating photo collages [162]. Recent development of domain-specific authoring tools also take into account the

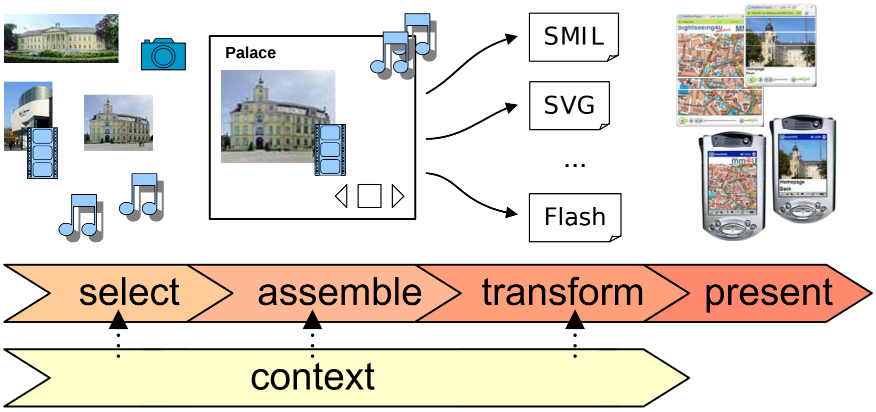

FIGURE 1.4
Depiction of the generic process for a context-driven generation of multimedia documents in xSMART (taken from [132]).

social web such as the video authoring tool by Laiola and Guimaraes [100] that is aware of the users' social network.

1.8.3 Adaptive Multimedia Document Models

Early work in the field of (adaptive) multimedia document models are the Amsterdam Hypermedia Model (AHM) [74] and its authoring system CMIFed [36, 155, 75] using events and timing-constrains. Constraints are also used in the adaptive document model of the multimedia authoring environment Madeus [88, 89]. The ZyX [23] multimedia document model provides besides a temporal, spatial, and interaction model an extensive support to reuse (of parts) of multimedia presentations and adaptability of the multimedia content. The Z$_Y$X model is used, e. g., for content authored with the domain-specific authoring wizard Cardio-OP [93] presented in Section 1.8.2.

With MM4U, we find a multimedia document model that allows for defining complex composition operators to encapsulate and abstract to higher level functionality [134]. It is based on ZyX and extends it by providing dynamic composition operators, where the structure of the resulting multimedia document is computed on-the-fly and depending on contextual parameters. The MM4U model is not yet another multimedia document model but has been derived by a backward analysis of the existing approaches [135].

The W3C standard SMIL [41] allows for the specification of adaptive multimedia documents by defining alternatives in the temporal course using the `switch` element. Some authoring tools for SMIL such as the GR*i*NS editor (not available anymore) provided support for the `switch` element to define presentation alternatives. However, a comfortable interface for editing the different alternatives for many different contexts is not provided. SMIL State [85] is an external state engine for modeling adaptive time-based multimedia presentations in the web. Unlike its name suggests, the state engine of SMIL state can be used in XML-based multimedia document models such as SMIL and SVG. Different variants of petri nets are also used as formal model for multimedia documents [121, 159] with the focus on the temporal organization of the media objects.

A quasi-standard defined by the industry is the well-known and widespread proprietary Flash format [5] by Adobe. The recent W3C standard HTML 5 [157] challenges Flash with build-in support in web browsers through the use of Javascript and agreed-on application programming interfaces (APIs). Although the new standard is quickly gaining popularity, until today the proprietary Flash format is still predominant. For further discussions on multimedia document models please refer to the literature such as [131, 23, 26].

1.8.4 Adaptive Hypermedia

Towards the creation of personalized multimedia documents, we find interesting work in the area of adaptive hypermedia systems (AHS) [94, 34, 33]. The adaptive hypermedia system AHA! [51, 49, 48] is a prominent example that also addresses the authoring aspect [141], e. g., in adaptive educational hypermedia applications [140]. Though these and further approaches integrate media assets in their adaptive hypermedia presentations, synchronized multimedia presentations are not in their focus. The main personalization techniques pursued are adaptive navigation support and adaptive presentation. With adaptive navigation [50] links are, e. g., enabled, disabled, annotated, sorted, and removed, according to the profile information about the user (also called link-adaptation [51]). The purpose of adaptive presentations [50] is to, e. g., show, hide, reorder, and highlight or dim specific fragments of the presented hypermedia content according to the user profile information (also called content-adaptation [51]). Recently, the AHA! system has been extended towards the Generic Adaptation Language and Engine (GALE) [30, 138]. Basically, GALE is a complete redesign of the AHA! system and allows for the use of distributed resources and supports the distributed definition of adaptations.

Approaches for adaptive hypermedia have also been extended to make use of social media such as the Adaptive Retrieval and Composition of Heterogeneous INformation sources for personalized hypertext Generation (ARCHING) system. The ARCHING system allows for the authoring of adaptive hypermedia from different and heterogeneous data sources including professional content and social media [142]. Another system making use of open resources on the web is Slicepedia [103]. Further work on adaptive hypermedia systems include considering provenance modelling for adaptation [95].

A comprehensive study of adaptive hypermedia systems has been done by Knutov, De Bra, and Pechenizkiy [94].

1.8.5 Intelligent Tutoring Systems

Closely related to adaptive hypermedia systems are so-called intelligent tutoring systems (ITS) [137]. ITS provide personalized content according to the learners' or students' knowledge. The aim of ITS is that the learners gain new knowledge and skills in a specific domain by independently solving problems in that domain. An ITS provides a model of the student, a model of the domain, and a model of educational strategies [137]. This means, it comprises explicit assumptions and information about the knowledge and level of knowledge of the user in the considered domain (student model or diagnosis model), an expert's knowledge in the domain (domain model or expert model), and a didactic concept of how to convey and present the learning materials to the learners (tutor model or educational model). Such models are also defined with adaptive hypermedia systems, e. g., [48, 160, 161], although they are named different there. Consequently, AHS are sometimes considered integration of ITS and hypermedia systems [45].

1.8.6 Constraint-based Multimedia Generation

A very early approach towards the dynamic authoring of adapted multimedia content is the Coordinated Multimedia Explanation Testbed (COMET) [54]. It is based on an expert system and different knowledge bases and uses constraints and plans to generate the multimedia documents [61, 110, 54]. Another approach in the same direction is the Multimedia Abstract Generation for Intensive Care (MAGIC) [47]. It is an expert system with static knowledge bases and a constraint-based content planer. Further approaches to automate the authoring of personalized multimedia documents are the Knowledge-based Presentation of Information (WIP) and the Personalized Plan-based Presenter (PPP). WIP is a knowledge-based presentation system that automatically generates instructions for the maintenance of technical devices by plan generation and constraint solving [14, 13, 12]. PPP enhances this system by providing a life-like character to present the multimedia content and by considering the temporal order in which a user processes a presentation [14, 13, 16, 15, 12].

Logics programming and constraints are used in the the Cuypers Multimedia Transformation Engine [105, 152, 154, 69, 153, 68] for the dynamic generation of multimedia presentations such as the example depicted in Figure 1.5. To this end, Cuypers makes use of its own internal representation model for multimedia content, called Hypermedia Formatting Objects (HFO) [152]. The HFOs are transformed to SMIL presentations using XSL style sheets [3]. The presentations Cuypers generates are adapted to user preferences as well as limitations of the targeted presentation platform.

Little et al. [104] present an extension of Cuypers that generates personal-

FIGURE 1.5
Screenshot of a multimedia presentation generated by the Cuypers Multimedia Transformation Engine (taken from [154]).

ized multimedia presentation through semantic inferencing. Subsequently to a keyword-based query, users start selecting media assets to be incorporated into the presentation. The media assets are automatically arranged in time and space using some *mapping rules*. The selected media assets are used to iteratively refine the query.

The Semi-Automatic Multimedia Presentation Generation Environment (Samp*Le*) builds a narrative structure of the generated multimedia presentation based on genre-specific templates [57, 59]. The user can modify the structure of the presentation, adapt the temporal flow of the presentation, modify the content selected for it as well as determine the interaction possibilities of the users with the presentation. The final arrangement of the multimedia material is made available for consumption to the users in HTML format.

1.8.7 Multimedia Calculi and Algebras

Multimedia query algebras and calculi can also be used to author multimedia documents. The multimedia presentation algebra (MPA) by Adali et al. [2, 1] considers a multimedia document as tree. Each node represents a non-interactive presentation, e.g., a sequence of slides, a video element, or an HTML page. The branches reflect different possible playback variants of a set of presentations. The MPA provides extensions and generalizations of the `select` and `project` operations in the relational algebra. However, it also allows to author new presentations based on the nodes and tree structure stored in the database using operators such as `merge`, `join`, `path-union`, `path-intersection`, and `path-difference`. These extend the relational algebraic join operators to tree structures. Lee et al. present a multimedia algebra [101] where new multimedia presentations are created on the basis of a given query and a set of inclusion and exclusion constraints stored in the database. The Unified Multimedia Query Algebra (UMQA) aims at integrating different features for multimedia querying such as traditional metadata like artist and author as well as content-based features like image similarity and spatio-temporal relations [42]. For the spatial relationships, the Rectangle Algebra [119] is used. Regarding the temporal relations, only closed intervals as defined in Allen's calculus [11] are supported. Open intervals like those defined by Freksa [65] are not considered. Interaction relations as it is aimed in this work are also out of scope. The Temporal Algebraic Operators (TAO) [120] allow for specifying multimedia documents along different sequential and parallel operators equivalent to the closed intervals of Allen. In addition, TAO provides an alternative operator that is similar to the `switch`-tag of SMIL and allows for an event-based synchronization of the media objects. Due to its focus on temporal relations, TAO does not support spatial relations or interaction relations. EMMA is a query algebra for Enhanced Multimedia Meta Objects (EMMOs) [163]. It allows to state queries against the media objects contained in EMMOs by following the typed edges of the EMMO graph. An edge type is similar to a property in the Resource Description Framework (RDF) [9] of the Semantic Web. For example, there can be an edge type saying that two movies are similar or that one movie is a remake of another, and the like. Fayzullin and Subrahmanian present the PowerPointAlgebra (pptA) for querying PowerPoint documents [60]. It is based on the relational algebra and provides some new operators like `APPLY`. The `APPLY` operator conducts changes of attributes, which are defined by transformation functions. A transformation function can, e.g., change the color or fontsize. The `APPLY` operator can be used on different levels of granularity like slides, presentations, or the entire database. Like other query algebras, the semantics of PowerPoint presentations is not considered with pptA. The multimedia query model proposed by Meghini et al. [111] bases on fuzzy description logics and aims at providing a unified approach for multimedia information retrieval for the two media types text and image. Finally, SQL/MM is a standard for managing spatial information in a relational database [144]. It supports spatial queries on geometric shapes as well as extended textual queries like stemming and structural conditions such as finding an occurrence of query terms in the same paragraph [112].

1.8.8 Standard Reference Model for Intelligent MultiMedia Presentation Systems

Finally, we find with the Standard Reference Model for Intelligent MultiMedia Presentation Systems (SRM for IMMPS) [139, 27, 28, 56] a generalized architecture for the domain of so-called Intelligent MultiMedia Presentation Systems (IMMPS). The aim of IMMPS is to automate the authoring of multimedia presentations in order to enable on-the-fly personalization of presentations according to the individual needs of the user [139]. Hereby, IMMPS exploit techniques originating from the research area of artificial intelligence (AI) [124] such as knowledge bases, planning, user modeling, and automated generation of media assets such as text, graphics, animation, and sounds [139]. The goal of the SRM for IMMPS is to provide a common framework for the analysis, comparison, and benchmarking of IMMPS. An example of a system employing the SRM for IMMPS is the Berlage environment providing for a dynamic authoring of adaptive hypermedia content [126, 127].

1.9 Classification and Comparison of Authoring Support

Classifying the existing approaches and systems is a difficult and challenging task. Thus, it is not very surprising that there is only little work so far. To the best of our knowledge, the only source is the work by Jourdan et al. [86, 87]. They provide a classification of existing systems and projects into different groups and valuate these groups. In this work, we modify and extend the classification proposed by Jourdan et al. [86, 87] by suggesting the following six categories for classifying today's authoring support for personalized multimedia content:

- plain programming,
- templates and selection instructions,
- adaptive document models,
- transformations,
- constraints, rules, and plans, as well as
- calculi and algebras.

When considering the existing approaches and systems, it is not always easy to decide to which of the proposed categories a specific solution should be associated. In addition, some of the existing systems and projects explicitly combine or "synthesize" different approaches and thus need to be associated to more than one category. This means that they employ more than one approach to actually implement their personalized multimedia functionality. Examples for such hybrid systems are [86] and [91].

The single approaches for multimedia personalization are described in the following Sections 1.9.1 to 1.9.6. For each personalization approach, we first introduce the characteristics of this approach. Subsequently, we refer to representative systems and projects for the considered approach. Finally, a valuation of the approach is given, i. e., the advantages and disadvantages of the approach are discussed. A summary of the different multimedia personalization approaches and their assessment is provided in Table 1.1.

1.9.1 Authoring by Programming

In the authoring by programming approach, regular programming languages are applied to develop the (multimedia) personalization functionality. Obviously, programming languages such as C++ and Java can be employed to develop a system that generates personalized multimedia content [86]. However, also logic programming, e. g., with Prolog, can be used to implement the personalization functionality such as in Cuypers. Programming is typically also employed with the generalized multi-purpose authoring tools presented in Section 1.8.1. Also domain specific authoring tools are typically programmed like the Cardio-OP Authoring Wizard for the medical domain.

With mere programming, every personalization functionality is feasible that can be implemented with a programming language. However, a well known disadvantage is the lack of independence between the programming code and the piece of information [86]. This makes it difficult to reuse some parts of an application for another one. In addition, as providers today typically develop their own specific solution and data models, the personalization

TABLE 1.1
Evaluation of different approaches for authoring personalized multimedia documents

Approach	**Valuation**
Programming	+ Arbitrary personalization functionality can be programmed – Providers develop their own (mostly) complex solution – High effort necessary for extending or adapting the solution to a different domain or model
Templates & Selection Operators	+ Well suited for applications where content selection can be split into a set of pre-defined database queries – Static templates are limited in their expressiveness – Difficult to handle global criteria spanning multiple queries for selecting and assembling media assets
Adaptive Document Models	+ Provide extensive support for build-in adaptation and reuse of media assets + W3C standards exist – Not practical to specify all presentation variants in advance
Transformations	+ W3C standards exist + Transformation tools like XSLT are calculation complete – Difficult to handle multiple transformations – Often results in complex transformations
Constraints, Rules, & Plans	+ Declarative description of the personalization functionality – Expressiveness limited to declaratively describable personalization problems – Additional programming required for complex and domain-specific personalization functionality
Algebras & Calculi	+ Formal description of the multimedia authoring – High effort to learn the algebraic operators and difficult to apply

functionality is tailored and designed for their particular application domain. As a consequence, high effort is necessary when extending or adapting the solution to a different domain.

1.9.2 Authoring using Templates and Selection Instructions

With the second category, personalized authoring takes places with templates and selection instructions. A template can be considered as the static part of a multimedia presentation. It is possibly designed in a concrete presentation language such as HTML or SMIL and is enriched with some selection instructions [86]. These selection instructions are executed when the user requests the template. Executing selection instructions means that information is extracted from external data sources [86] according to the users' profile information. The dynamically extracted information is then merged on-the-fly with the template. Merging the static part of the multimedia presentation with individually selected dynamic content on-demand allows the template approach to provide for a personalized composition and delivery of information to the users. The authoring approach by using templates and selection instructions is applied, e g., by the multimedia database METIS [90]. It uses XML-like data structures where specific parts of the presentation are only filled in when the document is requested by the client. Rhetorical presentation patterns are used by Bocconi et al. [21] for the template-driven generation of video documentaries.

The template-based approach for multimedia personalization suits well for applications in which content selection can be split into several database requests [86]. However, static templates are limited in their expressiveness. In addition, it is possibly very difficult to handle global content selection and assembly criteria when considering multiple database requests in order to choose those media assets that, e. g., best reflect the user's profile information or do not cross a maximum time limit of the presentation duration [86].

1.9.3 Authoring with Adaptive Documents Models

Personalization by adaptive multimedia document models provides for specifying different presentation alternatives or variants of the multimedia content within the multimedia document. The presentation alternatives are statically defined within the adaptive multimedia document. During presentation time, the document's alternative or variant is determined that best matches the user's profile information. Finally, the selected presentation alternative is presented on the end device. Consequently, with the personalization approach by adaptive document models, the multimedia player on the (mobile) end device decides within the range of the available presentation alternatives which variant of the multimedia document is presented. Examples of adaptive document models are the Amsterdam Hypermedia Model, SMIL, ZYX, and MM4U presented in Section 1.8.3.

Adaptive multimedia document models provide for an extensive support for the adaptation and reuse of multimedia presentations and parts of it. Another advantage of this approach is that there are W3C standards such as SMIL. However, adaptive document models are less practicable when a comprehensive support for personalization is needed as all different presentation alternatives have to be specified in advance within the same document.

1.9.4 Authoring by Transformations

With the authoring by transformations approach, two kinds of transformations can be distinguished [102]: the structural transformations and media transformations. Structural transformations can be, e. g., the transformation of an XML-document into a (standardized) multimedia format such as SMIL or SVG. Structural transformations also include changing the layout and arrangement of the media assets to different presentation styles (cf. personalization by style sheets in [86]), e. g., changing the spatial layout of the visual media assets. With structural adaptation, also an XML-document can be adapted from a desktop PC version to a mobile device, e. g., by dividing the content into different smaller screens or pages in the mobile situation. Consequently, structural transformations typically implicate an adaptation of the temporal and/or spatial layout of the multimedia presentation as well as possibly changing the interaction design of the presentation with the user.

In contrast, media transformations change the media type, e. g., exchanging an image asset to a text asset describing the same content. It also includes adapting the media format, e. g., transcoding an image asset from PNG to JPG, or conducting other binary operations on the media assets such as resizing a video asset or changing the color-depth of an image asset. Transformations are used by the Cuypers multimedia presentation engine to transform the multimedia content represented in their HFOs into the final multimedia format SMIL. XSL transformations (XSLT) are employed for generating SMIL documents within the Course Authoring and Management System (CAMS) [44] in the domain of e-learning. XSL-FO is used for providing different presentation styles [156]. Approaches that focus on media transformations are typically also found in the area of mobile multimedia presentation generation like the koMMa framework [84].

An advantage of the personalization by transformation approach is that the adaptation of the multimedia content can be described in the W3C standard XSL, employing XSLT and XSL-FO. XSLT is supposed to be computational complete [149, 151, 46, 128]. Thus, arbitrary transformations can be conducted with XSLT that can be described by an algorithm. However, due to recursive structures in XML such transformations easily become very complex and difficult to handle.

1.9.5 Authoring by Constraints, Rules, and Plans

With the authoring by constraints, rules, and plans, creating personalized multimedia content is considered an optimization problem [124]. The creation of the personalized multimedia content is explicitly described by using rules, constraints, and the like, which are, e. g., stored in different knowledge bases. The personalized multimedia presentation is generated on basis of such a declarative description and by taking the profile information about the user into account. Such a presentation generation can also be regarded as planning problem [124]. Here, the user's request is decomposed in some subgoals that are to be reached. The results of these subgoals are accumulatively assembled to the final multimedia presentation (cf. [86]). To answer the requests, even those that were planned at design time, different knowledge bases are used [86]. A prominent example of a system that employs constraints and rules for the personalized multimedia content generation is again the Cuypers Multimedia Transformation Engine. Although it also employs transformation sheets, the main means for generating the personalized multimedia content are constraints and rules. With COMET, MAGIC, WIP, and PPP, we find several knowledge-based systems for personalization. The Standard Reference Model for Intelligent MultiMedia Presentation Systems is a very generic approach for authoring personalized multimedia content making use of multiple knowledge bases and uses constraints for layouting.

Systems applying personalization by constraints, rules, plans, or knowledge bases operate on a declarative level for describing the personalization functionality. However, due to their declarative description languages, only those multimedia personalization problems can be solved that can be covered by such a declarative specification. Consequently, these systems and projects find their limits when it comes to more complex or application-specific multimedia personalization functionality and additional programming is required to solve that problem.

1.9.6 Personalization by Calculi and Algebras

With the last solution approach, calculi and algebras are applied to select media assets and merge them into a coherent multimedia presentation. This approach has emerged from the database community with the aim to store, process, and author multimedia presentations within databases. Consequently, work based on calculi and algebras are applied on the database level and provide for specifying queries that are send to a database system. The database system executes the queries and determines the best match of the different media items and presentation alternatives stored in the database. The result is then send back to the querying application. Examples of calculi and algebras for querying and automatically assembling multimedia content such as the multimedia presentation algebra are presented in Section 1.8.7.

The main advantage of the personalization by algebras approach is that the requested multimedia content is specified as a query in a formal language. However, typically high effort is necessary to learn the algebra and their operators. Consequently, it is very difficult to apply such a formal approach.

1.9.7 Summary of Multimedia Personalization Approaches

The classification of the existing systems and projects to the different categories of personalization approaches is not always easy and unambiguous. Nevertheless, we have presented a categorization of today's support for the authoring of personalized multimedia content. This provides for a more systematic management and examination of the tasks and challenges involved with the creation of such content.

1.10 Conclusion

In this chapter, we have defined the basic notions of media and multimedia. As further prerequisite for our analysis, we have investigated and have defined the terms of multimedia document models and their instantiations, multimedia formats, as well as multimedia authoring and personalization of multimedia content. Subsequently, we have conducted an extensive survey of existing authoring support for creating personalized multimedia content. This survey and classification will help in better understanding not only today's but also future multimedia authoring approaches and support. Thus, it provides a more systematic introduction to the field of authoring personalized multimedia content.

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