

MultiPresenter: A Presentation System for (Very) Large Display Spaces

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ABSTRACT

We introduce MultiPresenter, a novel presentation system designed to work on very large display spaces (multiple displays or physically large high-resolution displays). MultiPresenter allows presenters to organize and present pre-made and dynamic presentations that take advantage of a very large display space accessed from a personal laptop. Presenters can use the extra space to provide long-term persistency of information to the audience. Our design deliberately separates content generation (authoring) from the presentation of content. We focus on supporting presentation flow and a variety of presentation styles, ranging from automated, scripted sequences of pre-made slides to highly dynamic ad-hoc, and non-linear content. By providing smooth transition between these styles, presenters can easily alter the flow of content during a presentation to adapt to an audience or to change emphasis in response to emerging interests. We describe our goals, rationale and the design process, providing a detailed description of the current version of the system, and discuss our experience using it throughout a one-semester first year computer science course.

Categories and Subject Descriptors

H.1.2 [User/Machine Systems]: Human factors, Human information processing; H.5.2 [User Interfaces]: Graphical user interfaces (GUI), Interaction styles (e.g., commands, menus, forms, direct manipulation), User-centered design; H 5.m [User Interfaces]: Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Human Factors.

Keywords

High-resolution displays, Human-Centered Design, Multiple displays, Presentations.

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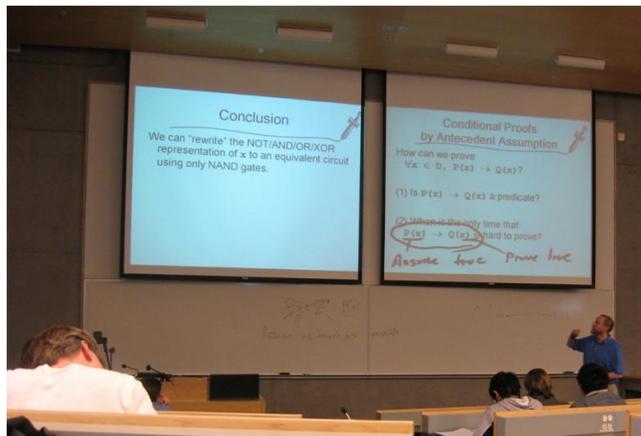


Figure 1: The MultiPresenter system in use.

1. INTRODUCTION

Electronic slide presentations are multimedia events that integrate visuals such as images, video, animations and text with the spoken words of the presenter. “Slideware” tools, the generic name for software such as PowerPoint that support these presentations, are enormously popular and are the predominant visual aid in business, conference and other types of presentations. Microsoft estimated in 2004 that about 1.25 million PowerPoint presentations were given every hour [18]. Slideware has become ingrained in presentation culture: a New Yorker article in 2001 suggested that to “appear at a meeting without PowerPoint would be unwelcome and vaguely pretentious, like wearing no shoes” [25].

Yet, many authors have suggested that slideware imposes a singular, sequential, frame-by-frame presentation style that best suits static and linear content [14, 16, 33]. Recent studies have demonstrated that academic instructors using traditional presentation technologies, such as blackboards or whiteboards, are able to more easily employ a far greater range of presentation techniques, such as referring to previously presented content, providing visual comparison between different concepts, and moving through presentation content non-linearly [16]. These presenters frequently make use of the larger space available with whiteboards, purposefully using some areas for content that will be referred to later, and using other parts to support ad-hoc or spontaneous presentation material. The problem we see is that slideware systems support dynamic multimedia *content*, but they do not as easily support dynamic *presentations*; they are primarily designed for preparing fixed, sequential presentations of slides.



Figure 2: Many lecture halls and conference rooms have multiple screens.

Our interest is motivated by the growing availability of very large electronic display spaces, especially in classrooms, and the limitations we have experienced giving slide presentations on a single, normal size display. No doubt as a consequence of the ubiquitous use of slideware, lecture halls are increasingly being built with advanced technological infrastructure to support electronic presentations. Because many universities and conference centres accommodate hundreds of audience members, lecture halls and conference rooms are now frequently equipped with multiple, high resolution display systems (Figure 2). This infrastructure can, in theory, provide instructors with the same amount of screen real-estate as do lecture halls that employ whiteboards. Most slideware does not yet take advantage of this extra screen real-estate; in fact, many lecture halls simply default to broadcasting the same slideshow on all of the displays.

We examined questions that address both pedagogical and pragmatic concerns: How can we build presentation tools to best support learning and retention of presented information? Further, how can these tools best employ the additional screen real-estate provided by modern lecture halls?

To test our ideas, we developed MultiPresenter, a prototype multiple-display presentation system (Figure 1). MultiPresenter realizes a design approach and philosophy that separates the creation of content from the presentation of content. It offers two key advantages over traditional approaches.

- Most slideware tools are *presentation content authoring systems*, and in many ways do not fully support the dynamic nature of presentations. In contrast, MultiPresenter was developed focusing on the actual *practice of presentation*. It supports many common presentation practices other than just sequential slides. It allows presenters to change the flow of a presentation, place persistent content on auxiliary screens for later reference, and interactively manipulate content and information *during* presentations.
- MultiPresenter supports fully scripted, semi-automated, and manual control of multiple screens. This provides presenters with more control over how visual aids are used during a presentation. For example, a presenter may show two slides simultaneously for comparison, or to have an important slide visibly persistent for a longer period of time, or to construct meta-slides based on content from other slides.

In this paper, we describe how prior work motivated our work with presentation systems, articulating how findings from studies exploring actual presentation practice suggested the need to support more dynamic presentation practices. We then articulate how separating content and presentation authoring gives presenters more conceptual control over the presentation material.

We then show how features of MultiPresenter provide additional control of visual aids to presenters, realizing this design approach. Finally, we discuss the experiences of a university instructor who deployed the system in a real classroom setting for one semester.

2. PREVIOUS WORK

There is a long history and a large literature on document preparation systems, of which slideware is just a subset, and dynamic visualization techniques ranging from animation systems to add-ons for common GUI interfaces. We focus on the shortcomings of existing slideware tools and recent attempts to return to more “natural” interaction styles that mimic traditional blackboard and whiteboard techniques.

2.1 The PowerPoint Debate

The most prominent presentation tool is PowerPoint, which in 2001 was said to control about 95% of presentations world-wide [25]. Consequently, PowerPoint has generated much criticism, but similar complaints can be applied to most presentation tools, including Apple’s Keynote or OpenOffice’s Impress. For clarity, we will use the terms slideware and PowerPoint interchangeably to refer to this class of tools.

The best-known critic is former Yale professor and information visualization expert Edward Tufte. In his essay “The Cognitive style of PowerPoint” [33] he claims that PowerPoint is presenter-oriented and not content-oriented or audience oriented. According to Tufte, PowerPoint has low resolution of data, degrades communication by forcing users to separate content and analysis, reduces concepts to bullets, and enforces strict hierarchies that are not needed. More relevant to our purposes, one of Tufte’s major claims (echoed by others) is that PowerPoint breaks up the narrative and data into small fragments [14, 25, 33] by supporting a rapid temporal sequence of thin information that is not suited for learning, instead of supporting complex reasoning and thorough analysis.

Tufte’s criticism was the high point of a backlash against commercial presentation tools [14, 25, 23, 31]. The debate was not entirely one-sided. Others suggested that PowerPoint and other commercial presentation software are only tools, which are sometimes used poorly by its users. Rather than being the *source* of poorly planned, disorganized presentations, PowerPoint simply reflects flaws in authors’ design skills, communication ability, or rhetorical expertise [22, 30]. A second argument in response to Tufte’s and others criticism is that oral presentation is different from written documents, so one should not analyze slides outside the context of the talk [6]. A core drawback of this debate is that it has been conducted primarily through essays that reflect authors’ opinions rather than relying on empirical study [9].

2.2 Presentation systems

Various researchers have developed presentation tools to address some of the limitations of PowerPoint and other commercial tools. Some focused on adding support for delivering a presentation, using physical index cards that are digitally linked to slides [17], or handheld devices to better control the presentation flow [21]. Others added support for a presenter’s view which is different than what is seen by the audience [3, 29].

Some support for more dynamic presentations focused on changing the linear manner of transitioning between slides. Mindmaps, special diagrams linked to and arranged radially, were

used [12] to avoid the inherent linearity of commercial presentation tools and to provide explicit information about the structure of a talk. Zoomable User Interfaces [11] have been used to break the linearity of a presentation; using ZUIs, static slides are arranged on a large canvas at various scales. Transitions are made between slides using pan and zoom across the canvas, allowing viewers to understand the structure of the talk according to the visual locations and groupings of the slides. These approaches separate content from the actual presentation by making the *navigation* through the information space a core part of the presentation delivery. Similarly, SLITHY [34] provided a conceptual separation between content and presentation and focused on design principles of animation for use during presentations. SLITHY incorporated animations into presentations by providing authors with a scripting language that operates the animation using a content layer. We build on this core approach of separating content from presentation delivery, and provide presenters with presentation mechanisms that facilitate persistence of content during a presentation.

Many multimedia projects have focused on capturing, processing, archiving and retrieving live presentations. Classroom 2000 [1] was the first major project to incorporate technology in the classroom to facilitate capturing, archiving and retrieving records of classroom activities. Mukhopadhyay and Smith [20] aimed at capturing lectures using a more passive and less invasive capturing process. Others emphasize integrating the various captured streams (audio, video, slides, and whiteboard) for later retrieving in various levels of automated methods [13].

Some projects deployed presentation technology in classrooms with the goal of enhancing learning. Approaches enhancing face-to-face communication in the classroom aim to make presentations more dynamic by adding electronic ink to the presentation. PowerPoint 2007 has some annotation tools to support electronic ink. Classroom Presenter [3] added more complex writing tools to augment prepared slides by integrating PowerPoint slides with pen-based writings on a tablet PC. E-Chalk [10] allowed instructors using electronic whiteboards to combine the ability to record whiteboard activities with multimedia items and pen-based writing in classrooms. All of these systems suggest the importance of electronic ink as a tool to add some degree of dynamic interaction for the presenter, whereas other systems added dynamic tools such as task management, polls or newsgroups to presentations systems in order to enhance participation of students in classrooms, utilizing workstations or mobile devices used by students [8, 26, 27].

There has been some effort to support delivering presentations on multiple projectors. Rößling et al. [29] implemented a system that showed previous slides on different projectors. They also supported electronic ink and a separate view for the instructor. Chiu et al. [5] also proposed a slide-based multi-display presentation system. In their system, the presenter was able to show previous slides on multiple displays, and was able to use a touch interface to control the flow of slide presentation. We use these systems as starting points, supporting multiple projectors for slides and providing support for existing slideware tools. We augmented this with support for dynamic presentation practices and some new static practices, and we simplified the infrastructure requirements to allow more rapid adoption.

3. PRESENTATION PRACTICES

In previous work [16], we briefly introduced MultiPresenter which was then in its early design stages. Our previous study was an observational study to understand how presenters employ visual aids such as blackboards, whiteboards and slides to inform the design of MultiPresenter. In this paper, we expand on those ideas, fully describing MultiPresenter's feature set, and on our goals, rationale and design process. Further, we discuss an initial evaluation of the system. To set the scene for MultiPresenter's feature set, we rearticulate some of the findings from prior work [16] that identified presentation practices common with traditional technologies, but are inadequately supported with current slideware tools.

Spontaneous and non-linear presentation styles. In contrast to slideware presentations, presentations using traditional technologies were frequently spontaneous, dynamic and often non-linear. Presenters frequently diverged from what appeared to be a planned path through the content, to drilling down into content when necessary, or spontaneously using visual aids either to answer questions or to follow important tangents or facilitate discussions when appropriate.

Revisiting earlier information. With traditional media, presenters many times referred back to previously written content—sometimes to information recently presented, and other times to content originating from much earlier in a presentation. This practice was employed differently for more recent content compared to older content, but in both cases there was convergent evidence of the non-linear presentation styles in what we observed. Revisiting illustrates the importance of persistent content on the display—it is only because information is persistent in traditional media (especially blackboards and whiteboards) that referring back to content is possible.

Creative use of multiple sliding whiteboards. Many lecture halls we observed had as many as nine sliding whiteboards in a 3×3 grid of boards, and frequently instructors made use of all of them. Sliding boards afford an extremely large surface, allowing an entire lecture to be visible to the audience, and, while it is a large space, the seams between the whiteboards facilitate a form of partitioning. We saw highly creative use of these partitioned spaces: instructors might place important content in a top corner to be easily referred to later as a reinforcing mechanism; in other instances instructors wrote a problem on one board, a diagram explaining the solution on a different board, and the formal solution on yet another board. During their explanation, instructors might switch back and forth adding additional information when referring to these three board areas.

Cognitive benefits of a larger space. In interviews we conducted, instructors suggested that they needed more space to present complex ideas, because with sufficient space, spatial relationships between concepts could be used to encode meaning. Indeed, studies by cognitive scientists have borne out this sentiment: spatial and temporal grouping of related items is important for learning [19]. When entities needed to be compared, instructors could draw them on adjacent whiteboards, allowing students to see both the construction of each entity, and to see them simultaneously for comparison purposes. Slides do not facilitate this practice so easily. As one instructor noted: *"I often feel a slide is too small, and a lot of times it's because there*

is something I'd put on one slide that I wish I could put on the other slide and see them at the same time."

Presentation as dialogue. Many presentations cannot be simply conceptualized as one-way monologues from the lecturer to the audience [32]. In many cases, lectures should be viewed as dialogues, where the instructor implicitly and explicitly ascertains whether the presentation delivery is clear *in situ*, and modifies delivery technique to enforce a point by revisiting a concept, or by providing more detail [4]. In these cases, presentation of prepared material was highly dynamic, enabled by the dynamic nature of the whiteboard.

Motivated by these findings, we designed MultiPresenter, a presentation system that provides the presenter control over multiple high resolution displays, and gives the presenter a suite of *in-presentation* tools to dynamically modify the flow of a presentation. These tools allow the presenter to make content persistent, modify content on the fly, and re-arrange the order slides *during* a presentation, independent of any originally authored flow and of the type of the authored content.

4. SEPERATION OF CONTENT AND PRESENTATION STYLE

Most slideware tools, such as PowerPoint, act more as *content authoring tools* than *presentation tools*. They facilitate content creation from a variety of media sources and provide highly sophisticated layout schemes. Indeed, the content created often has a life of its own outside of the context of the presentation, being used for other purposes such as exchanging information, official documents, students' notes or even entirely non-presentation purposes, like for greeting cards or posters. As *presentation tools*, they impose a fairly sequential presentation style. They are well suited to highly structured presentations that have a well-planned and singular flow. Yet we have seen that presenters often employ a variety of presentation practices beyond this structured sequential flow when given the presentation medium (boards) that affords this. Our core design approach was therefore to *separate content from presentation*, and in so doing, build a presentation system whose sole focus is *providing presenters with in-presentation tools* to support dynamic restructuring of content as well as to support various static practices. In this section, we articulate the philosophy behind this design approach.

We distinguish between the *content*, the *layout*, and the *presentation* of a presentation (Figure 3). The *content* of a presentation may include text, images, videos, clip art or other types of media. The organization of this content onto slides is the *layout*. The *presentation layer* consists of the animations within slides, animations between slides, and the transitions from one slide to another (i.e. – the order of slides presented). These three layers are logically distinct. In fact, they could be constructed by three different people. For example, a CEO of a company might have her assistant develop the content, a graphical designer formulate the layout of that content using PowerPoint slides, and then deliver the presentation herself using her unique personal presentation style.

With most conventional slideware tools, such as PowerPoint, all three aspects of a presentation are constructed simultaneously, thereby marrying content and layout alongside presentation semantics. The key drawback of this approach is that layout and

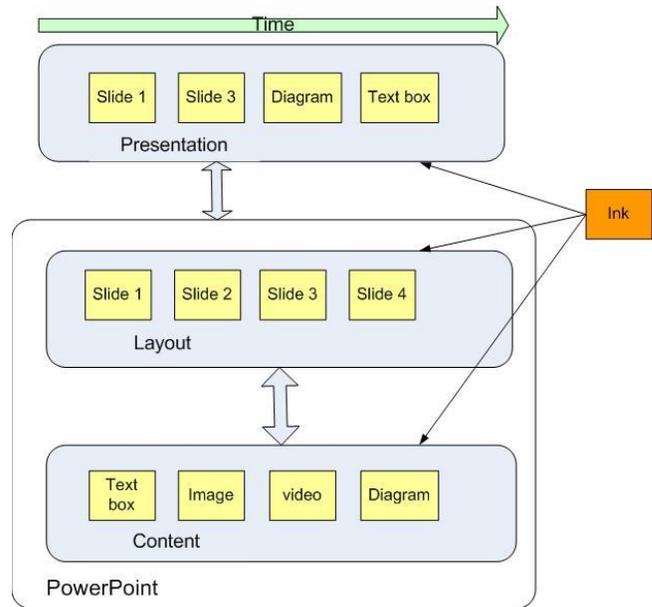


Figure 3 –Separating Content, Layout and Presentation style

presentation are unified instead of allowing flexibility during presentation delivery. Some presentations need to be more dynamic: instructors with traditional presentation technologies often reframe or spontaneously provide more detail about concepts if they see that students do not understand the content [4]. Thus, presentations are often dynamic events in which a fixed flow of slides (during authorship) does not meet the needs of either the instructor or the audience.

MultiPresenter focuses on the *presentation layer* of this process, independent of the content authoring and layout processes. It provides the presenter with different ways and styles to give a presentation, facilitating fully automated scripted transitions between slides, completely ad-hoc use of content, and hybrids that semi-automate presentation while still allowing spontaneity. MultiPresenter provides smooth transitions between these presentation styles even during a presentation. Thus, presenters can construct the flow, or “presentation layer” of a presentation independently (i.e. after) authoring the content and layout of the slides themselves, right up to and during the actual presentation of the material.

By separating the presentation layer from the layout and content, we facilitate more dynamic presentations because the flow of the presentation can be specified *during* a presentation, rather than during the authoring process. A presenter is able to choose before or during the presentation the specific content or layouts (slides) that he or she wants to be seen at a given time. This separation facilitates many different types of presentations other than the one-slide-on-one-screen commonly used by PowerPoint and other slideware tools. This can be seen in the upper part of Figure 3, which illustrates the presentation layer. Beyond simply supporting modification of the *flow* of the presentation, MultiPresenter also provides several tools that allow the presenter to change the *way* content is presented. We discuss these tools further in the next section. They allow content to be shown differently than in typical slideware. A presenter may choose to only show slides on one projector, while using the second projector as a scratch space. Alternatively, slides or specific

content can be selected for persistence and be displayed on the second projector for an extended period of time, allowing the presenter to refer back to that information. *Separating presentation from content* is a powerful enabling design concept that MultiPresenter uses in many ways.

Electronic ink is really another concept altogether, because it is related to the presentation, the layout and the content. Electronic ink is written during the presentation, and can be used for attentional gestures – to emphasize or show certain areas in a diagram on the slide [2]. It is therefore part of the presentation layer. Yet, it can also be part of slide layout, if the presenter uses ink to connect two objects on the slide, or as basic content if a presenter uses it to write persistent information. Ink should thus be considered as a separate layer, because in certain instances, such as when reusing the slides for a new presentation or when we are only looking at the presentation slides without the talk, we want to separate out or even completely disregard the ink layer.

Separating content and presentation has significant implications for archiving. Current slideware only provides limited support for creating several different presentations from the same content. By explicitly separating content creation from presentation authorship, multiple presentations can be created and stored referring to the same source content. Most slideware typically assumes that a stored presentation is a file containing the content and layout; however, if we wish to save the presentation level, we should also consider the dynamic *presentation delivery* as a core part of the presentation, so we must archive it for future viewing. Unlike content and layout, the presentation level is dependent on time. We must archive the events as time related – which content appeared where and at what time.

Separating content and presentation is a common design philosophy. We have seen the philosophy employed on the web, where XHTML defines the semantic content and structure of webpages, while CSS or XSL style sheets define the visual layout or presentation of content. Similarly, LaTeX [15], Scribe [28], and UNIX's troff [24] all employed this philosophy years earlier in the typesetting domain. These systems embody the understood advantages of separating the authoring of content from the presentation of that same content, which allows each process to be more flexible and independent. The same content can be easily presented in different styles (technical report, journal article, academic thesis) if either content or presentation can be changed without affecting the other. For example, a link can be shown in one style as a footnote, in another style as a reference to be written at the end of the document, and in another style it can be treated as a hyperlink to a web page. In MultiPresenter, we do much the same thing by separating the authoring and layout of content, which is done elsewhere, from the presentation of the content in real-time, which is done using our system.

5. MULTIPRESENTER

5.1 Infrastructure Support

Our goal was to build a system that would be simple and usable. Simplifying the infrastructure support from what was required by prior work, which often relied on complex technical setups [5, 29], was a core design goal to enable lightweight deployment: the system should be capable of running on a standard laptop connecting to existing projectors in any room. We believe that most presenters would like to retain control over their content and

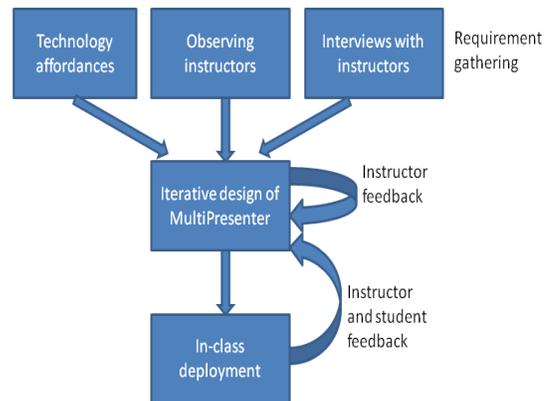


Figure 4: The User-centered approach of MultiPresenter.

use either their laptops or the room's PC to run their presentations. We definitely did not want to assume that major investments in new projector infrastructure would be made.

The primary requirement for MultiPresenter is for the computer to be able to control the entire display space. If there are two displays, this means having two video cards to control the two screens. Large lecture halls and conference rooms that have two or more projectors or displays set up in the room usually are accompanied by a dedicated computer that controls one or both of the screens. To accommodate the control of two screens by the room computer all that is needed is add another graphic card to that computer (if it does not already exist) and enable connection of the computer to the two screens via the control system of the room. This is a simple task that can be done in any room with existing infrastructure that controls two screens.

In order to run our system from a laptop, we need the laptop to have two or more graphic cards to be able to control multiple screens. In order to add another graphic card, it is possible today to use various solutions. The VTBook™ connects to the PCMCIA slot of a laptop and adds a graphic card that can connect to a DVI or VGA port. Matrox's DualHead2Go™ or TripleHead2GO™ are devices connected on one side to the laptop's VGA output and on the other side to two or three screens or projectors; allowing the laptop multi-display capability by simulating one large surface spanning all screens of up to 3840X1024 pixels. The simplest and cheapest solution that exists today (less than 100\$) is to use a USB to VGA adaptor that adds another graphic card to the laptop with a simple plug-and-play USB interface.

As the resolution of graphics cards increase, it is possible for a single computer to control a large volume of pixels. With the advancement of networked projectors, and the increased resolution of projectors, future laptops will be able to control more projected pixels either on one or multiple screens. The real challenge is not the technical question of how the infrastructure will be built, but rather how we can design tools that make use of this abundance of display space to create better presentations.

5.2 Design Process

In designing MultiPresenter, we took a User-Centered Design approach (Figure 4). Most systems have one type of user that the designer has to focus on when designing the system. In our case, users are both the presenters and the audience.

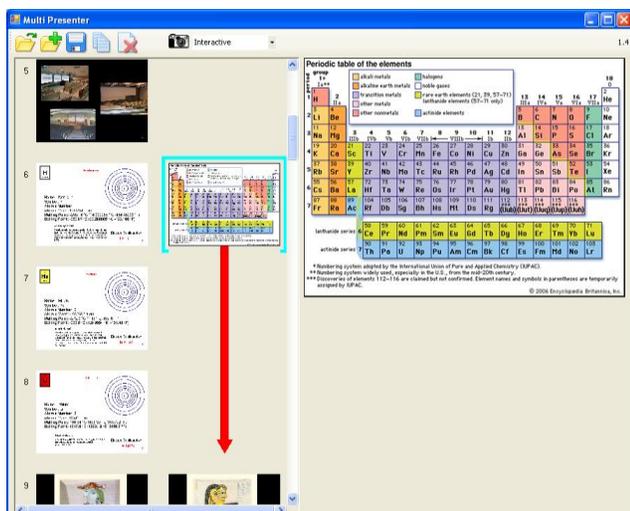


Figure 5 – Authoring view showing the visual presentation of the presentation across multiple projectors

First focusing on the presenter, we emphasized usability of the system. It was imperative that the system would be easy and intuitive to use – especially during a presentation when the presenter needs to pay attention to the material and often cannot afford to devote much cognitive effort to running the presentation. To better understand this and other requirements, we involved instructors and presenters early in our design process. Presenters were shown the interfaces of early prototypes and were encouraged to comment and to suggest needed features. We then iterated on the prototypes, changing the design and solving problems during each iteration.

We next focused on the audience, trying to understand how to build presentation software that would promote the audience's learning or understanding of the material. Using extra screen space in a presentation does not necessarily help the observer. Showing too much information that is redundant to the spoken words may in fact hinder the learning process [19]. Although, this is very dependent on the way the presenter uses the system, we tried to build the system in a way that the presenter would be guided to use it according to what we found would best aid audiences' learning [16].

5.3 Design Goals

During the design process of the system, we had several goals stemming both from our previous research and from the design process:

- *Separation of content and presentation* – As stated earlier, we wanted users to understand that the system was a *presentation system*, different from their existing slideware authoring tools. Presenters should understand implicitly that the system focused primarily on enhancing the presentation process. Thus, MultiPresenter does not support authoring of slide content. PowerPoint and other slideware tools already do a very good job building slides using different fonts, backgrounds, diagrams, clip art and other media. So content can be created with existing authoring tools and then be imported into MultiPresenter as a set of images. A PowerPoint plug-in to directly import content and run a presentation is possible, but not yet implemented.

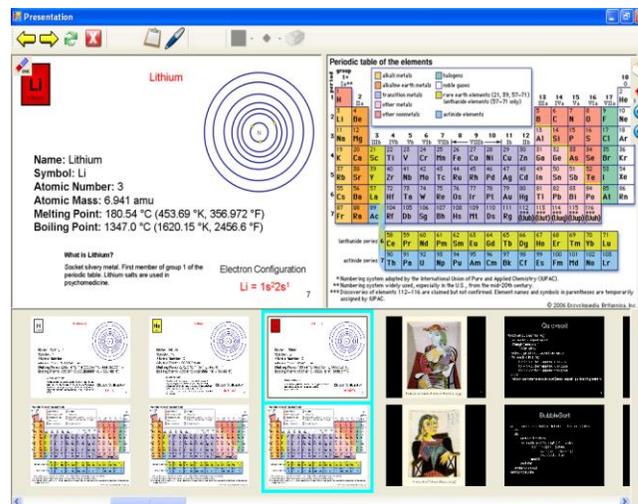


Figure 6 –Presentation view of the material shown in Figure 4

- *Support both dynamic and non-dynamic modes* – We wanted to support different types of presentation styles, most notably both dynamic and static styles of presentations. Static, scripted presentations are better for reducing cognitive load on the presenter because the presenter only needs to advance the pre-made materials. Dynamic presentations are important when some ad-hoc or spontaneous interaction with the audience are needed.
- *Usable in practice* – We wanted the system to be as usable as possible in the real world. We therefore designed the system to run from one computer. For the system to be adopted, we believe it must support compatibility with existing practices of current presentation software. Presenters already are used to running slide decks in a sequential matter. If we want people to use the system, we need to use this as a starting point, building upon users existing way of presenting slides while adding other features that afford other possibilities.
- *Reuse of content* – Presenters already have existing single-display slide decks. Some have invested significant effort in preparing this material. Presenters should be able to use previously authored content and existing presentations in the context of multiple screens with minimal effort.
- *Minimize cognitive load* – When giving a presentation, the presenter needs to focus on delivering the presentation itself, rather than on the interface to the presentation software. The use of the presentation system must be intuitive and must demand minimal cognitive resources from the presenter.

5.4 System Description

MultiPresenter comprises two pieces: presentation authoring and presentation delivery modes. The presentation authoring mode facilitates the creation of the *flow* of the slides, and is used before delivery of the presentation. The presentation delivery mode is invoked during presentation and provides the view displayed by each projector, and allows the presenter to easily switch between scripted flow, ad-hoc flow, or completely manual control of each projector view.



Figure 7 –Showing the two previous slides provides immediate context

5.4.1 Presentation authoring

The *presentation* authoring mode allows a presenter to author the flow of a two- (or more) projector presentation from existing slides, and should not be confused with *content* authoring (which is done using an external slideware tool such as PowerPoint). In the authoring view (Figure 5), the presenter can design a pre-made presentation for two screens. There are two columns of slots into which slides can fit, representing the two screens. An existing slide deck presentation loads into a single column. The user can author a dual-screen presentation using simple and intuitive direct manipulations tools such as copying, moving or stretching any slide to one or more locations in the second column. For example, the presenter can drag an overview slide to the second display and mark it so it will be seen during a predefined part of the presentation. When running the presentation, the slides will show as the presenter sees it in the two columns.

Using the authoring view, a presenter can build a pre-made presentation that will show slides on either of the two screens or on both simultaneously. This is useful when comparing two slides (e.g. an art history presentation comparing two paintings), when showing an overview slide and a detail slide (i.e. having an overview of the presentation with the current location always visible), or when keeping an important slide visible for part of the presentation alongside the regular stream of slides (i.e. a chemistry lecture showing the periodic table throughout the lecture). Any pre-made presentation that has been authored can be saved to be reloaded at a future time.

The basic authoring view supports building a scripted presentation that assumes the presenter does not wish to interact with the system during the presentation. Many presentations, like sales pitches or conference talks, are prepared talks in which the presenter has prepared the entire sequence of slides in advance. In these types of talks, there is usually no need for the presenter to interact with the system other than progressing to the next slide. Similar to PowerPoint, the presenter decides beforehand exactly what will be seen on the screen (in this case on both screens), and progresses forward in time in a linear fashion.

Our presentation authoring mode also affords creating multiple “presentations” from a single set of slides, each of which can be saved, loaded and employed separately without modification to

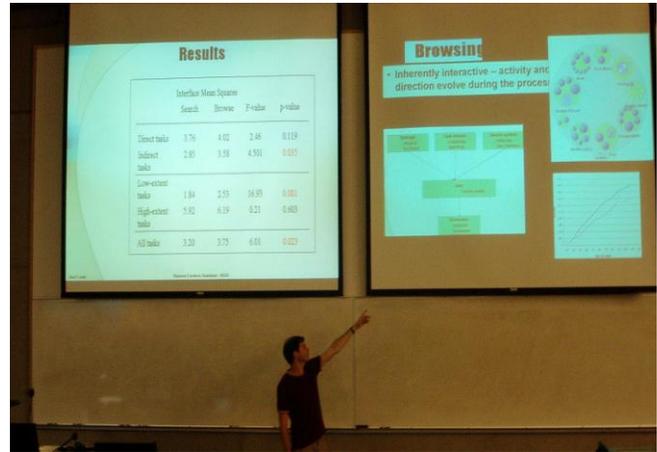


Figure 8 – Dynamically clipping content to the secondary screen

the content. While some existing slideware tools (e.g. PowerPoint) can be used in this way, the functionality is not readily exposed by the interface, and is frequently somewhat difficult to use. Typically, users create multiple versions of the same slide deck, and cut-and-paste slides—a non-optimal solution since content changes are not propagated across slide decks. Drucker et al. [7] explored ways to compare and manage multiple slide presentations, but their focus was on managing multiple presentation versions and not on the presentation act itself. This particular example highlights the strengths of the design philosophy of separating content from presentation.

5.4.2 Presentation delivery

Figure 6 shows the presentation delivery view (that the presenter sees). This view shows the current two slides on display, and enables the presenter to navigate to different areas in the presentation. The presentation delivery view gives the presenter a powerful set of tools that facilitate many of the presentation practices common to traditional presentations. The view also gives presenters the ability to dynamically manipulate the presentation of the content during the actual presentation.

Figure 7 illustrates how the first projector can be used to show the regular slide deck while the second projector can be used to show one, two or four previous slides. As the presenter moves through the slide deck, the second projector is automatically updated, giving the audience automatic context for the current slide. The audience is kept aware of the order of the previous slides using animations that transition each slide to the new location on screen. This simple configuration allows presenters to use their existing slide decks and without any extra effort to use the second screen, giving their audience some context for what has been previously shown. Much of the information needed to be referred to during a presentation is recently shown information [16], so showing the previous four slides can give the audience the necessary context needed to understand the current slide and can also allow the audience to look at previous content they might have missed.

Figure 8 shows how MultiPresenter gives presenters dynamic, interactive control of displayed content. First, the presenter can at any time decide to select and display any slide on the second projector, and this can stay on the display as long as the presenter likes. This affords using the second projector as the “reinforcing

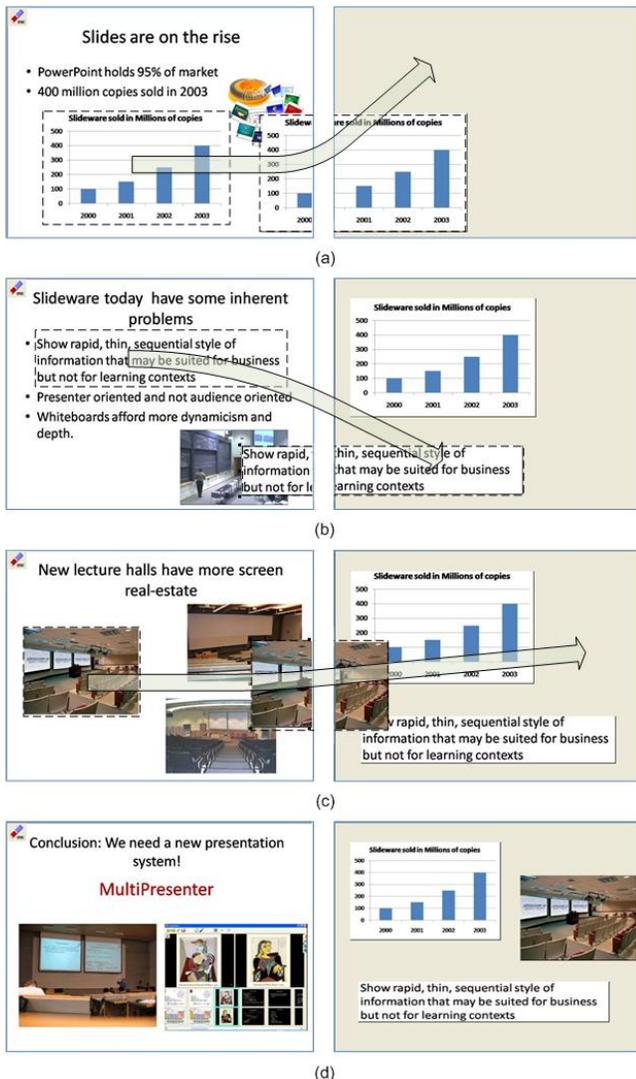


Figure 9 – Dynamic mode example. During presentation, the presenter drags content from the prepared slides on the left screen to the scratch screen on the right allowing long-term persistency of important content.

concept” that the presenter can return to throughout the entire presentation. Second, the second projector can be used as a “clipboard” of highly referred to content items that the presenter deems important to keep persistent. To modify this clipboard, the presenter can, at anytime, select a part of an existing slide (e.g., an important diagram or bullet point), the entire slide, or any number of slides. Each added slide is automatically laid out in size and location according to the number of existing snippets. The presenter can then move, resize or erase any snippet on the secondary screen. All interactions are shown on the presenter’s laptop as well as the audience to keep the audience aware of the origin of the information. Figure 9 shows an example of how a presenter would use this dynamic control during the presentation in order to keep some important information available longer.

This level of dynamics is useful, and allows the presenter to keep certain important items visually available for longer times. For instance, the presenter might realize during the presentation that

some information may be referred to again later. Using this mechanism, the presenter can ensure that the content is easily referred to without needing to flip back through the slide deck. The presenter might also want to keep certain data visible together to explain difficult concepts. In this mode, the presenter can gather the important concepts from the stream of slides and put them on the secondary display, thereby providing the audience with a visual connection between concepts. In classrooms, instructors usually prefer to have some level of dynamics to be able to perform ad-hoc explanations and to use the visual aid to answer questions [16]. In this mode, the instructor is effectively given full control of how to use the second display.

Electronic ink adds another level of dynamics and allows the audience to follow a presenter’s train of thought. Presenters who use tablet PCs can use a stylus in their presentations to add annotations to existing slides. Ink can be used by showing slides on one screen, and using the second screen as a drawing screen for ink alone. Electronic ink can also be used to gesture and emphasize important areas on a slide. Our system fully supports electronic ink in different colors and sizes. The presenter can add ink annotations to existing slides in the presenter’s view, while the audience immediately sees the ink annotations. Erasing ink is also supported, as well as persistence of ink through time when the presenter moves back and forth in the slide deck.

6. INITIAL DEPLOYMENT

To provide an early understanding of whether our design goals for MultiPresenter were actually useful, we recruited a university instructor to use the system to teach one of his courses. The instructor is technically very savvy, and has a keen interest in using and evaluating new technologies for teaching. He was also involved in the earlier design phase for MultiPresenter, so was already well-versed in the system’s feature set.

Figure 1 shows the instructor using the system in his classroom. The instructor used the system for most classes of his first year undergraduate basic computer science course (88 enrolled students). We observed the instructor using the system, recorded logs of the system in use (logging the events and types of usage), interviewed the instructor during and after the semester, and administered questionnaires to the students to assess their subjective perceptions of the system.

The instructor used the presentation delivery system almost exclusively in a fully dynamic mode, retaining full control over what was being displayed on both screens at all times. He used an existing slide deck from a previously taught version of the course that he updated each semester. He showed this slide deck on one screen using MultiPresenter and dragged slides to be shown on the secondary display during the lecture as he thought fit. He used the second display in several ways:

- Showing slides that were important to keep persistent for longer times (i.e. – important concepts, definitions, or concepts that would be useful later).
- Showing variants of a single concept on two screens. For example, the instructor often showed the problem slide on one screen, and the solution slide on another.
- Comparing between two items. In several instances, the instructor used the pre-made presentation mode to compare between two slides that showed comparable concepts.

- The instructor used electronic ink extensively in the class. Many times he used the second screen for extra writing space, either displaying a blank screen and using it as a space for the ink, or duplicating a slide on both sides but using different ink annotations on each side.

When asked about the utility of the system, the instructor was enthusiastic and commented favorably on the usefulness of the system. He noted that although the interface was intuitive and simple to use and did not take extra resources to operate, it took him some time to understand how to best utilize the extra display space. He said he wanted to use the system in his future classes.

To get subjective perceptions on the utility of the system on students' learning we asked students to complete an online questionnaire about their attitudes and thoughts on the use of the presentation system in class. Students were given a 5-point Likert scale to examine their opinions of several statements. Eighteen students filled the questionnaire. Seventeen out of the 18 students agreed or strongly agreed with the statement that having two screens helped the instructor present the material better. Seventeen of 18 students also agreed that they would encourage other instructors to use the system. Some of the questions and results are presented in Table 1. In the Likert scale 1 represented strongly disagree, while 5 represented strongly agree.

Table 1 – Students subjective ratings of the MultiPresenter system as they have seen used in class

Question	Avg.	SD
<i>Seeing the two slides helped me understand the material better than a one-slide presentation.</i>	3.78	0.73
<i>Having the two screens helped the instructor present the material better.</i>	4.39	0.78
<i>I would encourage other instructors to use the two screens in a similar ways.</i>	4.28	0.75
<i>It was helpful for me when the instructor showed certain slides for longer periods on the second screen.</i>	4.5	0.92
<i>It was helpful to me when the instructor used both screens to compare two slides.</i>	4.44	0.92
<i>The presentation system helped me learn better.</i>	3.78	0.87

Overall, we see that students were quite positive about the system, thinking it helped them learn and understand the material better, and that it helped the instructor present the material better. In an open-ended question about the advantages of the system one student commented on some specific benefits: *“Keeping an old slide up while talking about a new one is very useful and allows a longer time for note taking. Comparing examples on the two screens was also helpful.”*

7. FUTURE WORK

We plan to continue to develop MultiPresenter, and further evaluate the system to understand its viability. Planned studies include MultiPresenter's use in other university courses, and in more business oriented settings.

A tighter integration with PowerPoint and other commercial tools will be necessary to gain wide acceptance. Adding a plug-in to PowerPoint that enables it to run a presentation using our system will simplify things for presenters by having the authoring and presentation capabilities in the same platform, and will also enable them to easily run a multi-display presentation of existing presentations without any extra effort using standard representation templates such as “show the last four slides” or “show topic slides” on a second screen. Tighter integration with PowerPoint will enable lower level access to objects on slides, thus enabling control of individual objects during presentation time instead of only bitmaps, which is what is now implemented.

Other features we plan to add are support for more than two screens (our design already supports this, but we have not yet resolved the issue of how to design a presentation that scales across a range of display sizes or number of projectors), adding a variety of gesturing tools, adding a dynamic text box widget to support text entry in dynamic mode for presenters without electronic ink capability, and archiving of the dynamic mode interactions for long-term persistency. The archiving of actions in dynamic mode is part of the separation of presentation style from the content. We plan to save objects seen on all screens, and the interactions of a presenter with all of the objects. Electronic ink annotations will be saved on a different layer, consistent with our earlier comments about its role at each stage of the process.

8. CONCLUSION

We have designed, implemented and evaluated a prototype for MultiPresenter – a presentation system that allows users to show and author presentations on large display surfaces. In order for the system to be usable, we enable presenters to use existing presentations and, with simple infrastructure additions, they can run MultiPresenter from their laptops. MultiPresenter supports both short-term and long-term persistence of data, enabling a presenter to keep important information visible longer, and it supports both static and dynamic presentations. Using MultiPresenter, a presenter can use the multiple screens now available in many lecture halls and conference rooms to give a better, more interesting presentation that better promotes audiences' learning. We think audience members will also benefit by being provided with more context regarding previous information, so they can decide how to assimilate information and what to look at as they integrate earlier information with new information. Seeing the previous four slides, for example, an audience member can decide which slide to look at any given moment. We believe the control of what to look at on the enhanced display in any given moment being transferred from the presenter to the audience benefits both. Our initial evaluation of MultiPresenter in a real classroom setting has suggested a number of other improvements, and support our hope that we will ultimately be able to demonstrate clear pedagogical benefits.

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