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A Survey of Multimedia and Web Development Techniques and Methodology Usage

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Our survey results suggest that no uniform approach exists to multimedia systems development and that practitioners aren't using the multimedia models cited in the literature. We conclude that developers need new techniques that capture requirements and integrate them within a systems development framework.

The rapid emergence of multimedia-based (including Web-based) information systems in recent years presents a serious challenge for the development skills of information systems professionals. Until recently, many such systems were simple, stand-alone applications like electronic brochures. Some have now become extensive, complex, e-commerce applications. As Web-based systems integrate with organizational activities such as customer support, sales and marketing, and distribution and technical support, Web system developers will encounter similar development issues as conventional and multimedia systems development. Therefore, we propose a more sophisticated and disciplined approach toward systems development, which includes resolving various problems that accompany large-scale systems development.

Recently, structured methods for large-scale

systems development projects and visually oriented or object-oriented methods for interface design have dominated the systems development field. These approaches appear unsuitable for multimedia and Web application development.^{1,2}

The research literature has covered some excellent work for constructing understandings of multimedia systems and the methods by which they should be built.³⁻⁵ However, we've observed that practitioners aren't using these kinds of methods. Therefore, we wanted this study to answer a simple question: How exactly are multimedia and Web-based applications being developed?

Background

While much of the multimedia and Web software industry has concentrated on commercial, promotional, and training applications, we believe that large-scale, in-house, data-heavy business applications will dominate the field. If this happens, industry will need comprehensive, well-structured development techniques and methods.⁶ Furthermore, Web developers will need to understand how to manage these new technologies and adopt a more user-focused design process.

The information systems literature about multimedia reveals considerable academic effort during the mid-1990s and a rapid fall off since then. Although still in its infancy, the field seems to have been eclipsed by Internet-focused research such as Web engineering. For this study, we included Web-based systems within a general definition of multimedia information systems. However, this made identifying a sample group more difficult. We felt that a survey of the development practices of Webmasters would have revealed somewhat frenzied and chaotic activity. While this activity is worthy of research, we wanted to reveal richer development customs in the broader area of multimedia information systems development. Multimedia development is a key reference point in an evolutionary process that flows from multimedia into Web development practices. As a result, we sought to examine more mature multimedia development environments among general industry and multimedia companies.

Within the information systems field, comprehensive development techniques and methodologies often emerge in the wake of new types of systems such as management information systems, decision-support systems, and executive information systems. Lack of support for the development process and the consequential inadequacy of development practice lead to poor systems reli-

ability, low productivity, and high maintenance costs. Since the international multimedia software industry is relatively new, it's not surprising that multimedia development approaches are currently inconsistent and lack formal or tool-based modeling techniques.⁶ The sometimes ad-hoc nature of development and the efforts to move practice from a craft to a structured discipline⁷ mirrors the pre-structured era of data processing.

In recent years, organizations have been introduced, often unintentionally, to multimedia as information systems have grown in diverse ways. Systems have been distributed, ported into relational databases, front-ended with GUIs, tapped into via decision-support systems, and strapped together with data warehouse and enterprise systems. However, in all of these elaborations the fundamental data types have remained unchanged. Now, Web servers and intranets have added a further dimension to the information systems landscape. Systems have to process multimedia such as images, sound, video, and animation. The reluctance of most information system departments to experiment in any meaningful way with multimedia applications is being challenged as the Web brings multimedia in through the back door.

Research objectives

Our main research objective was to identify the current practice of multimedia software development methods in Ireland. Other objectives included

- examining the development approaches adopted toward conventional (nonmultimedia) information systems to assess the context for multimedia development,
- determining whether differences exist between the techniques and methodologies the literature suggests for developing multimedia systems and those actually used in practice,
- discovering the type and nature of multimedia applications being developed,
- uncovering future plans for multimedia application development, and
- comparing and contrasting the development approaches of general industry and the multimedia software industry.

To our knowledge, no previous research on mul-

timedia development has previously been conducted on such a broad scale in industry.

Research methodology

We conducted two studies—one that examined the top 1,000 Irish companies in general industry and one that looked at the principal 100 Irish companies in the multimedia industry. We had a 10 percent response rate ($n = 98$) from general industry and a 15 percent response rate ($n = 15$) from the multimedia industry. We analyzed the results using basic descriptive statistics and some cross-tabulations. We sent similar questionnaires to both industries to examine systems development environments; multimedia development practices; technique, methodology, and tool use; and the respondents' future development plans.

Findings

Here we highlight the main findings of our study. Where possible, we contrasted the positions of general industry with those of the multimedia industry. However, where response numbers were low or where it was sensible to do so, we analyzed aggregate positions.

Computing environment of general industry respondents

When asked what type of methodologies companies used for general information systems development, we discovered that one-quarter (24.6 percent) of 65 respondents who answered this question from general industry don't use any methodology. Of those firms who use some type of methodology, three-quarters use an in-house variant as their principal methodology. Where a commercial or proprietary methodology is being used, structured systems analysis and design method, or SSADM (16.9 percent), and rapid application development, or RAD (13.8 percent), were the most often cited, while only 6.2 percent use Unified Modeling Language (UML) and 4.6 percent use information engineering.

An instinctive interpretation of the reasons why respondents don't use a methodology might be that they have an immature and less developed approach toward systems development than those who use a methodology. However, we found that it's not the difficulty in using or understanding methodologies that's the main inhibiting factor; rather, it's the clear sense that they're too cumbersome, as 61.5 percent of the respondents reported. A significant number (30.8 percent) also

Table 1. General approaches used in multimedia development.

Approach	General Industry (n = 8)		Multimedia Industry (n = 15)		Aggregate Response (n = 23)	
	Affirmative responses	Percent of valid cases	Affirmative responses	Percent of valid cases	Affirmative responses	Percent of valid cases
Semistructured systems development life cycle (SDLC)	8	100	6	40	14	61
Prototyping	2	25	9	60	11	48
Production-oriented approach	1	13	8	53	9	39
Formal/structured SDLC	3	38	4	27	7	30
Advertising/graphic design	2	25	5	33	7	30
Object-oriented approach	3	38	3	20	6	26
Other	1	13	4	27	5	22
Artistic approach	0	0	4	27	4	17
Media design approach	0	0	4	27	4	17

felt that commercial methodologies were too costly. Other reasons cited were that methodologies are “not suited to [the] real world” and “long training is required.”

Of the techniques used during conventional information systems development, a revealing picture of the fundamental approach that respondents adopt toward systems development emerged. Many of the widely used techniques—such as systems flowcharts (70 percent), data-flow diagrams (53 percent), structure charts (26 percent), pseudocode or structured English (26 percent), and decision trees and tables (20 percent)—hark back to the dominant techniques of the structured era of the 1970s. That developers still use these approaches prominently contrasts with the lower usage levels of more recent data-focused techniques such as entity relationship diagrams and normalization, each used by 34 percent and 29 percent of respondents, respectively. The increasing reliance on systems that perform some real-time systems function wasn’t reflected in the use of techniques. However, the usefulness of decision tables for specifying aspects of real-time systems modeling may be concealed within the findings. Even old techniques like systems flowcharts and data-flow diagrams have been making a comeback in recent times for the purpose of workflow and functional specification. Not surprisingly, respondents widely cited (60 percent) the use of project management techniques. Only a small number of respondents employ use-case, class, and state-transition diagrams. Although these findings may surprise some people, we found that development practice generally hasn’t kept pace with the emergence of more contemporary and sophisticated techniques and methodologies.

Profile of multimedia industry respondents

The multimedia services provided by multimedia companies reflects the broad base of the industry. Most companies use CD-ROM as the platform for multimedia applications. Of 15 respondents, 9 said they deliver their multimedia content over Web sites. The principal remaining services are consultancy, kiosks, and video and audio production.

This part of the study examined the types of multimedia applications developed by respondents of both samples and the general approaches and techniques used in the development process.

Multimedia application types. In general industry, only 9 of 93 respondents who answered this question had previously developed or commissioned multimedia applications. Of these applications, the most frequently developed types are for training and education, promotional activities, and business applications with multimedia data, in that order. The average systems cost about \$70,500 and the average person days spent per application is 75 days with a team size of 2.6 persons. The companies outsource about 40 percent of all applications.

Within the multimedia industry, the picture is somewhat different. The greatest number of applications that respondents developed (averaging 54 each) were business applications that use multimedia data, at least three times as many as the next most frequently developed application types: information/reference and training/education. Other applications they developed were distributed among museums/galleries/libraries, entertainment/games, promotional activities, travel/tourism, and retail/point of purchase/shopping. The various application types cost about \$41,750

Table 2. Methodologies adopted for multimedia application development.

Methodology	General Industry (n = 6)	Multimedia Industry (n = 13)	Aggregate Response (n = 19)
Doesn't use any methodology	2	1	3
Object-oriented development methods	2	3	5
Hypertext design model (HDM)	1	0	1
Relationship management methodology (RMM)	1	0	1
Fully integrated environment for layered development (Field)	1	1	2
In-house methodology	1	11	12
Traditional systems development life cycle (SDLC)	0	3	3
Object-oriented hypertext design model (OO-HDM)	0	0	0
Other	0	0	0

and are completed in 127 person days with a team size of 4.3 persons. The most expensive systems to develop were training/education applications, costing about \$150,500 on average.

In both the general and multimedia industries, we found that companies deliver most business applications with multimedia data over Web sites while they produce most promotional applications on CD-ROMs. The only other application with a significant incidence is training/education, for which CD-ROM delivery is the most common platform.

Approach to multimedia development. We asked respondents about their general approach toward multimedia development and specific methodology use. This uncovered some interesting findings regarding general approaches used (see Table 1 where *n* represents the number of respondents to this question). General industry respondents have all used at some time a semi-structured systems development life cycle (SDLC) approach in multimedia development. Thus, respondents are adopting an approach that resembles conventional information systems development. A smaller number use a more formal SDLC-based approach or an object-oriented approach. The focus on the SDLC within general industry contrasts with a much broader mix in approaches used within the multimedia industry.

While prototyping is the most widely used approach (60 percent) among multimedia industry respondents, companies also use production-oriented (53 percent), semistructured SDLC (40 percent), and advertising/graphic design approaches (33 percent). The production-oriented approach reflects a commercial development strategy that, for example, starts with research and development and moves through preproduction, production,

and postproduction. The film and video industry use this approach widely. About one in four respondents use formal/structured SDLC, object-oriented, artistic, and media design approaches.

The finding that respondents use a multiplicity of approaches reveals that they don't agree on a common multimedia development approach. Such diversity may of course reflect the distinct nature of multimedia applications—that is, different approaches suit different types of applications. Some support for this contingency model may be that, on average, each respondent has used more than three different approaches. However, perhaps the background of multimedia developers in framing the development metaphor can better explain why they use so many approaches.⁸ This notion has some obvious, intuitive merit. We expect that those working on a multimedia application will bring to the project their experiences—that advertisement designers will use their media design skills, that systems analysts will use an SDLC as a development framework, and so on. The essential conclusion of the findings here is that no widely accepted approach toward multimedia application development exists.

The findings were dramatic regarding the use of specific methodologies (see Table 2 where *n* represents the number of respondents to this question). Overall, respondents don't use methodologies proposed by academics and researchers such as the hypertext design model (HDM), object-oriented hypertext design model (OO-HDM), relationship management methodology (RMM), or fully integrated environment for layered development (Field). Only 2 out of 19 respondents have used any of these methods. Given the absence of a widely accepted method, it's not surprising that 11 out of 13 multimedia industry respondents use some sort of in-house method—for all but one of these it's

Table 3. Effect of adding structure to the development process.

Affected aspect	Aggregate Response (<i>n</i> = 19)*		
	Decreased	Same	Increased
Productivity	1	2	16
Quality (with respect to error-free software)	1	3	14
Quality (with respect to customer satisfaction)	0	4	14
Achieving project deadlines	2	4	12
Meeting cost budgets	3	2	14
Minimizing predelivery change requests	1	6	11
Minimizing postdelivery change requests	1	6	12

*Note that one respondent didn't answer all questions.

their principal methodology. Three respondents use object-oriented development methods and a traditional SDLC as their methodology. In another question, we also discovered that 2 out of 14 respondents from the multimedia industry use computer-aided software engineering (CASE) tools to support their methodology. On a broader question on systems analysis and design, general industry reported that 66 percent of their development effort involves paper-based rather than computer-based modeling. In contrast, the average percentage of effort spent on paper-based modeling is just 27 percent in the multimedia industry.

In 69 percent of the cases, respondents cited an in-house methodology as the principal multimedia development methodology. When asked about the advantages or benefits of their principal methodology, the aggregate response from both sectors highlights cost effectiveness (74 percent), development speed (63 percent), understandability (58 percent), and adaptability (53 percent) as the most important ones. Secondary advantages were widespread acceptance/reputation (42 percent), results obtained (42 percent), ease of use (37 percent), and comprehensiveness (37 percent). The relative weight respondents gave to the benefits that emphasize improved efficiencies like cost and speed suggests an inclination to use methodologies that assist project management. Approaches like HDM or RMM don't emphasize project management—a task that's crucial to commercial development. Although it's unclear whether respondents had evaluated methodologies like these, this finding may point to reasons why companies haven't widely adopted certain prescribed methodologies. Of the three respondents who reported that they didn't use any methodology (in-house or commercial), two noted that methodologies were “too cumbersome.”

Seven of 17 respondents cited the following dis-

advantages of their principal methodology: it wasn't widely known, its level of complexity, and its high level of detail and obsolescence. Concerns about obsolescence and using a technique that's not widely known suggest fears about failing to use a more popular methodology. Other responses included “lack of developer acceptance” and “acceptability with older users,” hinting, perhaps, at management concerns about the predisposition of IS staff to methodology adoption.

We asked respondents from both samples for their opinions on the effect of adding structure to the multimedia development process (see Table 3 where *n* represents the number of respondents who answered this question). They were asked to indicate whether an aspect of development, such as productivity, would be decreased, remain the same, or be increased by adding structure.

From the findings we discovered that most respondents felt that all aspects, from productivity to quality to minimizing change requests, would be increased or improved. While this may be a perceptual position open to some interpretation, it suggests an essential belief that a structured development process is desirable.

When asked to identify the greatest inhibitors of a successful multimedia software development effort, respondents ranked staff shortages and inadequate staff skills as the two most significant factors. Slippage in scope and an unclear statement of requirements also rank strongly as factors—their prominence among the chief concerns is a significant finding, illustrating the apprehension among practitioners that success depends on articulating requirements clearly and avoiding slippage in systems scope. A lack of systems development methodologies wasn't seen as an inhibiting factor to success. This is interesting since it supports a growing academic view^{9,10} that simply adopting a formal development methodology in itself isn't enough to assure success. Clearly, practitioners strongly believe that the development process needs support and structure but that these may not necessarily be delivered through methodology use alone.

Future trends in methodology usage. While respondents haven't felt that the absence of methodology is an inhibiting factor to success, a significant number of them expect increased methodology use. Drawing on a question from

Table 4. Use of techniques in multimedia application development.

Technique	General Industry (<i>n</i> = 7)	Multimedia Industry (<i>n</i> = 15)	Aggregate Response (<i>n</i> = 22)	Percent of valid cases
	Frequency of affirmative responses	Frequency of affirmative responses	Frequency of affirmative responses	
Project management	6	13	19	86
Prototyping	5	11	16	73
Flowcharting	3	12	15	68
Storyboarding	3	10	13	59
Menu maps	2	9	11	50
Data-flow diagrams (DFD)	2	7	9	41
Object-oriented techniques	2	2	4	18
Relationship management data-model (RMDM) diagram	1	3	4	18
Movie authoring and design (MAD)	1	3	4	18
Class diagrams	2	1	3	14
Entity relationship diagrams (ERD)	1	2	3	14
Dialogue charts	0	3	3	14
Other	1	1	2	9
State transition diagrams (STD)	0	2	2	9
Functional decomposition diagrams (FDD)	1	0	1	5
Use-case diagrams	1	0	1	5
Joint application design (JAD)	0	1	1	5
Microcosm/Mavis	0	0	0	0

Fitzgerald's study,¹⁰ we asked respondents about future methodology plans. Both industries expect that they will be moving toward an increased use of multimedia development methodologies (77 percent overall), while none of the respondents reported that they would be expecting decreased use. When looking at industries separately, only 1 out of 7 in general industry feels that the methodology adoption strategy would remain the same. A somewhat higher number, 4 out of 15, in the multimedia industry expressed the same view, suggesting these respondents already have a more comprehensive development framework.

Use of techniques in multimedia application development. We asked respondents about the techniques they used in multimedia application development. We presented them with a list drawn from traditional structured techniques (such as data-flow diagrams), contemporary techniques (such as use-case diagrams), as well as others focused on multimedia development, drawn from actual use (such as storyboarding) and research literature (such as relationship management data-model, or RMDM, diagrams). Clearly, not all the techniques are diagram-based (for example, prototyping) but we considered the list

adequate to get a picture of the general environment. From Table 4, we see that project management and prototyping are, not surprisingly, widely used. (Note that *n* represents the number of respondents who answered this question.) The next most widely used techniques are flowcharting, storyboarding, and menu maps, the popularity of which may stem from their ability to specify the presentation, navigation, and temporal aspects of a multimedia application. The use of multimedia-specific techniques such as RMDM diagrams and movie authoring and design, or MAD, (by 4 out of 22 respondents in each case) may be explained by the fact that software tools exist for both (RM-CASE¹¹ and MAD¹²).

Respondents said they occasionally use a variety of other techniques, from object-oriented to data modeling. This may not be coincidental since many multimedia methodologies are grounded in either object-orientation or entity-relationship modeling. Perhaps to compensate for the lack of comprehensive or specific modeling tools, developers are improvising with techniques not designed for multimedia development but that perform some useful modeling function. The fairly widespread use of data-flow diagrams (41 percent) is more difficult to interpret because they neither

Table 5. Future multimedia development intentions within general industry.

	Affirmative Responses (<i>n</i> = 89)	Within		
		6 months	1 year	2 years
Definitely yes	13 (14.6%)	5	5	3
Likely	30 (33.7%)	3	15	12
Probably not	37 (41.6%)	N/A	N/A	N/A
Definitely not	9 (10.1%)	N/A	N/A	N/A

Table 6. Multimedia content in future information systems within general industry.

	Affirmative Responses (<i>n</i> = 87)	Within		
		1 year	3 years	5 years
Definitely yes	11 (12.6%)	6	4	1
Likely	33 (37.9%)	6	19	8
Probably not	39 (44.8%)	N/A	N/A	N/A
Definitely not	4 (4.6%)	N/A	N/A	N/A

represent sequential flows or data modeling. It may be that they are popular because they're well understood as a legacy technique. Whatever the reason, this is worthy of further research.

Future multimedia development

Our study concluded by asking respondents from general industry what their future multimedia development plans were. We also asked respondents from both samples what types of applications they expected to develop.

General industry plans. We asked respondents from general industry if they expected to develop multimedia applications in the future (see Table 5 where *n* represents the number of respondents who answered this question). We asked all respondents this question (89 out of 98 answered), whether they had previously developed or commissioned a multimedia application or not. Forty-eight percent said they will or are likely to do so within two years. Since only 10 percent of the sample is currently developing such applications, this represents a substantial expected increase. Of this 48 percent, two-thirds expect that they will or are likely to develop multimedia applications within a year. If this happens, then the earlier identification of staffing issues as a major inhibitor of successful multimedia development is likely to pose a serious problem. This problem may be further exaggerated in the Irish and European labor market where shortfalls in IT skills are expected to continue for several years.¹³

We asked general industry respondents

whether they expected their large-scale, organizational information systems to contain multimedia data within the next five years. As Table 6 shows, we discovered that 51 percent expect that these systems will or are likely to include multimedia data within this timeframe. (Note that *n* represents the number of respondents who answered this question.) Of those who have such expectations, most (35 of 44) expect it to happen within three years. This is a significant signal to practitioners and researchers alike that they must be prepared to anticipate the widespread introduction of multimedia applications and consequent technologies.

Expected multimedia application types. We asked respondents from general industry and the multimedia industry, who will or are likely to develop multimedia applications, what types these might be. We found that a small number of applications were likely to be widely developed. Business applications with multimedia data (61 percent) and information/reference (57 percent) applications are more widely cited than other application types, followed by training/education (48 percent) and promotional activities (36 percent). General industry expects to focus on a few specific types of applications, while the multimedia industry expects a greater spread.

Conclusions

Companies in general industry aren't developing multimedia applications on a widespread basis today. However, the future plans of companies suggest that this is about to change. The finding that more than half of general industry respondents expect or think it likely that their large-scale information systems will soon contain multimedia data is significant. Furthermore, the application type that all respondents most expect to develop in the future is business applications with multimedia data. These findings have consequences for many aspects of systems development such as staffing, new technology adoption, upgrading hardware and software systems to handle multimedia data, and development methods and techniques. Researchers need to relook at multimedia application development within the organizational context in which these relatively new technologies will have to work and coexist with extant human activities and information systems.

This research effort is timely. It has been several years since researchers proposed the most widely cited methodologies for multimedia systems development.^{3-5,14} That these methods have slow-

ly trickled down to practitioners is disappointing for academics—at some level theory should inform practice. Interpreting why this has occurred isn't easy. Although Garzotto's HDM methodology is a solid reference point for researchers in this field, it appears not to be used in practice.³ This may be because it's too difficult for developers to apply, that it has little CASE-based support, or that it concentrates on the production of a design representation rather than assisting the design process. More generally, the focus of many multimedia methodologies is on a particular domain or aspect of development,¹⁵ making their widespread use unlikely.

Our study shows that practitioners find development difficult. There's increasing demand for them to deliver high-quality, complex, Web-based software products rapidly, and even the most advanced RAD processes are incapable of doing so.¹⁶ Furthermore, no automated support exists for anything more than basic HTML editing, and barely any CASE tools support advanced Web-based application development. As a consequence, developers have to frequently resort to manual production mechanisms, with negative impacts on both productivity and efficiency at a time when both are more critical than ever before.¹⁷ Lowe also noted that design tools aren't integrated properly with the development process.² Changes are afoot, however, as certain methodologies have tried to address more life-cycle stages. For example, RMM supports design and construction phases of systems development, and OO-HDM uses a step-based prototyping strategy. Recently, OO-HDM has evolved toward a Web-based focus.¹⁸

While the findings tell us that no universal methodology exists, most multimedia developers are using a semistructured SDLC approach toward multimedia development, especially within general industry. The multimedia industry uses more diverse development approaches where developers are drawing on different backgrounds and experiences. This lack of consensus is by no means undesirable and perhaps demonstrates a flexible attitude toward development.

Nonetheless, the extensive use of development approaches dating from the structured era is disconcerting. If the SDLC and traditional structured techniques don't model fundamental multimedia constructs, why are developers using them? We contend that developers are using traditional methods to bring structure and organization to the development process, rather than endorsing an underlying development philosophy. Since many

multimedia projects are contract-based commissions, SDLC may be serving as an effective project management and pseudolegal framework.¹⁹

While developers don't want a cumbersome and expensive methodology, there's a clear perception that they would like to add structure to the development process. Perhaps a multimedia and Web development methodology that exploits the advantages of SDLC and couples it with suitable representational models would be more appropriate. If this were so, researchers and practitioners need to develop a set of usable techniques that assist the modeling process.

Despite problems in the practice of multimedia and Web development, research efforts continue. Projects such as Hyper-G²⁰ and Matilda,² which have yielded promising results, may translate into useful tools for developers. Furthermore, Web engineering is emerging as a discipline that addresses more wide-ranging topics than just Web-page design.¹ More recently published methods like the view-based hypermedia design methodology²¹ and the HyDev approach²² offer some incremental improvements to support the process. Lee's call for a "systematic approach to capturing users' navigational requirements" has merit and perhaps some urgency.²¹ User-centered approaches must be developed that translate needs into system representations. Modeling techniques that aid in requirements representation and communication will be an essential part of the multimedia and Web developer's tool set in the future.

While research and development into multimedia information systems development has been superseded recently by more popular projects in the Web-based world, we hope that the work on improving structural understanding and enhancing process support will soon be revisited and that the pursuit of improved practice in multimedia and Web-based systems development continues. **MM**

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