Perspectives in Multimedia Software Engineering

Shi-Kuo Chang
Department of Computer Science, University of Pittsburgh
Pittsburgh, PA 15260 USA (e-mail: chang@cs.pitt.edu)

Abstract

Multimedia software engineering can help small businesses compete with big businesses by overcoming barriers in space and time to establish a global presence.

1. David vs. Goliath

USA Today on December 31, 1998 carried an interesting article, "Birth of a New Order", talking about the year that *the world's lines of time and space collapsed.* The most incisive paragraphs are excerpted below:

The global, time-crunched market driven by electronic information "*forces things to get bigger and smaller at the same time,*" says Nicholas Negroponte, author and technologist at the Massachusetts Institute of Technology. "And that's so ironic, when things want to do both but not stay in the middle. There will be an increasing absence of things that aren't either very local or very global". Oil and cars aren't much suited to being small and local. So they're moving to become gigantic and cross-border. As for being small and local, that's where the Internet, or World Wide Web, comes in -- and it works in two ways. *It lets little companies be global,* so a start-up in a garage can put its goods or services on a Web site and sell worldwide, competing against midsize or big companies, wiping out disadvantages (such as distribution and scope) that once had to do with distance. And since little companies can change direction faster than bigger ones, they have an advantage in time. *Big companies used to have time and distance on their side. Increasingly, little ones do.* And so in 1998, we had the phenomenon of Amazon.com, which has become such a symbol of small beating big that business people have turned it into a verb: to be "*amazoned*".

It is interesting to study how Internet and multimedia technology might help the "little guys" compete against the "big guys". Indeed, this investigation may lead to a better understanding of the roles of *multimedia software engineering (MSE)* in this new industrial revolution.

2. High Presence and High Touch

Internet and multimedia are changing the rules of the economy and redefining our businesses and our lives. It is destroying solutions such as *mass production, segmented pricing*, and *time* and *distance* for big businesses. A company can develop a web page and advertising campaign and quickly compete in the world market. This has led to the *flattening* of the economy, whereby established companies and individuals doing business on their own can compete on an equal plane.

The small companies that succeed in challenging the large companies are the ones who can *maintain a global presence and yet make people feel that they are personal and easy to deal with.*

(1) Small companies can interact closely with their customers, so that the customers feel that they are able to communicate to the small company what they need, as opposed to the customers merely accepting the mass-produced product that large companies will sell and not give much ground for derivation from the product.

(2) Web changed from just a means of advertising, to a medium to rapidly exchange ideas with potential customers. Since the small company listens to what they say, it not only results in having a satisfied (and probably a faithful) customer but increases sales significantly with time.

(3) The Internet's primary advantage in advertising is not so much in attracting attention and conveying a brief message (the tasks assigned to traditional advertising media), but lies instead in delivering in-depth, detailed information. Its real power is the ability to provide almost infinite layers of detail about a product or service, interactively, at the behest of the user.

However, small companies have to *work smarter and respond more quickly* [Murr98]. They have to avoid mistakes and make the best of possible use to everything. Corporations with big budgets can afford to lose their investments, while a small company looks at web as *survival,* not as an investment.

The small businesses also need to realize having a web site does not automatically mean that the company will reach millions of potential customers. It simply means that there is the *potential to reach millions of potential customers.* Company has to promote the site through advertisements, e-mail, links to other sites, and cutting edge multimedia technology to attract lots of visitors.

For a new start-up small company, a brand new idea is always crucial. Second, multimedia technology should be used to provide various kinds of services on the web site. Third, once the site starts catching on and e-mails start rolling in, more and more person hours should be put into keep up with it all.

3. What Businesses Want from Multimedia Technology

3.1. How Small Businesses View Technology

There are significant differences in how large and small businesses view technology [JBR95]:

(1) **Affordability** - small businesses have to be extremely cost conscious, while big businesses have a larger capital to invest in technology.

(2) **Scalability** - all small businesses have ambitions to become big and this is an important requirement in the technology they buy.

(3) **Fast return on investment** - while large companies can wait up to 12-18 months for returns, small businesses want instant gratification.

(4) **Simplicity** - most small businesses want 'Plug and Play' products such as, for example, the Unix multiserver networks, or the Peer-to-Peer Networks.

3.2. Advantages of Multimedia Technology

From the perspective of a small company, the advantages of multimedia technology are perceived as follows:

(1) Helps develop advertising that could be used in many different media, thus cutting advertising costs.

(2) Cuts down on the amount of time the development staff needs to deal with customer service issues.

(3) Gives the appearance of having all the customer service support of a larger company.

(4) Facilitates out-sourcing [Neil98].

(5) Keeps clients aware of progress in almost real time by allowing them access to the site in development.

3.3. Wanted: Flexible MSE Tools

What businesses want from multimedia, in the above context, become quite clear: (1) Affordability => *software tools;* (2) Scalability => *scalable software tools;* (3) Fast return on their investment => *prototyping tools;* (4) Simplicity => *easy-to-use tools;* (5) Helps develop advertising that could be used in many different media => *adaptive multimedia tools;* (6) Cuts down on the amount of time the development staff needs to deal with customer service issues => *customer-service-oriented tools;* (7) Gives the appearance of having all the customer service support of a larger company => *scalable tools;* (8) Facilitates out-sourcing => *specification tools;* (9) Keeps clients aware of progress in almost real time by allowing them access to the site in development => *incremental tools.*

4. Internet and Multimedia Technology Trends

To support the design of such flexible MSE tools, we note the following Internet and multimedia technology trends:

(1) The Browser will become the preferred interface.

(2) Java, already known as the de facto standard, will offer more attractive features in reducing the cost of Internet development to that of classical client/server projects.

(3) Event-based modeling will provide software developers significant advantages over in-house development.

(4) Sophisticated tools will monitor events as they change. Agents will be used to post events and make their own decisions about how to process events [Blak98]. Window dialogs will assist engineers with dynamics of objects.

(5) Businesses will find they will not be equipped to keep-up with new technology. To compensate, they will defer to out-sourcing to obtain Internet and multimedia technology.

(6) The proliferation of the internet will give rise to *data centers* that will decentralize data and provide multiple companies access to data on a global basis [Neil98]. This in turn will promote the development of higher speed communication lines with remote management software systems. Internet 2 will replace existing multimedia standards with higher speed and enhanced video-conferencing.

(7) Embedded wireless communication will find its way into the Internet. This technology will facilitate remote access to the Internet, rendering further proliferation of its use [Patr99].

(8) Personal Digital Assistant (PDA) and/or Palm Top Computer will become popular because of their cheap price. People will use PDA to connect to Internet or do personal information processing. It can display video clip, play audio file or control household equipment. Mobile agent software will be the important application for the PDA. Such "Agent" software can do various activities such as downloading or finding interesting information from Internet, exchanging information among them, etc.

(9) There will be multimedia components in software engineering process. Multimedia software in the future will be multi-lingual in order to gain widespread usage rather than specific in any particular language.

5. Web Site Life Cycle

A web site in many ways resembles other types of corporate information systems. Each web site has a limited life span, similar to the water fall software life cycle model. One major difference is the *emphasis on content development in multimedia applications*.

The phases of web site development are as follows: idea formulation, general web site design, detail design of web site, testing of an implementation, and maintenance.

(1) **Idea Formation**: During the idea formulation phase, specific target-marketing program, content goals, and objectives must be set. Since a web site development project can become very time consuming and a major capital investment to owners of small businesses, it may be more effective to identify opportunity of specialized markets big companies have ignored. Furthermore, the

profile of *netizens* must be carefully studied [Choi99] to find out who is surfing the net and what these people are looking at. Small businesses should be aware of the dynamics of the online market place and develop strategies and plan accordingly. The ideas of this phase can pave the foundation for developing a comprehensive plan for Web site design.

(2) **Web Site Design**: Web site should be integrated into the company's backbone information system so that the web site can grow along with the business. To be successful, companies must integrate e-commerce into their overall business strategies and processes. Moreover, content needs to be targeted to specific user's needs. Visitor's information should be collected so that the company will be able to tailor the web pages to the specific needs of the interested customers. Furthermore, it is important that the web site can be surfed fast and efficiently. In addition, the users should be involved by providing an opportunity for them to input suggestions and complaints. The development of navigational cues and the user interface is of critical importance. The actual design tasks can be out-sourced for a small company. Also a new web site should be linked to as many search engines as possible. This can increase the chance that the web site is visited. Financial infrastructure should be developed properly as well.

(3) **Testing**: Once the implementation is complete, the company should conduct a pilot to test its integrity and effectiveness. The pilot provides an opportunity to obtain feedback from functional groups, customers and business partners. It ensures the quality and usability of the site.

(4) **Maintenance**: It is essential that the new content is developed and the web site is kept refreshed. Timeliness is the key on the web. Moreover, appointing a web master to manage the site on day-to-day basis is imperative. Web master can trouble-shoot any errors such as a link to a defunct web address, track the traffic of the web site, use reader feed back to build a loyal following and ensure server maintenance and security. Also, this person should make sure that the company's web site supports the latest versions of popular browsers.

6. Dual Roles of Multimedia Software Engineering

Having discussed what businesses want from multimedia technology and the web site life cycle, we now discuss the roles of multimedia software engineering. We can view MSE in two different, yet complementary, roles: (1) to apply multimedia technology to the practice of software

engineering; (2) to apply software engineering principles to the design of multimedia systems.

Multimedia has two fundamental characteristics that can be expressed by the following formula:

Multimedia = Multiple Media + Hypermedia

How can software engineering take advantage of these two characteristics? Will these two characteristics pose problems in multimedia systems design?

Advantages of *multiple media* are: (1) full utilization of all senses (eye, ear. etc.), (2) dynamic presentations, and (3) better understanding by the user. The disadvantages include: (1) greater demands on storage, bandwidth and computing resources, (2) cognitive overload, and (3) system complexity.

Hypermedia is a style of building systems for information representation and management around a network of multimedia nodes connected together by typed links [Hala95]. The advantages of hypermedia include: (1) ease of documentation, (2) ease of conceptualization and/or visualization, and (3) dynamic expansion of information hyperspace. The disadvantages are also well recognized: (1) "lost in hyperspace" problem, (2) cognitive overload, and (3) system complexity.

7. A Survey of Current Research in MSE

In this section, we give a focussed survey of current research in MSE to apply multimedia technology to the practice of software engineering; or to apply software engineering principles to the design of multimedia systems. Since multimedia is basically *multimedia objects plus links,* in the following survey the concept of links and navigation will come up time and again as two of the central themes.

One successful application of multimedia technology to software engineering is in project management using hypermedia CASE tools [Wild98]. Since the traditional project management tools lack the ability to capture multitude of decisions and do not provide document control, a new Decision Based Systems Development paradigm (DBSD) was developed [Wild91]. In the Decision-based Hyper-multimedia CASE (DHC) tool, objects in extended document base are linked by five types of links: (1) Reference to problems/decisions in problem space (*SEE links*), (2) Reference to a single on-line document (*REFER on-line links*), (3) Reference to a

Decision View of a document set (*VIEW links*), (4) Timed reference to a contact person (*CONTACT links*), and (5) References to off-line documents (*REFER off-line links*). This approach was applied to Low-Visibility Landing and Surface Operations (LVLASO) project at NASA Langley Research Center.

Another successful area of application of multimedia technology is in software documentation. By utilizing the nature of hypermedia, a multimedia-based program documentation system can be developed. Variorum [Chiu98] allows programmers to record the process of "walking through" codes using multimedia technology. Variorum modifies the source code to include *annotation links.* However its effectiveness depends critically on individual authors' annotation style.

For the specification of multimedia software systems A new paradigm is espoused: software engineers will do evolutionary design of complex systems through: (1) architecture specification, (2) design rationale capture, (3) architecture V&V, and (4) architecture transformation, using an object-oriented architecture description language [Tsai99].

In the model-based approach to hypermedia design, the key concept is to provide a comprehensive model for software specification and design. For instance, the Relationship Management Methodology (RMM) comprises (1) Entity-Relationship design, (2) Application diagram design, (3) M-slice (aggregate) design, (4) Navigational design, (5) User interface design, (6) Protocol conversion design, (7) Run-time behavior, and (8) Construction and testing [Isak96]. The RMM Access Primitives include: (1) *Unidirectional link,* (2) *Bidirectional link,* (3) *Grouping,* (4) *Conditional index,* (5) *Conditional guided tour,* and (6) *Conditional indexed guided tour.*

Links can be explicit or virtual. For example, queries can be considered as *virtual links.* The Virtual Multimedia Object (VMO) [Hoch98] is virtually created based upon other multimedia objects. A *pointing entry* (a kind of virtual link) represents the mapping between a VMO and its original data. It can be implemented as user-defined deriving procedures.

In the *pattern-based approach to design* the idea is to identify important and relevant design patterns, so that complex design can be constructed from these design patterns [Lyar97]. This approach can be applied to hypermedia applications [Garr97]. The patterns for hypermedia applications mainly deal with navigational structure and interface organization. The navigational

contexts may include: *class-derived context, link-derived context, composite-derived context,* and *arbitrary context.* Two important navigational structures are *News* for new information and *Landmarks* for subsystems.

8. A Conceptual Framework for MSE

From the above focussed survey it can be seen that multimedia is useful in software documentation, but whole-hearted incorporation of multimedia in software engineering has not yet happened [Hira99]. There is an ongoing paradigm shift -- from business orientation to entertainment orientation [Hira99]. New software process models and paradigms, such as object-oriented approach, are needed in multimedia systems design. Other interesting approaches include model-based approach to define navigation and access primitives; virtual multimedia objects approach to construct complex multimedia objects using virtual links; and identification of patterns (of navigation, news, landmark, etc.) to facilitate multimedia design. A long-term goal of MSE should be to design multimedia systems by multimedia.

A framework for MSE based upon the notion of *Multidimensional Language (ML)* is suggested below:

The *primitives* of ML are complex multimedia objects. The *syntax* of ML describes the static multimedia objects constructed from other multimedia objects. The *semantics* of ML describes the dynamic multimedia objects derived from other multimedia objects. Last but not least, the *pragmatics* of ML is based upon the *patterns* for various multimedia structures. MSE thus provides a principled approach, a set of scalable, adaptive tools and an environment for the specification, design, testing and maintenance of MLs for multimedia applications.

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