LACROSSE UNIVERSITY

Multimedia Systems & Authoring

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To Zainab

Animation is about creating the illusion of life. And you can't create it if you don't have one.

Brad Bird

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PREFACE

The aim of this Applied Knowledge Paper is to give a deep insight on the basics, components and applications of multimedia systems and authoring. A detailed overview has been given for the multimedia systems; their history and the components that make it.

The document starts by giving a history of multimedia systems followed by the characteristics, challenges and components.

Further the multimedia authoring has been talked about. Types of tools present in market today have been reviewed upon Next its applications and trends have been highlighted.

Finally, the document wraps up the paper by evaluating the benefits of multimedia systems. The author of the paper hopes that this discussion will serve as a comprehensive guideline for the readers.

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Next, I would like to thank my family who provided me with all the sources and material required for making this possible. Lastly; I would like to thank God Almighty who gave me the strength and will power to complete this piece of work.

ABBREVIATIONS

DSP	Digital Signal Processing
FDDI	Fiber Distributed Data Interface
Gb	Gigabyte
HDTV	High Definition Television
I/O	Input Output
Mb	Megabyte
RAID	Redundant Array of Independent Disks
SVGA	Super VGA
VGA	Video Graphics Array
VR	Virtual Reality

1. Introduction

1.1. Purpose

The purpose of this paper is to describe a well-formed and a thorough analysis of the Multimedia Systems. This paper also gives an insight into history of Multimedia authoring. Further throws light on Multimedia System's components, characteristics, desirable features and challenges.

It focuses on the design metaphor for multimedia authoring and introduces the types of tools present in market today and discusses them. Further the best suited scenarios for using these tools have been talked about.

This paper provides an understanding of the trends and applications of Multimedia Authoring. And it concludes by critically evaluating the benefits of Multimedia Systems.

This paper will assist the novice programmers/non-programmers to have a better understanding of Multimedia Systems and Authoring

1.2. Scope

The paper provides answers to what, when, how and who questions related to Multimedia systems and Authoring; such as:

- What is Multimedia?
- What are Multimedia systems?
- Components and characteristics of Multimedia Systems.
- Introduction to Multimedia Authoring Tools.

- Types of authoring tools.
- Which tool is best suited for a particular scenario.

2. Multimedia Systems

2.1. History

Newspaper was perhaps the first mass communication medium to employ Multimedia -- they used mostly text, graphics, and images.

In 1895, Gugliemo Marconi sent his first wireless radio transmission at Pontecchio, Italy. A few years later (in 1901) he detected radio waves beamed across the Atlantic. Initially invented for telegraph, radio is now a major medium for audio broadcasting.

Television was the new media for the 20th century. It brings the video and has since changed the world of mass communications.

Some of the important events in relation to Multimedia in Computing are shown in the table below:

Table 1

Important events in relation to Multimedia in Computing

YEAR	EVENT
1945	Bush wrote about Memex
1967	Negroponte formed the Architecture Machine Group at MIT
1969	Nelson & Van Dam hypertext editor at Brown
Birth of Internet	
1971	E-Mail
1976	Architecture Machine Group proposal to DARPA: Multiple Media
1980	Lippman & Mohl: Aspen Movie Map
1983	Backer: Electronic Book
1985	Negroponte, Wiesner: opened MIT Media Lab
1989	Tim Berners-Lee proposed the World Wide Web to CERN (European

	Council for Nuclear Research)
1990	K. Hooper Woolsey, Apple Multimedia Lab, 100 people, educ.
1991	Apple Multimedia Lab: Visual Almanac, Classroom MM Kiosk
1992	The first M-bone audio multicast on the Net
1993	U. Illinois National Center for Supercomputing Applications: NCSA Mosaic
1994	Jim Clark and Marc Andreesen: Netscape
1995	JAVA for platform-independent application development. Duke is the first applet
1996	Microsoft, Internet Explorer.

2.2. Introduction

Multimedia can be defined in many ways. *Multimedia* means that computer information can be represented through audio, video, and animation in addition to traditional media (i.e., text, graphics drawings, and images). Another good general definition is: "*Multimedia* is the field concerned with the computer-controlled integration of text, graphics, drawings, still and moving images (Video), animation, audio, and any other media where every type of information can be represented, stored, transmitted and processed digitally."

A *Multimedia Application* is an application which uses a collection of multiple media sources e.g. text, graphics, images, sound/audio, animation and/or video. Hypermedia can be considered as one of the multimedia applications.

2.3. Multimedia Systems

A *Multimedia System* is a system capable of processing multimedia data and applications. A *Multimedia System* is characterised by the processing, storage, generation, manipulation and rendition of Multimedia information.

Before a multimedia system can be created from an information system, have a look at what a multimedia system is and how it is made up.

The term multimedia refers to a variety of differing characteristics that make up a presentation of some type. These presentations will use all the characteristics in order to make a multimedia system.

1. Text, hypertext and numbers

In order to achieve any multimedia system, the following characteristics are important.

- Text, hypertext and numbers are the building blocks of any multimedia system.
- Text and numbers are the word-processed words that aid and begin communication in any information system.
- Hypertext is the associations of these words into hot links that enable connections to other sections of text or other characteristics within a multimedia system. This begins a process of making the information system into a multimedia system through the linkages created and the content on the other side of the link.
- The information contained is in static form to enable the reader to develop a written understanding rather than audio or visual communication.
- Information technology that is required for text, hypertext and numbers consists of word processors that are capable of completing the links and are effective text converters, as some data may need to be changed from ASCII code in order to be used within the multimedia system.

2. Audio

Consideration needs to be given as to the use of audio, as the file is usually very large and will need to be compressed. Information technology required for audio is varied, but audio can be

captured mainly through a microphone and recorded onto the hard drive of your PC. Once there, the audio is modified and added into the multimedia system.

3. Images and/or animations

Images are either vector or bit-mapped images. Vector graphics use reference points that draw lines between two points. This enables memory to save the images much more effectively, as the frame buffer has to hold the information for only 2 sets of coordinates. Bit-mapped graphics take up more space in memory however; a more detailed shape can be drawn in this form of graphic. File compression will be needed in order to store the images in bit-mapped graphics. These images, which could include a photo, are said to be "static" or motionless.

Animations are images that appear to move. There are two types of animation.

- Cell-based animation where each cell is reproduced and variations are made to the next cell. This continues until there is a series of cells. Each cell is slightly different from the previous. It gives the appearance of movement, thus animation.
- An excellent example of cell-based animation is to watch any of the Disney movies especially Snow White and the Seven Dwarfs. All cells were hand drawn and painted.
- Path-based animation where the first (original) cell or frame is drawn and the last cell or frame is drawn. The software then fills in the gaps between (tweening) these two frames, giving the appearance of movement. An example of path-based animation is the ballroom scene from the Disney movie, Beauty and the Beast.

4. Video

Using video in multimedia systems enables moving images in real-time to be displayed to enhance the text, audio and other graphics images. Video is used to add extra meaning to the other characteristics. An example of this is in encyclopaedias, where video clips are inserted

that reflect the content of the other features of the section displayed. Hyperlinks and buttons are frequently employed to activate video within the presentation.

2.3.1. Characteristics

A Multimedia system has four basic characteristics:

- Multimedia systems must be *computer controlled*.
- Multimedia systems are *integrated*.
- The information they handle must be represented *digitally*.
- The interface to the final presentation of media is usually *interactive*.

2.3.2. Challenges

Supporting multimedia applications over a computer network renders the application *distributed*. This will involve many special computing techniques.

Multimedia systems may have to render a variety of media at the same instant -- a distinction from normal applications. There is a temporal relationship between many forms of media (*e.g.* Video and Audio. There 2 are forms of problems here

- Sequencing within the media -- *playing frames in correct order/time frame in video*
- *Synchronization* -- inter-media scheduling (*e.g.* Video and Audio). Lip synchronization is clearly important for humans to watch playback of video and audio and even animation and audio. Ever tried watching an out of (lip) sync film for a long time?

The key issues multimedia systems need to deal with here are:

- How to represent and store temporal information.
- How to strictly maintain the temporal relationships on play back/retrieval
- What processes are involved in the above?

Data has to represented *digitally* so many initial source of data needs to be *digitize* -- translated from analog source to digital representation. The will involve scanning (graphics, still images), sampling (audio/video) although digital cameras now exist for direct scene to digital capture of images and video.

The data is *large* several Mb easily for audio and video -- therefore storage, transfer (bandwidth) and processing overheads are high. Data compression techniques are very common.

2.3.3. Desirable Features

Given the above challenges the following feature a desirable (if not a prerequisite) for a Multimedia System:

- Very High Processing Power: Needed to deal with large data processing and real time delivery of media. Special hardware commonplace.
- Multimedia Capable File System: Needed to deliver real-time media -- *e.g.* Video/Audio Streaming. Special Hardware/Software needed *e.g.* RAID technology.
- Data Representations/File Formats that support multimedia**:** Data representations/file formats should be easy to handle yet allow for compression/decompression in real-time.

- Efficient and High I/O: Input and output to the file subsystem needs to be efficient and fast. Needs to allow for real-time recording as well as playback of data *e.g.* direct to Disk recording systems.
- Special Operating System**:** To allow access to file system and process data efficiently and quickly. Needs to support direct transfers to disk, real-time scheduling, fast interrupt processing and I/O streaming *etc.*
- Storage and Memory: Large storage units (of the order of 50 -100 Gb or more) and large memory (50 -100 Mb or more). Large Caches also required and frequently of Level 2 and 3 hierarchy for efficient management.
- Network Support: Client-server systems common as distributed systems common.
- Software Tools: User friendly tools needed to handle media, design and develop applications, deliver media.

2.3.4. Components

The Components (Hardware and Software) required for a multimedia system are:

- Capture devices: Video Camera, Video Recorder, Audio Microphone, Keyboards, mice, graphics tablets, 3D input devices, tactile sensors, VR devices.
- Digitizing/Sampling Hardware
- Storage Devices: Hard disks, CD-ROMs, Jaz/Zip drives, DVD, *etc*
- Communication Networks: Ethernet, Token Ring, FDDI, ATM, Intranets, Internets.
- Computer Systems: Multimedia Desktop machines, Workstations, MPEG/VIDEO/DSP Hardware
- Display Devices: CD-quality speakers, HDTV, SVGA, Hi-Resolution monitors, Color printers *etc.*

2.3.5. How are Multimedia Systems displayed?

In order to display any multimedia system, one needs to be able not only to display but also to create. The variety of hardware that is needed to display and create multimedia systems is:

- Screens – These can be CRT, LCD or touch screens
- Projection devices
- Speakers and sound systems
- CD-ROM
- Video
- Head-up displays and headsets

2.3.6. Creation of Multimedia System using display devices

There are several methods that enable one to create a multimedia system using these display devices. The methods include the use of

- Presentation software
- Application software
- Authoring software
- Animation software
- Web browsers
- HTML editors

2.3.7. Information processes in Multimedia Systems

1. **Collecting**: When collecting data, one needs to consider what data needs to be collected and how to collect such data.
2. **Processing:** Multimedia systems need to process data for presentation. This covers the aspects of how text, number, audio, image and video are integrated into the system.

3. **Organizing**: In order to organize a presentation from a multimedia system, one needs to look at using a storyboard to show the flow of the screens. A storyboard can be in one of 3 main formats or a combination of all 3 together. The 3 main formats are:
    - Linear
    - Hierarchical
    - Non-linear
4. **Storing and retrieving:** There are various file formats that are used in multimedia systems that enable data to be stored and retrieved. Some of these formats are:
    - JPEG
    - Quicktime
    - MP3

A multimedia system using different data structures in order to give, a presentation a true multimedia feel requires the ability to store a large amount of data. The needs of the system are to compress data and decompress data as necessary in order to store and retrieve data effectively and therefore enable the presentation to truly be a multimedia system. The need to use compression and decompression software becomes a necessary part of the multimedia system

3. Multimedia Authoring

Authoring tools provide an integrated environment for binding together the different elements of a Multimedia production.

Multimedia presentations can be created using:

- Simple presentation packages such as PowerPoint
- Powerful RAD tools such as Delphi, .Net, JBuilder
- True Authoring Environments, which lie somewhere in between in terms of technical complexity

PowerPoint can be used to create interactive multimedia and some business people master it. But it's a bit like using a dinner knife to tighten a screw!

Software tools and their integrated development environments enhance the productivity of programmers, in particular allow them radically to alter the scope and flow of the software to meet the customer's needs, but the IDE can be flaky, buggy and/or demand huge resource. Authoring environments were originally conceived to let non-programmers program. They are often the product of much ergonomics and usability research.

3.1. Two Tensions

Costs:

- UK/US Salaries are undoubtedly better for Java programmers than Director authors, but programming is done in low cost-base countries
- Authoring productivity is greater, development cycle can be shorter and less prone to bugs

Functionality/Control

- "With code, one knows where one stands" (if one knows code)
- With code, one is not limited to the inbuilt functionality or what it affords (if one has the time)

3.2. Market Position

- The most expensive tool is not the market leader but neither is the cheapest.
- Cheap tools helps one get a company off the ground but have poor workflow and productivity, and/or constrains one to pre-determined solutions (templates, wizards)
- Expensive tools immediately distinguishes in the marketplace (pay to play), have incredible productivity and functionality, but may have a long learning curve and/or require advanced hardware platforms

3.3. Overview

A good authoring tool should be able to:

- Integrate text, graphics, video, and audio to create a single multimedia presentation.
- Control with precision interactivity by the use of menus, buttons, hotspots, hot objects etc.
- Publish as a presentation or a self-running executable; on diskette, CD/DVD, Intranet, WWW
- Be extended through the use of pre-built or externally supplied components/plug-ins/Extras etc
- Lets onr create highly efficient, integrated workflow.
- Have a large user base.

3.4. Design Metaphor

- The suitability of an authoring environment for creating a specific solution depends on its metaphor/paradigm.
- Most based around one of the following designs.
  - Card and Page Based Tools Icon Based Tools
  - Time Based Tools
  - Object-Oriented Tools
  - Tagging (Mark-Up) Tools
- Each type of tool competes in the marketplace against other types; mimic each other's functionality.

3.5. Types of Authoring Tools

Authoring tools used different metaphors for sequencing and organizing multimedia elements and events. On this basis they can be classified into five categories:

- Card- and page-based tools
- Icon-based tools
- Time-based tools
- Object-oriented tools
- Mark-up tools

3.5.1. Card- and page-based tools

In these authoring systems, elements are organized as pages of a book or a stack of cards. The authoring system lets one link these pages or cards into organized sequences. One can jump, on command, to any page one wishes to in a structured navigation pattern. Card- and page-

based systems allow playing audio, video and animations. Some examples of card- and page-based systems include:

- HyperCard (Macintosh)
- SuperCard (Macintosh)
- ToolBook (Windows)
- Visual BASIC (Windows)

Best Suited

Card- and page-based systems are best suited to applications where the bulk of the content consists of elements that can be viewed individually.

3.5.2. Icon-based Authoring Tools

In these authoring systems, multimedia elements and interaction cues or events are organized as objects in a structural framework.

Icon based, event driven tools simplify the organization of a project and typically display flow diagrams of activities along branching paths.

Some examples of icon-based systems include:

- Authorware Professional (Windows)
- IconAuthor (Windows)
- Rational Unified Process (Some aspects of it.)

In the figure below; Authorware screenshot has been shown.

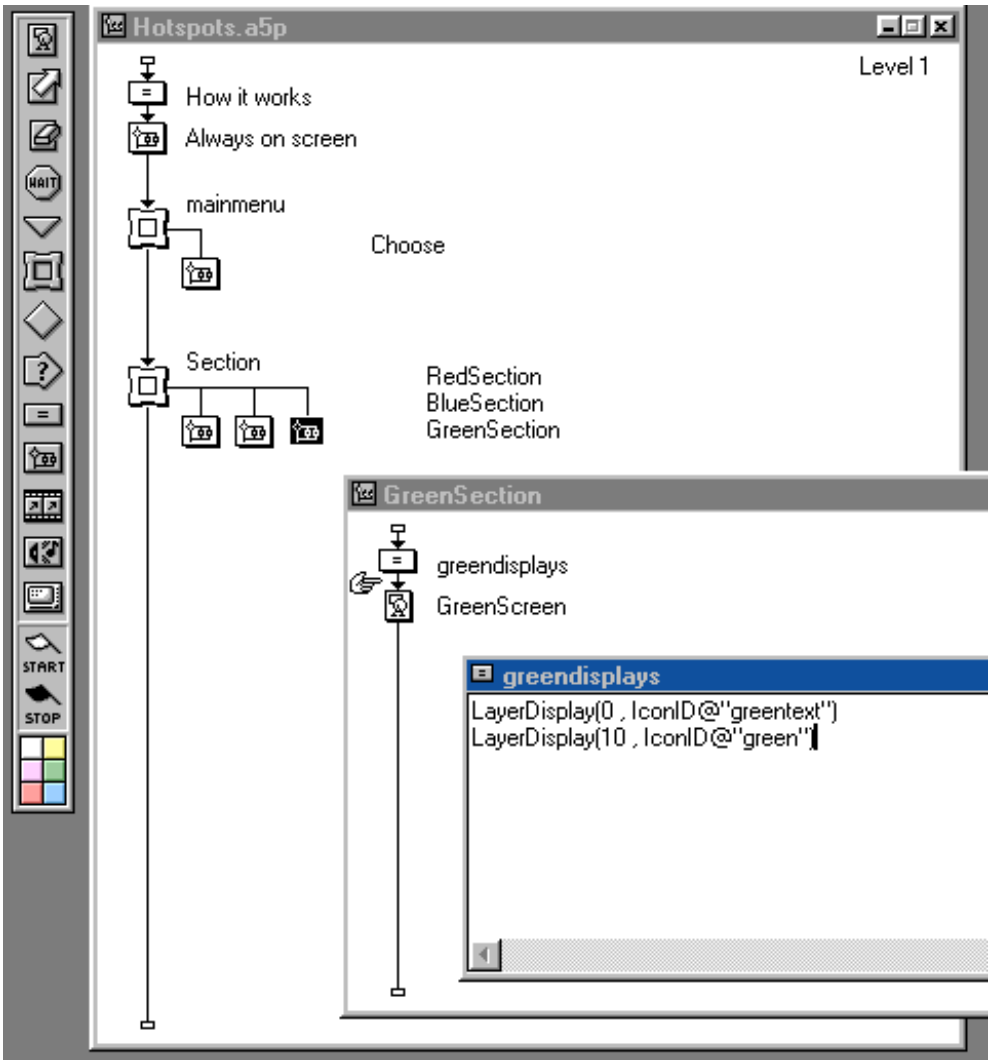

Fig. 1. Authorware

Best Suited

Its suited to a wide range of applications and offer a high level of support when developing packages with complex navigation structures, best when the user:

- Is unsure about requirements.
- Wants to maintain future versions themselves.

- Wants to create generic, reusable components.
- Wants highly interactive environments, rather than interactive front ends to essentially linear animations.

It is mainly used for educational/training software.

3.5.3. Time-based Authoring Tools

In these authoring systems, elements are organized along a time line with resolutions as high as 1/30th second. Sequential organized graphic frames are played back at a speed one can set. Other elements, such as audio events, are triggered at a given time or location in the sequence of events.

Some examples of time-based systems include:

- Macromedia Director (Macintosh and Windows)
- Macromedia Flash (Macintosh and Windows)

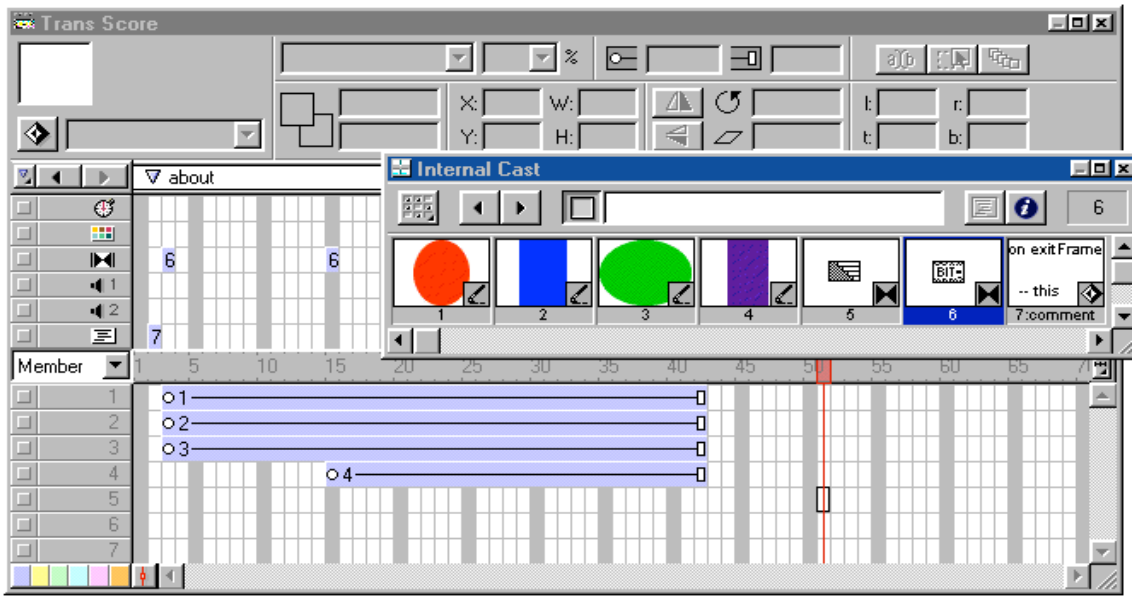

Fig. 2. Director

Best Suited

- Time Based systems are best suited to applications which have a message with a beginning and an end.
- Some of the more powerful time based systems allow the program to jump or branch to a specific location, thereby offering interactivity and navigational control.

3.5.4. Object-0riented Tools

In these authoring systems, multimedia elements and events become objects that live in a hierarchical order of parent and child relationships. E.g. Ferrari is a type of car

Messages passed among these objects order them to do things according to the properties or modifiers assigned to them. These may be inherited attributes (or specific) – Ferraris can do everything generic cars can (and more)

Some examples of object-oriented systems include:

- Tropolis (Macintosh/Windows)
- QuarkImmedia (Macintosh/Windows)

JAVA is also an object-oriented programming environment. Increasingly Lingo, the scripting language used in Director is taking an object-oriented approach.

In the figure below; a screenshot of Lingo has been shown.

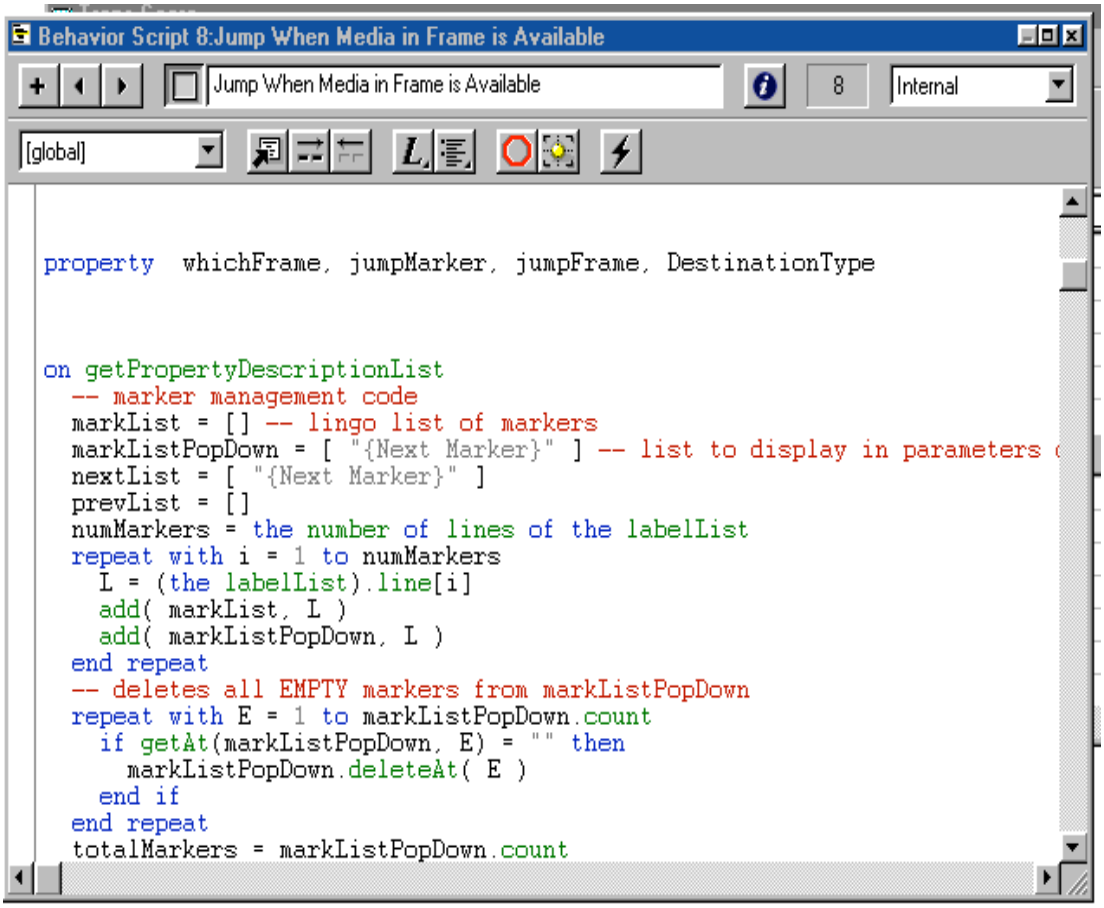

Fig. 3. Lingo

Best Suited

- Object-oriented tools are particularly useful for games that contain many components with many 'personalities'
- And for simulating real-life situations, events, and their constituent objects

3.5.5. Mark-up tools (Tagging)

These are primarily used to mark up documents so that they can be viewed in web browsers. The Tagging metaphor uses tags in text files (i.e. HTML) to link pages, and integrate multimedia elements. This metaphor is the basis of the World Wide Web. This limited environment can be extended by the use of suitable multimedia tags.

Examples of tagging tool systems include:-

- HTML
- VRML
- XML
- SMIL

Applications such as Macromedia Dreamweaver and Microsoft FrontPage allow creating web pages without learning the underlying HTML. However familiarity with HTML allows tweaking when required to resolve additional design issues that the tool doesn't address.

3.6. The Right Tool for the Job

The following should be considered:

- Editing features
- Organizing features
- Programming features
- Interactivity features
- Performance tuning features
- Playback features
- Delivery features
- Cross-platform features
- Ease of learning
- Personal preference

3.7. Programming Basics

One should become familiar with the following:

- Variables

- Functions
- Handlers
- Branching e.g. if-then-else
- Repetition e.g. repeat-while
- Logic operators e.g. not, or, and

4. Multimedia Applications & Trends

4.1. Applications

Examples of Multimedia Applications include:

- World Wide Web
- Hypermedia courseware
- Video conferencing
- Video-on-demand
- Interactive TV
- Groupware
- Home shopping
- Games
- Virtual reality
- Digital video editing and production systems
- Multimedia Database systems

4.2. Trends

Current big applications areas in Multimedia include:

- **World Wide Web:** Hypermedia systems -- embrace nearly all multimedia technologies and application areas. Ever increasing popularity.
- **MBone:** Multicast Backbone: Equivalent of conventional TV and Radio on the Internet.

- **Enabling Technologies:** developing at a rapid rate to support ever increasing need for Multimedia. Carrier, Switching, Protocol, Application, Coding/Compression, Database, Processing, and System Integration Technologies at the forefront of this.

5. Social and ethical issues related to multimedia systems

A multimedia system has a number of social and ethical issues that need to be addressed. Acknowledgment of the source of data within a multimedia system is necessary in order to satisfy copyright the data.

Copyright is important to the owner of the intellectual data that he/she be recognized therefore, obeying the copyright laws that cover all types of media. It is important that when one uses data that is not one's own it is acknowledged correctly and the author compensated.

Accuracy of data and appropriate information used should also be considered when viewing and downloading live video from the Internet. As a system user, the information obtained from any technology area needs to be used appropriately and accurately. Integrity of the data and information is vital not only for copyright purposes but also to enable the original to be used for educational purposes.

The way in which people are using and updating the use of data and information through the improving methods of digitizing is changing the nature of work practices. The Internet has made this possible and has been continued in other media forms.

6. Benefits of Multimedia Systems

In many ways, it's been a multimedia society for decades. A variety of media - print material, film strips, and visual aids - have been used in the classroom for years. Conferences and seminars have long made effective use of music, lights, slide projectors and videotapes. And ubiquitous televisions have shaped a new multimedia generation, albeit a passive one.

What differentiates multimedia as the buzzword of the nineties, however, is the partnership potential of multiple media and computer technologies. Computers can now present data, text, sound, graphics, and limited motion video on the desktop. Computer based multimedia skill and knowledge applications offer benefits and value difficult to equal in non-technology implementations.

Why turn to multimedia learning systems? What are their advantages over traditional approaches? How can they assist one's organisation in reaching its productivity and profitability potential? What does the multimedia revolution means to one?

6.1. Organisational advantages

Today's business edge depends upon the ability to respond quickly to change - whether it stems from economic, regulatory, or competitive pressures. And organisations that wish to adapt rapidly to new environments confront well documented hurdles. Some of these include:

- *The volume and velocity, or rate of change, of information.* It is estimated that 10,000 scientific articles are written each day, and that the sum total of information doubles every five years.
- *Reductions in product life cycles.* With new research and information come new products. IBM produces smaller, faster chips every year. The swift, worldwide

dissemination of information means that, to remain competitive, new products must reach markets faster than ever before.

- *The downsizing and decentralising of lean organisations in the 1980s.* Fewer employees remain, and those who do are tasked with cross functional responsibilities increasingly performed as team members, rather than individually, and with less managerial support. To add to this complexity, individuals and teams are frequently geographically dispersed, increasing the need for standardisation and collaboration.

- *Mismatch between job requirements and entry level worker skill/knowledge.* Organisations have a dwindling supply of skilled applicants from which to recruit. And many new workers will be the product of our declining school system. Literacy and graduation rates are down at a time when jobs are often more complex and team as opposed to individual performance is critical. There is a disconnection between education and economic systems.

Preoccupying corporations, then, are issues that are categorised as the "Three Cs": Consistency, Competence and Currency.

First, is *consistent* information being received by all employees in the company, local to or remote from headquarters? Performing well clearly depends on the quality of available information. If information is missing or workers receive variable information and instructions, then inconsistent performance levels are assured.

Second, is the work force *competent,* or ready to perform? Do they know where to find and how to retrieve critical information? More importantly, do they know what to do with that information to perform faster, with fewer errors, and smarter? With a broader range of

responsibilities and less managerial support, competence has become more difficult to achieve.

Third, is the work force *current,* keeping pace with new information and products? Yesterday's product catalogue cannot meet tomorrow's business plan. How quickly can the organisation and its personnel respond to changing business realities? Can the organisation sustain high performance levels?

Consistency

Multimedia learning systems, be they instructional or informational, offer the same content presented in the same manner each and every time an application is used. Program providers are assured of getting a standardised message out to their frequently geographically dispersed audience. Reducing inconsistencies in the message makes it more likely that programs will yield intended results and less likely that there will be errors or rework due to poorly covered content. Furthermore, the quality of the information is higher (i.e. it is not merely textual), fostering attention and the likelihood that critical messages will be received.

Competence

Multimedia learning systems permit users to see, hear, and interact with instruction and information at their own pace. Learners can repeat or revisit realistic scenarios as often as they like. In many cases, needed data and explanations are at their fingertips for use during real time interactions with customers and colleagues. Furthermore, computers offer a variety of efficient mechanisms for monitoring and measuring knowledge and skill acquisition and tracking areas in need of remediation or improved explanation.

Currency

Perhaps one of the greatest advantages that multimedia learning systems provide is the rapid distribution of timely information. Should information content change - be it a new procedure for repairing a piece of equipment, a new health and safety regulation, or a new price list - it can be quickly and efficiently downloaded to local workstations or made available via diskette or CD-ROM on non-networked learning stations. The delays and overhead of cascading seminars, printing and distributing volumes of updates and revisions, or videotaping and distributing addenda are avoided. Further, program providers have built in mechanisms to assure that critical messages have been heard by user populations.

It is apparent that computers themselves can take a fair share of credit for many of these advantages, given their raw speed, storage capacity, geographical reach, and fingertip accessibility. However, multimedia adds the critical dimensions of high information quality and high appeal, providing the extra "bandwidth" that motivates workers to transfer knowledge and skill into on the job performance.

6.2. Instructional advantages

From early computer based training (CBT) "page turners" - predominantly text and simplistic ASCII graphics - to analog interactive video instruction (IVI) multimedia systems, to the latest all digital multimedia implementations, instructional methods continue to improve. Enabling technologies that underpin these improvements include: lower cost, more powerful processors; faster, higher capacity networks; greater amounts of low cost storage; feature rich operating environments; and more intuitive graphical user interfaces.

In areas as diverse as interpersonal skills, procedural training, knowledge of facts, or development of intellectual abilities, multimedia learning systems have proven benefits and

value. Described below are their main instructional features, followed by research based benefits information.

Multiple information modes

As the name implies, multimedia learning systems communicate through the use of a variety of modalities, including audio, scanned images, bit mapped computer graphics, animation, text, and motion video. Regardless of the delivery method, experts agree that appealing to more of the learner's senses enhances attention, motivation to learn, and retention of material.

Interactivity

In 1991, US corporations with over 100 employees spent more than $2.5 billion on externally provided seminars and conferences, exclusive of trainee travel and per diem costs (Lee, 1992). By far the greatest number of training programs today relies on leader led workshops, which are minimally interactive. Learners are predominantly passive, called upon to answer questions or occasionally participate in role playing exercises. They have little opportunity to initiate activity and less still to direct the course of it.

Contrast this with highly interactive multimedia learning systems. Coupled with effective instructional design, these systems provide extensive branching through a variety of instructional strategies, including: inquiry; observation/coaching; trial and consequence; and guided learning. Learners see, hear, *and* do, confirming wisdom that has existed for centuries:

If you tell me, I will listen.

If you show me, I will see.

If you let me experience, I will learn.

(Lao Tzu)

Training when and where it's needed

There are often significant scheduling and throughput problems with classroom based training. Classes may not be available when they are needed. And for large numbers of students, it may simply take too long for training to occur in blocks of classroom time. IBM, for example, estimated it would take 18 years to upgrade the skill levels at one manufacturing plant using community college instructors.

Several factors make scheduling less a concern for multimedia learning systems located in learning centres. *First,* courses are always available and can be installed on systems in a matter of minutes. *Second,* technology based training significantly compresses learning "seat time", so learners can move through course work more quickly. *Third,* learners can spend as much or as little time as they can afford at one session: bookmark features allow them to return to courses without repeating material that has already been mastered, accelerating material completion. Of course for multimedia learning systems located on the desktop, delays and inconvenience are no longer an issue.

Learner control of pace, direction

The issue of who controls the learning experience has a profound effect on the instructional outcome. Again, contrast multimedia learning systems with the workshop, or leader led, experience. Workshops are designed to appeal to the broadest common audience. Material has to be covered in the prescribed time, and there is little flexibility for learners to diverge from the content or flow of information dictated by the instructor's guides.

The branching strategies designed into effective multimedia learning systems allow for varying degrees of flexibility, from complete discovery learning to highly guided and forced choices. As noted earlier, learners can stop or resume at their convenience. They can review

material, observe models, and practice responses as frequently as they see fit, without the peer pressure of appearing to be "slow" or interruptive. Furthermore, with the advent of new hypertext, hypermedia, and underlying database technologies, learners will have ever increasing opportunities to chart the paths and avenues of their own learning adventures. Learners are in control; they can make their own choices.

Individualised treatment, feedback and remediation

The workshop is largely a group based activity; everyone gets the same treatment. But people learn differently, have different learning styles and frequently do not need all the instruction but only that part targeted to their specific learning needs. Even in highly interactive workshops (when there might be extensive large and small group interaction), the amount of individual learning practice and feedback is minimal.

Multimedia systems are ideally suited to provide tailored information and feedback to each individual. Selective presentations can be made based on what one knows, how one performs or what one's job is. Multimedia branching simulations can be effectively presented that confront learners with decisions to real life problems and then the final result actually depends on the earlier decisions reached. Specific, targeted presentations, feedback and remediation are significant factors that contribute to the research based advantage of multimedia systems.

Performance tracking

There are many reasons why corporations are now concerned than ever before with tracking learner performance in order to measure training results. Among them:

- Training budgets are competing for scarcer financial resources. The tougher economic climate is causing overhead costs to be more closely scrutinised. Demonstrating results can save unnecessary cuts.

- The Total Quality Management movement is placing greater emphasis on the measurement of success in all areas, including human resource programs.

Whatever the motivation, monitoring performance is a multi-level process that can be greatly facilitated by multimedia learning systems. While the evaluation of classroom based learning usually limits itself to paper based course reactions and attitudinal input from learners, multimedia learning systems generally rely on online criterion tests linked to a course's learning objectives. Resulting data can be made available to management for review and coaching activities. It can also be uploaded to corporate wide courseware management systems that can issue performance trend reports linkable to business results, showing worker readiness to meet strategic business objectives.

6.3. Research based benefits/value

The preceding features associated with multimedia learning systems, coupled with effective interactive design, have been shown to greatly shorten the learning curve and improve mastery and retention of subject matter. There is, in fact, a growing body of research on the advantages of multimedia training (Wright, 1993; Fletcher, 1990). A number of industry leading companies have tested multimedia technologies against traditional forms of training.

The following chart, reported in the March 1992 edition of the *Multimedia and Videodisc Monitor,* represents a summary of key data from six of these studies. (Adams, 1992) In each case, a given course was produced in both interactive video instruction (IVI) and classroom formats. Content included both soft skills and hard skills training.

Research highlights: Interactive videodisc Vs live instruction

Learning Curve	60% Faster
Content Retention	25-50% Higher
Learning Gains	56% Greater
Consistency of Learning	50-60% Better
Delivery Variance	20-40% Less
Training Compression	38-70% Faster

Source: US Army, Xerox, United Technologies, WICAT, and Federal Express

Fig. 4. Interactive Videodisc Vs Live Instruction

Probably the most significant research finding is the increase in content retention over a three to six month time period. In general, research indicates that retention is usually poor. Educational and academic literature suggests that a 10% to 15% retention factor is normal in passive learning situations.

If the retention data presented above are further substantiated, a significant and meaningful result has been realised by the use of multimedia learning systems. Of course, retention is critical to performance because it demonstrates that the learning gain is enduring and therefore laying the appropriate foundation for improved performance.

6.4. Business impact of multimedia

The organisational and instructional benefits of multimedia training should result in performance improvements, both individually and corporate-wide. In turn, these performance gains will have a measurably positive affect on business results. (Miller, 1992)

It is important to acknowledge the complexity of the linkage between performance improvements and business results. There is always the question of the extent to which learning programs themselves directly caused the impact. For example, if employee turnover

is reduced after a new learning program has been implemented, other causal factors might include changes, if any, made to: labour pool entry qualifications, the selection process, pay, working conditions, management support, and career development opportunities.

However, it is equally important to gather data that attempts to address improvements attributable to multimedia learning systems. Each organisation must define its own success criteria and perform its own return on investment (ROI) analysis. Among the most important business results are cost reduction, increased productivity and revenue gain. (Forman & Ives, 1991) Specific findings are listed below.

Training time is reduced by 50%

This is the most widely accepted and often used business result. There is research to support a 50% reduction or compression time (e.g. a two day workshop can be taught via multimedia self delivery in one day). The travel and living savings alone can be significant; a figure of $350-$400 T&E per day is not unusual.

This figure can be even more significant if a calculation is made to determine productivity per day rates. Because people are back on the job quicker, they are productive sooner.

Reduced number of instructors

If more training is to be accomplished via multimedia, then fewer instructors will be required. In many organisations, these instructors are sub-contractors; attrition can also be a natural way to effect this reduction. Fully burdened instructor costs can range from $60,000 to $100,000 per year per individual.

Increased span of control

Fully competent employees, with multimedia systems that are available for review, recurrence, and reinforcement, as needed - require less supervision. These employees can get many of their questions answered via the learning system, not by their boss. A 10% increase in span of control is conservative; 20% is not unrealistic.

Reduced employee turnover

Retention and turnover are significant issues in many industries. A useful metric is to calculate or approximate the cost to recruit, hire, and train a new employee. In the insurance industry, for example, an industry association indicates that the investment per .surviving" agent at the end of the third year at a moderate level of productivity is $130,000. This is exclusive of recruiting, hiring, training, and lost productivity/sales costs for those agents who leave prior to three years' of employment; for one of our insurance clients, of their 600 newly financed agents, 150 were projected to remain after three years.

Increased safety/lower accident rates

The key indicators in this category are cost per accident, down time, and time off the job. Federal Express, for example, has quantified the savings from a two week course for people who drive vans. There was a significant difference in accident rates between people who did and did not go through the course, and the average cost of an accident was determined to be $1,600. The end result was an ROI of 23.9 % and a first year savings of $474,747 (Hassett, 1992).

Increased speed of service

Speed is a key variable. If activities can get done faster with high quality, then bottom line results will follow. Cycle time in manufacturing is critical. In customer service and

telemarketing, the time taken to solve a problem on the phone can directly affect profits. Marriott, for example, answers 17 million reservation inquiries each year; for every second slashed from the average call time, $67,000 is saved.

Less rework/higher quality

It is often practical to calculate the cost of errors and then to carefully monitor performance against this standard. At Federal Express, for example, roughly 1.5 million packages are shipped each night. Even if Federal Express is 99% successful (which they often beat), this still means that 15,000 packages aren't where they should be. And with the service excellence guarantee at an average of $10 per package, this amounts to $54 million yearly. Fractions of a percentage increase can mean significant savings.

Higher customer retention

Customers are the primary asset of any company. The Customer Service Institute estimates that it costs five times as much to acquire a new customer as it costs to service an existing one. They point out that a company that each day for one year loses just one customer spending $50 a week will find its sales reduced by $949,000 for the following year.

It is possible and useful to calculate the "lifetime value of a customer"; this value will, of course, vary from industry to industry. In the automobile industry, for example, a lifetime customer is worth $150,000 - $175,000.

To further underscore the tremendous value of retaining customers, a recent study by Bain Consulting (*Business Week,* 1992) shows that increasing customer retention by 2% has the same effect on profits as cutting costs by 10%.

Increased sales

The most direct way to increase revenue is to boost sales. As previously discussed, there may be several reasons for increased sales in addition to the implementation of a new multimedia learning system, but training can make a difference. Massachusetts Mutual Life Insurance Company conducted a longitudinal study for an IVI and Reflection based training program (Spectrum Interactive, 1991). The results showed:

Increase in first year commissions	27%
Increase in second year commissions	50%
Increase in initial calls	16%
Increase in kept appointments	24%
Increase in approach interviews	43%

Executives expect this type of business case approach; they want to examine the data, even if it is not totally quantifiable; they are looking for a payback within two to three years; and they expect a reasonable return on their investment. Hurdle rates will differ from company to company and it is important to ascertain these goals early in the process.

6.5. Keys to a successful multimedia initiative

Based on consideration of organisational, instructional, and business related advantages, one's company may decide to proceed with the implementation of a multimedia learning system. Below are the seven factors that Spectrum is correlated with successful multimedia efforts.

1. **Careful Planning.** Project managers must understand the vision and specific goals of their multimedia project; the resources available to commit to it (personnel, financial, capital); timetables; evaluation criteria, including baseline data; and payback/ROI goals.

2. **High Level Sponsorship.** Multimedia learning systems frequently involve collaboration between many departments: line organisation managers (sales, service); training personnel; information systems resources; financial analysts. As in any cross functional endeavour, the likelihood of success increases the higher the sponsorship within the company.

3. **Link to Business/Strategic Goals.** In making the business case for a multimedia project to high level management, it is important to describe explicit links to the "hurt factors" or competitive pressures that cause organisations to take action. The tighter these links, the greater the impetus to sustain continued forward movement on multimedia projects.

4. **Internal Marketing to Build Consensus and Support.** Many of the clients begin multimedia development with rapid prototyping efforts. Prototypes give learning system designers a useful tool for soliciting user feedback on the interface and functionality of the final implementation. They also give project managers something that shows the "look and feel" of the real system to other constituencies, helping to generate enthusiasm and internal cooperation. It is important to view the entire multimedia project as a marketing effort. It is critical to involve people, develop campaign themes, publicise the benefits, share the success stories and involve executives.

5. **Staged Implementation.** Successful multimedia learning systems may be phased into corporations over a period of years in successive waves. Staging implementation in this manner is especially important when new hardware is involved, system integration

issues are complex, support and maintenance staffs need to be recruited and trained, and many courses/learning system components are being built. Staging could also involve rolling a completed implementation out first to a small part of the total user population, allowing problem areas to be addressed before the remaining audience becomes involved.

6. **Support.** Having trained staff who can distribute and install course material, integrate and repair system components, prepare usage/performance reports, and answer learner questions about course use and/or content are all ways to assure that learners have successful experiences on the system. Whether the staff is comprised of internal personnel or sub-contractors, speedy and competent support is critical if multimedia learning systems are to yield intended results.

7. **Commitment to Next Steps: Continual Learning Organisations.** Successful multimedia learning systems help employees take control of their own jobs, careers, and futures. According to Robert Reich, the current Secretary of Labor, "A work force capable of taking responsibility for its own continuous learning will prove a more precious national asset than countless new factories and equipment." (Reich, 1991) Corporations that foster and support learning initiatives as more than one shot experiments will set the competitive and performance standards that others must follow for years to come.

7. Conclusion

This paper has attempted to document the many varied benefits achievable by companies that make a commitment to multimedia learning systems. *Organisational advantages* of multimedia systems are summarised by the "Three Cs": improving information or instructional consistency, especially critical for geographically dispersed populations; keeping learners current with rapidly changing facts and figures; and improving learner competence through their instructional features and benefits.

Instructional features discussed include multiple information modes; interactivity; learning that is available and accessible when and where it's needed; student control of the pace and direction of the learning experience; and performance tracking, which helps close the loop between learning objectives and critical business and strategic needs.

A growing body of research indicates that the *benefits and value of these instructional features* relative to classroom training involve shortened learning curves and faster times to full productivity; better mastery of instructional objectives; greater consistency of learning; reduced variance in delivery of content; compressed learning times; and greater content retention.

The *business impact* of multimedia learning systems will vary, depending on the nature and scope of the systems themselves. A frequently used set of parameters includes: a training time compression factor of 50%; reductions in the number of instructors; increased managerial spans of control by 10-20%; reduced employee turnover; increased safety/lower accident rates; increased s~ of service; less rework/higher quality output; higher customer retention; increased sales. It is important to arm executives with data that are as specific as possible to support a credible payback analysis.

The high bandwidth, high appeal of multimedia learning systems provides an innovative new use of computers that will play a leading role in the critical deskilling of the work force. Through careful planning and implementation, high level sponsorship and broad internal support, multimedia learning systems can change the way an individual, a work group, an organisation, and a society work and grow.

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