Numbers—A Medium That Counts

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As computational carriers of numbers, spreadsheets bring hypermedia to the office. A hypermedia spreadsheet we developed helped us construct a template for the first hypermedia version of business case study.

As the computer industry waits for multimedia consumer demand to build, industry experts look for a successor to Lotus 1-2-3, the application that generated exponential growth in the personal computer industry in the 1980s. We propose that the spreadsheet might also be the vehicle that carries hypermedia to the business desktop in the 1990s.

Numbers: An important medium

Multimedia is generally defined as a user-directed medium that incorporates a range of data types, including text, graphics, sound, audio, video, animation, and other computer programs. Ironically, numbers—basic to computing and widely used in the personal computer since its genesis—seem to have been ignored in definitions of multimedia environments. This omission results in an impoverished information space.

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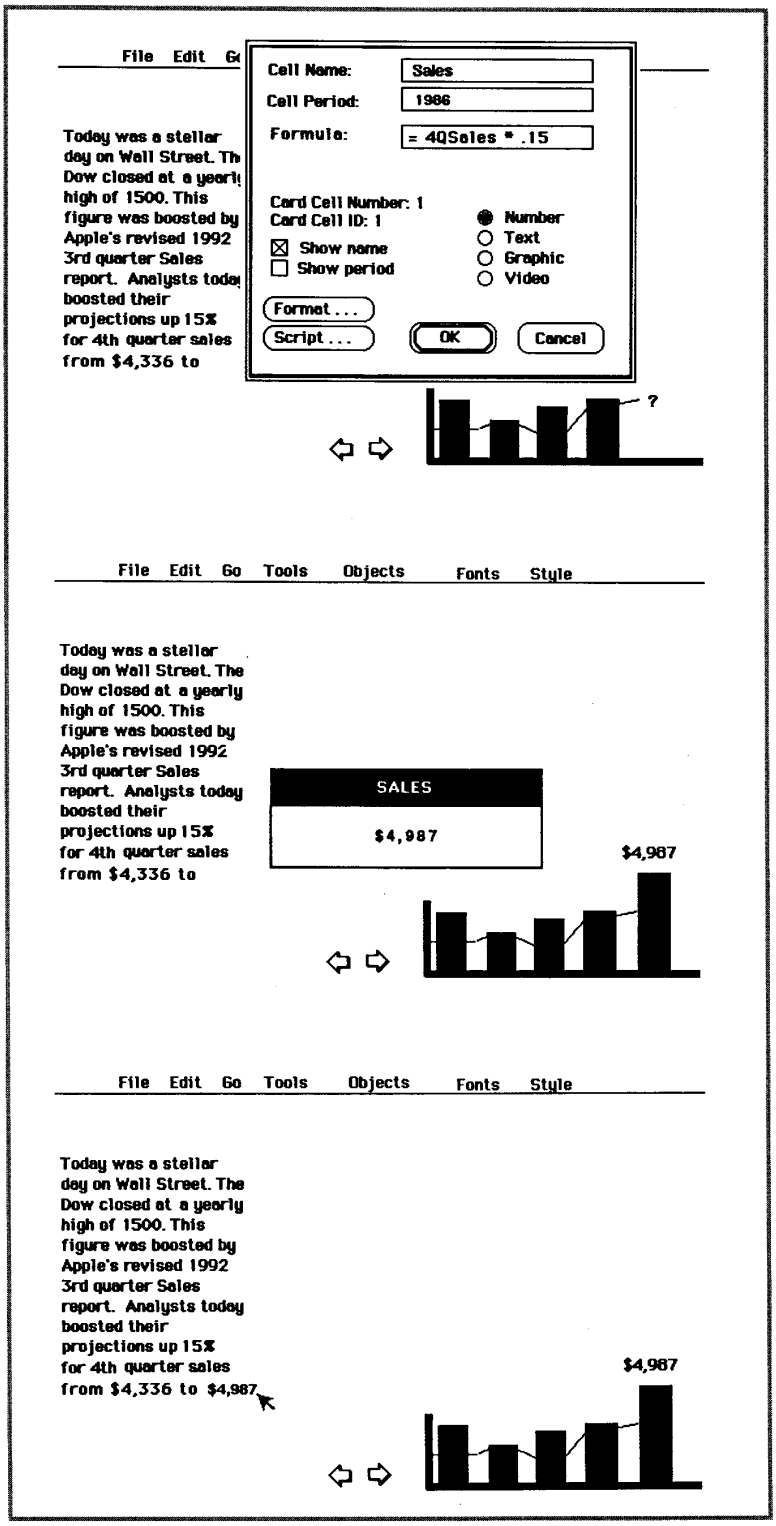

Figure 1. A potential interface for incorporating a cell into a document.

Consider the difference between numbers in a word processor and in a spreadsheet. Numbers are dynamic and have scientific properties that you can use in a spreadsheet. But when you copy a number to a word processor, you lose those properties.

The cell

In 1987 Apple Computer began distributing Hypercard, a software program for Apple's personal computers that gives users the power of hypermedia authoring. Hypercard provides text fields, buttons, and graphics as generic object types. Since 1987 other software companies have incorporated hypermedia capabilities into their products. Unfortunately, most of these products omit the cell.

We propose that the numeric cell is a powerful generic object type. A cell might be considered the smallest unit of computation. As such it has the potential of carrying link information. When creating a document or application, you should be able to create a cell in any location and relate it to other cells or events by using a full set of computational rules or formulas. Figure 1 illustrates a potential interface for incorporating a cell into a document architecture such as Hypercard.

Although hypermedia and multimedia have become somewhat synonymous in recent publications, note that "hypertext," the origin of hypermedia, was first proposed by Vannevar Bush in 1945 as a description of a computerized library system with the ability to search by associations. Reviewing current work in the industry, we might ask "What happened to the hyper in hypermedia?" Associations and interactivity within documents of multiple media require computing capability and some form of programmability. The generic cell could provide this needed link.

If you question the impact of including the cell as a generic object type, consider again the difference between numbers as they appear in a word processor and numbers in a spreadsheet. If a number were truly treated as another data type, it

should have the same properties across applications.

Authoring with numbers

An installed base of sophisticated authors knows how to work in the medium of numbers: the spreadsheet users of the world. Analysts who work with spreadsheets know how to manipulate numbers and operands in a spreadsheet to express subjective analysis of data sets. They understand how to define rules by defining formulas that drive numerical analyses (for example, the Lotus 1-2-3 formula @IF (a2 > a1, 1980, 1990)). As analysts pass spreadsheet files among themselves, the spreadsheet becomes a publication medium. It provides an application to think with; numbers and the computational formulas constitute equal parts of the content carried.

Cells as active agents

Vast quantities of information are becoming available in digital format. As computers become linked to live information streams, we need agents to proactively filter data and inform users of relevant events as they occur. The generic cell could provide this capability.

For example, suppose a cell is linked to on-line stock prices that update a client's portfolio of stocks. The client might wish to know when one of the issues drops by 10 percent. By defining a formula in the cell that monitors an issue, a broker can cause price changes in that stock to trigger numeric analyses, audio, graphics, or even video. Because we can think of cells as independent agents, we can expect that soon a computer application will call clients on the telephone to inform them of changes in their portfolios—before a broker has the chance.

Applications for hypermedia spreadsheets

Spreadsheets already have the capability to access real-time stock quotes and news services. Time-shared systems and CD-ROM from several data vendors provide a reservoir of historical financial information. With the imminent realization that digital television will soon be available, we can imagine the "broadband telecommunications society of the future," in which a spreadsheet has access to network broadcast stories. The closed caption description goes directly into a cell. Other cells are defined with rules that look for specified topics in the closed caption. You might be working on an analysis of IBM when a window appears with a live broadcast on a merger announcement, as it happens.

If cells were generic objects that we could incorporate into documents, any computer environment could provide access to dynamic sets of data that are continually changed, analyzed, and updated. The integration of cells and multiple media on the desktop as hypermedia spreadsheets would serve several business applications well:

- Multimedia quarterly and annual reports
- Sales videos with pricing information
- Advertisements with circulation and demographic data
- CEOs' messages
- Executive information systems
- Training on a library of financial analyses
- Analyses of manufacturing facilities with efficiency calculations

Hypercalc

At the MIT Media Lab and the MIT Sloan School of Management, we set out to explore the implications of driving multimedia from a spreadsheet. We constructed Hypercalc, a prototype hypermedia spreadsheet, in the spring of 1990 by combining an authoring interface with a series of video device drivers written for Informix's Wingz, a graphical spreadsheet with a built-in scripting language. From within Hypercalc, an author can combine numbers, video, text, graphics, sound, and animation. A message in any of these media can be evoked by a numeric change in a cell. Hypercalc operates as a template for building multimedia applications.

To explore how business education might benefit from multimedia, we applied Hypercalc to business case study.

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Business case study

Traditionally, business school faculty author the business case as a way of communicating management-related issues. The professor presents a particular corporation or industry from a viewpoint such as finance, marketing, or strategy. These studies typically have been distributed as textual documents with graphs and sometimes a spreadsheet.

Hypercase

The Hypercase model proposes a new framework for business case study.[2] Using our hypermedia spreadsheet Hypercalc, Hypercase structures an industry so that readers can gain a gestalt of it by interacting with the system. In defining how to analyze an industry and its competitors, Michael Porter identified two types of data: "published data and those gathered from interviews with industry participants and observers."[3] The first three sections of Hypercase—Competitor Analysis, Industry Applications, and Industry Experts—contain such data. The fourth section contains a set of analytic tools that participants

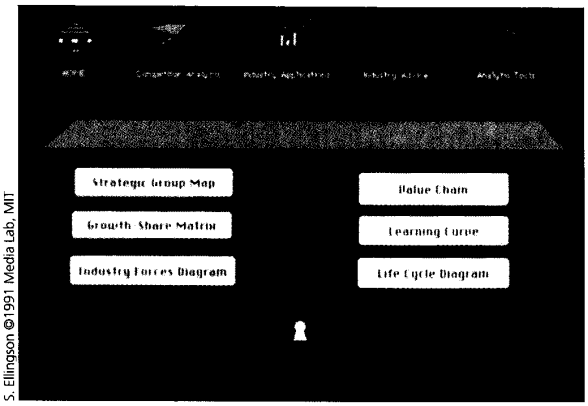

Figure 2. The analytic toolbox.

can employ as they navigate through the material in the first three sections. Figure 2 shows the graphical interface for this analytic toolbox. By evaluating the case data, students learn the methods for industry research and analysis.

Within the Hypercase environment, the line between author and viewer often blurs. While the developer of the case is responsible for collecting source material, a simple set of tools allows another professor using the published materials to detail a particular issue or problem for students to track. Likewise, a student, while browsing information along a path, can interact with the material using a variety of analytic tools. These tools allow students to alter or add to the information and use the same set of tools used by the author and professor.

The first Hypercase prototype

In 1990 we developed "The Emerging Multimedia PC Industry," our first Hypercase prototype. We videotaped interviews, product demonstrations, and market applications and collected financial information on a range of multimedia PC hardware and software companies. We then edited the interviews and demonstrations and assembled them onto a videodisc that we integrated into a Hypercase. The project was developed on an Apple Macintosh II using a Mass Micro videographic card set and a two-screen display. The screenshots and examples in the following sections come from "The Emerging Multimedia PC Industry."

Analytic tools

The set of strategic tools in Hypercase draws directly from established management models such as the Five Forces Model,[3] Growth Share Matrix (from the Boston Consulting Group), Life Cycle Diagram, and Value-Added Chain.[4] Industry analysis, according to Porter, aims to unveil "the structural features of industries, the important forces causing them to change, and the strategic information . . . about competitors."[3]

As students browse through a Hypercase, they can use the strategic tools in the analytic toolbox to help crystalize their understanding of the industry's structure and of the relative strengths and weaknesses of its participants.

Hypercase tools

We can liken the information body in a Hypercase to a snapshot of an industry at a given moment. Though this information is arranged in a structured framework, we can imagine an infinite number of possible cross sections of the data world, each with relevance and each highlighting different concepts. This is the essence of traditional case study design. To teach a concept, a case writer will look to the real world to provide situational examples. The writer will "slice" through the set of data available to script a cohesive, bounded view of the real environment.

Using the tools in Hypercase, case writers, professors, students, or other users can make their own slices of the Hypercase to illustrate concepts and pose new questions. A template helps guide case writers in producing an easily used case study with a standard Hypercase interface. This template appears in the screen shot of our sample case about Apple Computer (see Figure 3). Using the Hypercase tools, which include Segment-Builder, Sheet-Builder, Cell-Link, and Link-Tool, authors can enter data into a case template and link it to numbers, video segments, sound bytes, or text. Many of these multimedia programming constructs build upon the Elastic Tools, a hypercard toolset built for the Elastic Charles Project.[5] Hypercase tools, whether graphical or menu driven, allow authors to concentrate on content rather than on the programming environment.

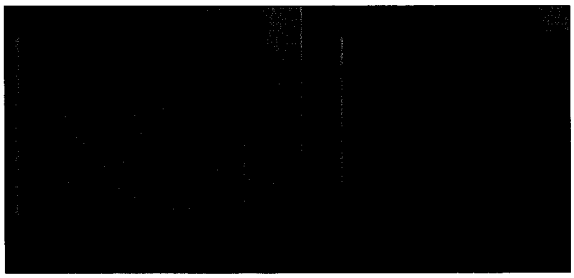

Figure 3. Apple case using the Hypercase template.

Segment Builder

Hypercase allows readers to browse video information by referencing segments. A video segment is defined as a sequence of linear video with a begin point, an end point, and a context that justifies its grouping. A video frame representing the segment—selected by the author—can be associated with a segment when the segment is defined; this pictorial icon later serves as a button to play the video segment.

Hypervideo

Hypertext, as coined by Ted Nelson,[6] provides a metaphor for presenting textual information in a manner corresponding to the human process of association. When we read a body of text, certain words might cause us to reflect on related thoughts. Hypertext provides the ability to covertly include such links in a document by defining "hot words," which are indicated in bold face or by a unique color. Ideally, we would like the same link capability with any media format.

Video is a temporal medium. Therefore, we cannot define links solely between static segments. Over a time period within a segment, we must be able to define a link to another associated segment. In explaining their Elastic Tools, Brondmo and Davenport refer to this as "dynamic links in temporal media":

> Links are used to associate content-related chunks with each other and ultimately to navigate between them. Some indication that a link has been associated with a chunk of information must present itself to the user. The user has the option of following the link or ignoring it.[5]

To provide this possibility within Hypercase, we created a linking tool that allows linking one segment to another segment, to multiple segments, or even to a spreadsheet. A link is defined within a segment by a start point, an end point, and an associated segment. During playback of a segment, an icon superimposed on the video indicates the existence of a link.

Cell-Link tools

Although many early multimedia applications allow users to interact with "sight, sound, and motion" (as defined by Phillip Schiller of Apple Computer in "The Emerging Multimedia PC Industry"), Hypercase puts a heavy emphasis on numbers. Not only can a user interact with numbers, but the numbers themselves can interact with other media. Using the Cell-Link tools, you can establish rules that link conditions to actions. For example, you can place threshold levels on a cell value that, when met, drive a relevant video segment to play on the monitor. The action does not impede the user from leaving the cell above the threshold level, but rather provides some "expert" advice or reminder regarding the decision.

In the case of "The Emerging Multimedia PC Industry," we implemented a brief exercise in which the student is to allocate staff between hardware and software development groups for a digital video R&D department. We defined a rule, or cell link, to activate when the ratio of software staff to hardware staff falls below 50 percent:

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=IF(SoftwareRatio<50%, Play:Segment1,0)
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If this rule becomes active, it triggers a video segment in which an industry representative (Kenneth Wirt) declares "... Multimedia without software is like a boat anchor. The days of developing hardware without software are over! Gone! Done!..." In this instance, the educational impact of using a cell link is twofold. First, it offers students immediate feedback on their analyses and assumptions. Second, using video as the feedback medium provides a dramatic and entertaining message.

Why multimedia for case study?

Why is multimedia an improvement over text? By looking specifically at case study, we were able to isolate several generic limitations of monomedia that a multimedia environment can improve upon. The following eight points outline some of the shortcomings of the traditional case study model.

1. Interpretation. Many managerial decisions must be based upon nonverbal, nonquantifiable cues. Human characteristics often make the difference. The decision maker wants to ask "Is this individual trustworthy?" "Is he articulate?" "Can he command the respect of others?" In current case study, direct statements of fact convey such information: The case writer, not the reader, performs the task of interpreting an individual's character traits.

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2. Objectivity. Any publication or representation of reality must by definition carry some subjectivity from the author or artist. Even if the author provides unaltered data as collected, he or she must choose a search path in collecting that data and deciding which information to include. In a case study, we would like to get as close to an objective representation of the real world as possible to allow students to form their own views, untainted by the author's biases. Multimedia provides a better ability to publish objective data.

3. Linearity. Case study conveniently packages information for the reader. We begin on page one and read through to the end. Not only does this force the author's cognitive mapping on the reader, but the reading process has little likeness to the way we search for and collect information in the real world. When researching a topic, bits of information provide us with clues that can lead down multiple search paths. In the real world, the researcher must decide which path to follow and when.

4. Interactivity. The traditional case model provides information in a static medium. Case study need not be passive, unilateral communication. When preparing a case, you should be able to interact with it, testing assumptions and receiving comments.

5. Perspective and role play. No coin has just one side. Yet current case study often provides only a single perspective of a situation, thus leading readers to confuse perspective with fact. In addition, dialogue based on a single perspective usually boils

down to black-and-white conclusions. Because no two people see the world the same, issues are confronted and resolved by parties with different perspectives and goals. Ideally, we would like case study to have sufficient amounts of data to provide multiple perspectives on the same environment. Through role play of multiple perspectives, a more true-to-life discussion of an issue can evolve.

6. Scope and comprehension. Most case studies today have a narrowly defined scope. One reason for limited scope is the desire to highlight a particular concept. Another reason, which we feel drives the constraint, is limited time and overloaded memory capacity. The richer our active data set, the more meaningful is our analysis and discussion. Therefore, we would like to have an environment, such as multimedia, in which comprehension comes easily and information can be reviewed quickly.

7. Engagement. Disregarding the more philosophical problems with current case study method, we still see an equally grave shortcoming: They are often tedious. Students frequently read more than 100 cases in their first year of a masters program. Case study that engages and entertains, bringing readers into the material, might provide a compelling educational alternative.

8. From academics to applications. As you would expect from a methodology so far abstracted from reality, current case study as a framework does not present a smooth transition to real-world problems. If case study truly prepared us for the business world, we should be able to replace the limited data set with live feeds and use the same framework to analyze and understand actual environments.

Although we extracted these eight points from our considerations of case study, they might prove useful in determining the appropriateness of multimedia in other publications. If these categories are an important part of the message an author tries to convey, most probably a singular medium will not suffice. Multimedia, defined as a computational mixture of numbers, video, sound, text, and graphics, can be a viable solution.

Conclusions

Numbers are a medium that counts. By replicating the properties of a spreadsheet cell, we can ensure that the number returns to its dynamic context when mixed with other media. Providing computation within a range of document types is integral to the acceptance of hypermedia, because the business world works in the medium of numbers and spreadsheets. Incorporating the cell as the programmable unit for accessing multiple media types will ensure that multimedia becomes a form of communication for the mass market of computer users, not just a technology for a handful of developers.

The multimedia industry has referred to intelligent television as a receiver that will filter many real-world sources looking for data interesting to viewers. In the financial world, spreadsheet templates often define a layout and series of analyses for incoming numbers. If we stretch the analogy for a hypermedia spreadsheet, a template becomes an effective way to define a personalized interface to the outside world. We could choose to have television stories on current events in one cell, live stock quotes in another, and a list of client activity in a third. Beneath the interface would be cell links defined to determine the content displayed.

Including numbers in an application as a dynamic medium enables the creation of an engaging, powerful, interactive document. Hypercalc and Hypercase provide a valuable platform on which to build business-related multimedia applications. The framework defined in the Hypercase environment can help managers analyze an unrelated industry, then extract the tools and methodologies needed to perform strategic analysis on their own company's behalf. Therefore, we think Hypermedia, as implemented in Hypercalc, can prove its effectiveness both as a learning environment and as a real-world management tool. ❑

Acknowledgments

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