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Interleaf, Inc.—1981 to 2000

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Interleaf, Inc. was an early entry into the computer-based publishing business, initially based on computer workstations and focusing on technical publishing. The company was formed in 1981, shipped its first product in 1984 which included a variety of hardware and software innovations, and was in a strong position to go public in 1986. In the later 1980s, other companies entered the business in competition with Interleaf, and personal computers then had the power that once required an expensive workstation; there was also standardization around window systems such as the X-window System, Motif on top of X, and Microsoft Windows. Also some of Interleaf's innovations were no longer competitive advantages as the industry coalesced around alternative technologies such as PostScript and Acrobat Reader. Redirecting its business strategy once and then again, Interleaf continued on with up and down success until 2000 when it was acquired by BroadVision.

The materials in the Interleaf archive at `history.computer.org/annals/dtp/interleaf` may be useful as one reads the story below. Also at `history.computer.org/annals/dtp/interleaf/anecdote-additional-notes.pdf` is additional narrative that didn't fit within the *Annals* page quota along with less important notes and references; the places where these "Webnotes" would have been located in the main text are marked with successive superscripted lowercase letters (after the letter z, aa, ab, etc., are used).

1 Early years, 1981–1984

Both David Boucher and Harry George had been with Kurzweil Computer Products company which was acquired by Xerox in 1980. They were interested in starting their own company and looked at a variety of different possible businesses. While temporarily helping someone else with a plan for a new business, Boucher looked into workstation applications including electronic publishing. Boucher and George then broadly investigated electronic publishing for themselves.[1,a,b] This revealed the potential for companies to replace traditional manual integration of text and graphics into documents; money could be saved by using workstations to combine text and graphics into a high-quality printed documents. Boucher says that for their business plan they focused on consulting firms where they could calculate the potential average dollar savings per page over manual methods which would be compelling data when seeking financing. Boucher and George started Interleaf (as in interleaving text and graphics), Inc., in January of 1981. Boucher was president and George was chief financial officer, and their equity interests were equal.

Boucher says that initially they believed that they had to develop a workstation and appropriate printer, and to begin work on these they hired Jon Barrett and Allen Anderson. Two other early hires were Jim Crawford, a biochemist but also an exceptional computer programmer, and Robert Morris, a professor in computer science at the University of Massachusetts at Boston, who had a great interest in typography and who took a leave of absence from UMass to join the company.[2]

Boucher says that they always knew that the software for their workstation would be the critical component and looked around for software systems that could be relevant to Interleaf's new business. They heard about the Etude system being developed in Professor Michael Hammer's office automation research group at MIT. Etude was aimed at increasing "the functionality of office document production systems . . . while *reducing* the complexity of the user interface."[3,4,c] The Etude system ran on a DECSystem 20, eventually using the NuMachine (a prototype microprocessor-based, networked workstation) as a graphics terminal.[d] Boucher says that the moment he saw Etude, he knew this was what Interleaf needed—"it was a different concept of what a word processor could be." Professor Hammer (increasingly well known as a business consultant) also joined the board of directors of Interleaf.

One of the programmers on the Etude project at MIT was Bahram Niamir (known informally as Bern) who had converted a subset of Etude from the CLU language to C and also made it run under Unix and added mouse input. He called it Ecrit. Niamir officially joined Interleaf in July of 1982 (about the same time as Crawford and Morris) but had been working for a few months already producing the basis for the Interleaf system from Ecrit.[5] Steve Pelletier remembers that when he arrived at Interleaf in early 1983, "there was a running version of the eventual Interleaf product that was based on Ecrit plus business charting".[6,e,f] Eight or so months after

†This anecdote was edited by the issue guest editors.

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Pelletier joined the company (by this time appointed to lead engineering) he brought in several additional strong programmers (including the first author of this paper).

The original product concept was for a powerful graphics arts system running on an Interleaf-developed workstation. The intended market was technical publication shops which were manually cutting and pasting text and graphics together into documents and getting proofs from a print shop. Just as Pelletier was arriving at Interleaf, the decision was made instead to use OEM workstations such as Sun and Apollo for the turnkey system the company intended to sell.[7] Boucher states that Barrett telephoned Andy Bechtolsheim at Sun, and that resulted in their having perhaps the first Sun-1 on the east coast.

According to a Seybold Report,[8] David Boucher initially turned down an invitation late in 1983 to participate in Seybold Seminars '84 (in March) because "Interleaf did not sell a publishing system" in Seybold's sense of the words. However, he still "tested the waters" by bringing a demonstration system to a Seybold Seminar where the system was enthusiastically received by potential customers from the publishing systems marketplace. It was a WYSIWYG system (with its graphical user interface designed and implemented by Interleaf including use of a 3-button mouse), and potential users liked its functionality and especially its speed and that it ran on off-the-shelf workstations. The company shipped its first product in May of 1984. From then on the company sold computer-based publishing systems.[8,g] The company went into the publishing systems market that was on the verge of developing, and Interleaf was perhaps the earliest significant player. The same 1986 Seybold report said, "Thus far, Interleaf has been the biggest winner in the 'tech-doc' revolution. It has sold fast, easy-to-use and cost-effective systems to a lot of first-time users, most of whom had not typeset documents in the past."[h]

Starting out with a turnkey hardware-software system mindset, Interleaf primarily used traditional direct sales methods and quickly built marketing, sales, and support organizations. By 1984 the company had approximately 100 employees. They counted on the margin on the hardware they OEM'ed as well as direct sale of their own software to generate revenue. They also began to make deals to have the Interleaf system run on workstations of other companies (e.g., DEC, Apollo) which had their own sales forces to sell the Interleaf system along with the company's hardware.[i]

Regarding the competitive situation in the early years, Harry George has emphasized[9] that the "opportunity that Interleaf was pursuing was enabled by the Canon laser printers coming on the scene and computers becoming fast enough to deal with placing a (few) million pixels for each document page versus dealing with pages of text by the character." "Companies such as NBI, CPI. Wang, and Harris-Lanier were the leaders in the whole character-based word processing world." George and Boucher figured they would "develop the pixel-based software needed to drive the new laser printers and most likely one of the [above] companies would buy [them]. That did not happen. Instead each of [those] business failed or got out of the word processing business." Half a dozen competitors did see the opportunity, such as Texet and Xyvision in the Boston area, "but Interleaf beat them out."[j]

An obvious question is, where did funding come from in those early years when Interleaf was not yet a public company? Of course, there was the profit on sales (both product sales and being paid to port the Interleaf software to vendor workstations), although this was not enough in total to reach profitability until 1988. Initially the founders put in a little of their own money; next the Massachusetts Technology Development Corporation (a state agency trying to grow business in the state) invested some money; then angel investors put in some hundreds of thousands of dollars; then three venture capital companies invested some millions of dollars; then the same VCs plus Kodak invested tens of millions of dollars; finally most previous investors plus others invested some millions of dollars.[10] There were bank lines of credit both before and after Interleaf's initial public offering, but the company tried to minimize use of them. After the IPO there were three limited partnerships to develop technology (for $3.5M in 1987, $3M in 1988, and $2.250M in 1989).[11] (For more details about the pre-IPO funding of the company, see the Webnotes.[k])

2 Great success, 1984–1988/9

With prior typesetting systems (e.g., Atex, TeX) the user specified where to place on a page each bit of text and graphics. WYSIWYG systems need to make assumptions about how users want to display things and implement higher level commands for enabling those displays. Interleaf was selling turnkey systems that included expensive hardware. Customers tended to be big companies and government organizations, and such entities have lots of different needs for how things are displayed. Thus Interleaf had to implement lots of different capabilities. Such users also often have large or very large documents—hundreds or thousands of pages. WYSIWYG systems also need to instantly change what the user sees in a computer window when the user types another character or drags something somewhere on the page. The underlying system cannot recompose the entire long document from the beginning—that would be too slow. Thus, the system must be implemented in a

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sophisticated way so that what the user is seeing is changed immediately and any consequent changes throughout the document cause no detectable delay for the user. All of this—plus adding basic capabilities not in the original system and keeping up with competitor offerings—led to the necessity for a series of software releases.

OPS-2000 and TPS releases 2.5, 3, and 4

OPS-2000 was the name of the first production system (internally it was release 2.0 with a release note dated 2 November 1983).[l] The sales brochure[12] for that system emphasized: the benefits of using the computer instead of prior manual and slow turnaround methods; creating graphics within the system as well as inputting text; availability of multiple fonts; enabling the same stored document to be displayed in different ways according to the "property sheet" used; accepting ASCII input from other computers of a variety of types (word processors to minicomputer to mainframes); ease of use; and a high resolution display [for the time] and output to a high resolution laser printer. The first system delivered ran on a Sun workstation with an Intel 68010 processor[12] and one megabyte of memory, a 17-inch display, a 42MB disk, and included a Canon LBP-10 laser printer (240 dpi). It cost $52,000 (the equivalent of about $130,000 today).[13] The system was quite revolutionary for its time.[m,n]

From this first release on, "filters" were an important aspect of the system. Filters were mechanisms for converting documents created in other systems, particularly word processors and later PCs, into Interleaf documents by translating codes for document properties, such as font and layout markup, into Interleaf-specific codes.

The next several releases after OPS-2000 had a new name—Technical Publishing System. TPS 2.5, 2.75, 3, and 4 are sketched in the Webnotes.[o]

The market and market pressures

During this same period, competing products entered the market: Aldus PageMaker for the Mac (1985) going after small-office and individual customers, Ventura for the IBM PC (1986) with a goal of handling both short and long documents; FrameMaker for the Sun workstation (1986) directly competing with Interleaf, and QuarkXpress for the Mac (1987) but for high end users such as professional typesetters. Eventually Microsoft Word also became popular, especially once Windows was replacing DOS. Adobe's PostScript had also come on the scene in 1984.

While Interleaf was trying to follow its competitors into the market of less expensive computers and less sophisticated publishing systems, it also was working hard at providing total publishing solutions to its traditional more high-end customers.

Over the series of releases mentioned above, the system was also made to work on more platforms with their various differences. For instance, by Release 4, the system could run on the IBM VM and MVS and DEC VAX/VMS mainframe systems as well as various workstations and was moving into the personal computer world with two new products—PCEditor and PCViewstation. These could run on off-the-shelf PCs; both could be part of a local network of TPS systems with the former a less expensive station but only handling text and the latter allowing a less expensive device for viewing documents anywhere in the organization.

The "corporate-wide solution" that Interleaf was offering and promoting allowed companies and government agencies to "employ electronic publishing at every level of the organization, at every phase of the document development cycles." Document style throughout the organization could be controlled from a central location. Example customers were Boeing, Ford, Monsanto, General Electric, Federal Express, the U.S. Department of State, and the Federal Reserve Board—big companies and institutions with needs for big and complex documents. "Books" is an example of a capability for handling the sometimes very large documents (perhaps hundreds of thousands of pages, maybe more) of large organizations such as those just mentioned. A "book" could contain any number of documents which could be formatted consistently with the page number sequence running through all selected documents; there could be page number cross references such as "see page nnn of chapter NN"; all selected documents could be indexed together and have a common table of contents; and so on.[p]

Non-domestic (foreign) sales were important to Interleaf, providing one-third to two-fifths of company revenue, again primarily big dollar sales to big organizations.

Company organization

As shown in a 1989 organization chart at `tinyurl.com/interleaf-org`, Interleaf had a fairly standard looking functional organization (and had had since its early years).

Founders David Boucher and Harry George were still president and VP finance, and early employees George Potter and Steve Pelletier were VP marketing and chief technical officer. There were also VPs of the product management and planning (Larry Bohn), systems integration, and operations.

In 1989 Interleaf was selling turnkey systems (hardware and software) and had a large operations (manufacturing) organization which put together the pieces of hardware for each customer order and had lots of hardware components (e.g., workstations and

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printers) in inventory. Within a year, much of that organization was significantly reduced in size as the company switched from selling turnkey system to selling only software (described in section 3).

The company had been building a field sales and support organization as part of its marketing organization since the early days of the company. By the time of the first annual report in 1988, Interleaf already had 21 U.S. field offices, five offices in Canada (a joint venture with the Nexa venture capital firm of Ottawa), a London office, and offices about to open in Paris and Milan. At the time of the 1989 organization chart, more than half of the 750 employees of the company were in one of the boxes under Marketing.[q]

Over time the number of Canadian and U.S. offices varied a bit as did other international offices (or locations with partner companies) including Melbourne, Sydney, Brussels, Paris, Frankfurt, Hamburg, and Munich, Milan, Tokyo, Hong Kong, Madrid, Stockholm, Zurich and Montreux (Switzerland), and London. In some instances, the field activity was technically a subsidiary of Interleaf. The company sold both directly to customers and through other companies such as workstation manufacturers. The groups both at headquarters and in the field offices did customer support and maintenance for both the direct and indirect channels. Interleaf had the usual conflicts resulting from competing with its distributors.[r] (Also at headquarters were other marketing activities—some quite inovative.[s])

The organization under the chief technical officer (called "engineering" below) included the developers of the base TPS system and many of its options. It also included quality assurance and documentation, and (at the time of this chart) the font group. The Quality Assurance activity was unusual in that each system developer had an assigned QA person, and overall there was 1-to-1 ratio of QA people to developers. (A hint at how this worked may be found in Tracy Kidder's book[14] which describes the interaction between Paul English and his QA person Brenda White.) The engineering group was doing highly innovative work. David Boucher has said, "the product was the most important thing, and particularly the engineers who created the product were given freedom to be creative." Some members of the Interleaf engineering organization have described it as "the best place I ever worked" or "an engineering playground". However, not all the development work happened in engineering. Some was done in the systems integration group, and some might have been done in the maintenance and support organization.

A later leader of the system integration group has said, "Systems Integration was oriented around integrating Interleaf's main products, across platforms, and with other products of other sources or manufacture. Most often these activities grew out of specific customer involvements. Each of these projects involved substantial customer-oriented work."[15]

The product management and planning organization (about 30 people in 1989) had been created to better direct how the company invested in research and development. (For examples, see the interview of Larry Bohn in this issue.)

It is interesting to note that departments throughout the company used the Interleaf system constantly for all documents, including annual reports and all of the extensive user documentation, which provided a huge base of "free" QA testing. People called this "eating your own dog food".

Product development and TPS implementation

Interleaf's product development activity was always a big source of the company's competitive capability.

The base TPS development group (product development on the 1989 organization chart) was only 12 people; 25 people were working on peripheral technology (5 in font design, 5 in printer systems, 10 in special projects, plus 5 more); 32 were doing workstation engineering (4 for the 386, 3 for Apollo, 3 for Ultrix, 4 for DEC VMS, 6 for Sun, 4 for IBM RT, 6 for release engineering, and two more); distributed publishing technology had 9 people (Lisp, batch, PC editor, mainframe, and Viewstation engineering); engineering operations had 20 people (7 in administrative services, the rest in network services); quality assurance had 48 people (8 for product development, 10 for peripheral technology, 13 for workstations, 8 for PC and distributed products, 5 in operations control, plus 4 more). One can see from this long list of people and functions that there were a lot of variations in adapting the base system to customer platforms and Interleaf options.

At the time of the 1989 chart, there were 114 people in what we are calling engineering (15 percent of company employees); nearly half of them were doing quality assurance. This is consistent with what David Boucher told us saying he "always felt that the product was the most important thing", "the system had to work right all the time", and "the QA people were to get rid of the bugs; it was a complex system, and it was hard to test all the parts."[1]

The core product development group was small, it was an elite group of programmers, and its manager knew the strengths of its members when assigning projects.[t] The Release Engineering group (part of Workstation Engineering) played a big role in integrating the components together into an overall system; naturally they also had a big role in rolling out new releases to customers.

By 1985 Interleaf had an "advanced Continuous Integration process in place"[16]—"doing nightly builds and nightly test"—"quite consciously" doing

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process innovation.[17] Pelletier gives Joe Mahoney much credit for the company's process innovation that "made engineering much more manageable". Paraphrasing Mahoney,[18] the big innovations were release engineering with nightly builds for the various platforms on which the Interleaf system ran with their various user interfaces, and software testing with QA and product development tightly coupled (not the model of the tester working separately from the developer) and with the QA people having domain expertise. Pelletier also notes Mahoney's "innovative hiring practices" which "sought out liberal arts graduates with a demonstrated affinity for software, sort of a groupie psychology, but with both intellectual rigor and high empathy for software engineering personalities."[17]

The base TPS system had always been coded in the C programming language and also from the beginning used an object-oriented paradigm. Program editing was primarily done with Emacs, within a "home-grown integrated development environment (IDE) based on emacs Lisp. The IDE included version control and source merging tools which made it easy for some engineers to work across the entire codebase. There was a custom bugs database, and all source code changes were carefully documented in a templatized 'release mail' sent to the entire team with each code release."[19]

Because of its early entry into the electronic publishing market, Interleaf developed its own user interface. (This was before stardard graphical user interfaces were developed for Windows, Mac and Unix.) Interleaf's graphical interface design included two important menu design ideas that made it different from what the market because accustomed to later: *smart defaulting* and *stickiness*. An example of smart defaulting was that after a Copy operation, the default would be Paste, and a quick mouse click[20] would cause a paste without bringing up the menu, since that was very frequently the desired operation after a Copy. An example of stickiness would be that if you selected a graphic object and then rotated it 20 degrees, if you selected another object and did a quick click, the same rotation would be performed.[u]

Additionally, Interleaf's graphical user interface featured windows that could be resized, moved around the screen, and overlap each other. Interleaf was an early (maybe the first) commercial product to use overlapping windows, a choice that quickly became standard in other window systems.[21]

TPS immediately became known for its speedy response to user commands, and this was an explicit goal of its implementors. Several clever techniques were used.[v]

As part of TPS 4 (released in 1987),[22,23] a new desktop command language was added to the system; it was written in Lisp. With it users could modify base system operations, including creating sequences of operations.[w]

TPS 4 was a first step toward Interleaf 5, whose release is noted in section 3 but we will say a bit about its implementation and capabilities here.[24,25] In prior releases, Interleaf used its own user interface implemented as part of the system. Starting with Interleaf 5, it depended as much as possible on the user interface of the underlying operating system and implemented (with the Lisp system added in TPS 4) the look of the TPS interface on top of the operating system interface. Interleaf 5 also moved on from the modularity of TPS 4. Interleaf 5 was a modular system programmable at every level, supported on many different hardware and software systems (more than a dozen platforms[26]) and further allowing users to extend the base systems pretty much however they desired. Structured and active documents were an important component of such flexibility.[27,28,x,y] Such extension capabilities were important for Interleaf's customers with complex document requirements.

Font and RIP technology

The basic parts of the Interleaf system were a workstation running the Interleaf system and able to print to a relatively high resolution printer (e.g., 300-dpi laser printer).[29,8] With these a user could mix text and graphics on the workstation screen and then print camera-ready copy on the printer. When Interleaf was founded, while it was developing its system leading to its first sale in 1984, and for years afterward, there was little standardization of font and printer technology.[30,z,aa] Various companies had their own systems of sending pages of text to a printer including in some instances their own raster image processor (RIP) technology to convert their internal font and page description technology into a bitmap that could be printed.

Although Interleaf had given up the idea of developing its own workstation, it carried on with Jon Barrett's RIP development project.[31] This RIP was cross-licensed with printer manufacturer Dataproducts. Interleaf also preferred to use this RIP with printers such as the Canon CX. Using the Interleaf RIP provided better control of output typefaces and spacing.

Already by August 1983, Interleaf hired Les Snow from Compugraphic to work in the font area. In February of 1984, Kathy Nitchie, also from Compugraphic, was hired. Over time the font group varied in size, having up to half a dozen people.

For use in Interleaf's systems, the font group developed bitmap fonts in eight sizes for its Classic (somewhat like Times Roman) and its Modern (somewhat like Helvetica) typefaces, optimizing both for 75-dpi screen display and 300-dpi printer output. To keep character proportions equal in characters for screen display and printer output while maintaining legibility of the low resolution font, in small fonts

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the font people sometimes had to make a character have more pixel width than was usual.[ab]

Each typeface had roman, italic, and bold fonts. Product releases also included two typewriter fonts. a math font, an extended math font, a symbol font, and a Greek font. Occasionally the group was asked to add a custom character to a font. To get more typefaces to keep customers happier, Interleaf eventually licensed fonts from Bitstream and cleaned them up in the same ways—still bitmaps harmonized for screen display and printing. They didn't move from bitmap to outline font technology until 1991–2 (Interleaf 5) when they began to use Speedo technology fonts from Bitstream.

The detailed work of originally cleaning up, testing, and later maintaining the bitmaps for all the typefaces and sizes was a massive effort for the font group, even before they had to deal with other printer resolutions, adding special characters, supporting non-English languages and their accented characters, and eventually also dealing with outline font technology. To try to deal with the effort, they developed Flexifonts, where the idea was generic sets of low resolution bitmap characters of different widths that could be used for screen displays where the width and point size of the high resolution printer font being used would determine the Flexifont parameters for screen display.[32]

In the long run, Interleaf moved into the world of PostScript printers and Adobe, Apple, and Microsoft font technology, as did other companies who had developed font and laser printer technology or were using other page description languages and font technology.[ac]

Sources of revenue

Curves prod, serv, and othr in Figure 1 show Interleaf's sources of revenue over the period through 1988/9 described in this section. (Curves rev and inc are explained in a later section.)

From 1985 to 1988 the product sales (curve prod in Figure 1) went from $4.8M to $47.1M, while services revenue (curve serv) went from almost nothing to $5.0M, and software license and royalty revenue plus a little other revenue (curve othr in the figure) moved from $3.4M to $6.2M. (From 1988 on, curve othr is maintenance revenue.) The company became profitable, approximately $7M, in 1988; and thanks to its 1986 IPO (next subsection), it had plenty of working capital. Not too surprisingly, the company thought it was on a path to great success in what was essentially a software/hardware systems business. Interleaf was first into the market, their systems addressed a major problem for big corporations, and the system was highly popular. (This was despite the entry into the market of the desktop publishing companies and systems mentioned above and the existence of Adobe's PostScript.) With regard to PostScript, Interleaf's goal was for its page description language, Printerleaf, and WorldView viewer to become the industry standard.

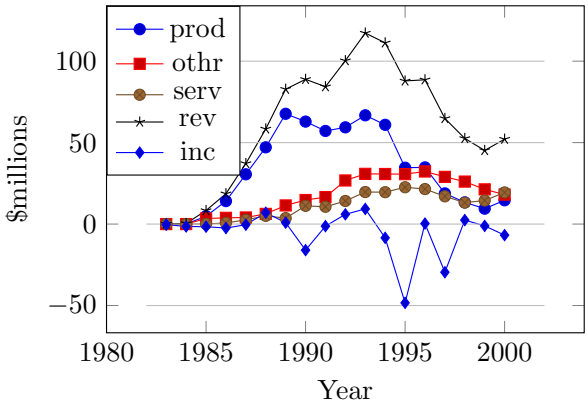

Figure 1. Financial summary[33]

A more thorough, two-page financial summary is at `history.computer.org/annals/dtp/interleaf/interleaf-financials.pdf`

Initial public offering

Revenue growth in the first five years, getting closer to profitability, and future prospects justified an initial public offering. It was the usual opportunity for investors, founders, and employees with stock options to cash out at least a bit and for the company to have cash for future growth. In particular, investor Kodak was able to sell its 7.4 percent stake in the company; having a share of Interleaf was increasingly awkward as the two companies found themselves competing with each other.[ad]

On May 16, 1986, the company did its SEC registration for an IPO, at a share price of $11.[ae] The registration statement noted a potentially large subcontract under an Electronic Data Systems printing services contract with the U.S. Government Printing Office that was being protested by competing vendors. On June 20, after a few hours of trading, Interleaf rescinded its IPO because the government had rescinded its contract to EDS.[34] This was a shock to employees ("there was despair"[1] although not apparently to the financial markets or customers). On June 26, the IPO actually happened at the reduced share price of $10.[35,36] David Boucher credits this quick turnaround to co-founder and chief financial officer Harry George: "Harry George was key to that coming out OK. With investment companies one needs a relationship of trust, and Harry was good at building relationships of trust. No one had ever heard of an IPO being rescinded before . . . But the repeat IPO was possible in a short time because of the relationships Harry had built."[1] (For Harry George's description of the IPO events, search for "the IPO, etc." in Webnote k.)

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3 Software and services, 1989–2000

As shown in Figure 1 and in charts at `history.computer.org/annals/dtp/interleaf/interleaf-financials.pdf`, revenue growth had been excellent and the company was moving toward profitability, which it achieved in 1988 (approximately 10 percent of revenue). In addition to bringing out Release 4.0 (fiscal 1987), the PCEditor and PCViewstation were released in fiscal 1988; the former only handled text; both could be part of a local network of TPS systems providing lower cost terminals than the systems that could run full TPS. Other offering were Interleaf Publisher for the Mac II and IBM Publisher for the IBM PS/2 and the IBM RT PC. Things were looking good.[af]

However, in 1989 the profit had disappeared despite a 50 percent revenue increase, and in 1990 the company lost $16 million (on revenue of almost $89 million, which was only 7 percent growth over the prior year).

These problems had several sources. First, the company was investing heavily in moving into the personal computer market in addition to remaining in the workstation market. Second, the company was caught with lots of aging inventory it had to sell at a discount (and to move to a more just-in-time system of operation). But third, in general platform prices were going down quickly and there was less margin on hardware sales to be had. Consequently, the company left the turnkey system business, "re-focusing Interleaf's resources on high-margin software and services".[37] This incurred restructuring costs of $13.5 million—severances for 135 people, inventory and fixed assets write-offs, and costs of consolidating facilities.[38] However, the company still needed a big direct sales effort because the desired customers still had sophisticated publishing environments. By this time, international sales were 30 percent of revenue.

The platform user interface technology was another problem. Interleaf had had its own graphical user interface for years, but the computer world was increasingly using Microsoft Windows, the Mac user interface, and Unix window systems—interfaces users were coming to expect and all of which were developed after Interleaf's own innovative user interface (described as early as 1983 in the preliminary manual for Release 2.0[39].)[40]

For the rest of Interleaf's years as an independent company, it followed rapidly changing market and competitive forces with new releases of its base system and other software packages (some developed internally and some acquired from external sources) to continue to sell software and services to its customers. The results are shown in the total revenue (rev) and net income (inc) curves of Figure 1.[ag]

Through these years, there were four changes of president of the company: David Boucher through FY1989, Robert Weiler in 1990, Mark Ruport 1991–4, Ed Koepfler 1995–6, and Jamie Ellertson from 1997 on. There were changes in organization. There was downsizing. There were changes in strategy—moving into document management in parallel with high-end electronic publishing and simultaneously trying to compete in consumer level electronic publishing, getting deeply involved with SGML, and playing catchup in getting involved with the Internet.[ah] Central to the company's development efforts, early in this period Interleaf 5 (a new name for what would have been TPS 5) was released with the system significantly opened up to allow it to fit into more application situations.

In some years, there were hopeful signs without big losses; however there was a loss of $48M in 1995 and a loss of $29M in 1997. More details are in the Webnotes.[ai]

Jamie Ellertson became president of Interleaf in the last quarter of fiscal 1997 and announced that the company would be going back to core competencies of distributed publishing on more platforms, more standards, etc. The next year, 1998, there was a $2.4 million profit on an 18 percent reduction in revenue; and in 1999 there was a $1.1 million loss on a further 15 percent reduction in revenue. Over these two years, the company did lots of market research, met with many customers, and reduced its international sales force significantly while increasing the size of its domestic sales effort. The company would focus content management and on complex publishing (using proven Interleaf 6, which had been released in 1994, and the coming Interleaf 7).[aj]

Late in fiscal year 1999, Interleaf announced Interleaf 7, "a next-generation e-content publishing solution that allows users to author and publish complex documents to a large variety of Web and e-content formats, including HTML, XML, SGML or PDF." Having perhaps not jumped on the Internet bandwagon when it originally had an opportunity, Interleaf in 1999 seems to have been positioning itself solidly in the Internet/Web world.

4 Acquisition by BroadVision

In early calendar 2000 (before the end of the fiscal year on March 31), Interleaf was acquired by BroadVision of Redwood City, California. Apparently Interleaf had positioned itself sufficiently well to take financial advantage of the later stages of the dot com boom.[41] In the prospectus for the acquisition, Ellertson of Interleaf says, "At Interleaf, we have spent the past three years repositioning the company around new XML and wireless technology. This past year we have successfully penetrated the e-business marketplace by delivering state-of-the-art XML-based e-content management tools." In the

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same document, Dr. Pehong Chen, President, CEO and Chairman of the Board for BroadVision, said, "Through the acquisition of Interleaf, BroadVision will be able to quickly expand our leadership in delivering personalized e-business applications across multi-touch points such as web and wireless." Larry Bohn has suggested that BroadVision was a big company in the website development business, sort of stalled in its growth as Interleaf had been, but it had money; and Interleaf had lots of customers, and the customers needed websites in addition to Interleaf's capabilities. Whatever the reason, BroadVision paid $851.6 million to acquire Interleaf—certainly a good conclusion for its shareholders.

5 Retrospective assessment

Interleaf was an early entrant (if not the first) in what became the desktop publishing industry. Given the early state of the platform technology (workstations, not personal computers), RIP and printer technology (before the Apple LaserWriter), and page description and font technology (before PostScript, PDF, Type 1), innovation was essential. The early hardware technology was expensive, and thus customers tended to be large organizations with extensive and often unique publishing needs. In this early environment, Interleaf hoped its technology could become industry standards as the desktop publishing industry developed while at the same time it was in the business of selling systems adapted to a customer's environment and needs.

As the use of personal computers spread, competitors delivered products oriented to small users (individuals and small offices) of which there were many more than there were customers for Interleaf's system It was hard initially to fit the Interleaf system into these smaller machines, and simultaneously the company came under great pressure to replace its original graphical user interface with the Mac and Microsoft Windows user interfaces that personal computer users were used to seeing. Interleaf was always playing catch up in what became the mainstream of desktop publishing. However, their system business—the business that they really had always been in—the business where they supported so many different system configurations—remained viable for quite a few additional years.[ak]

Ultimately most of the desktop publishing companies went away. Aldus and Frame Technology got themselves acquired by Adobe. Ventura was acquired by Xerox. Microsoft Word became the de facto standard for almost all low-end desktop publishing users and for much of the publishing industry. Interleaf lasted as an independent company longer than the others (not count Microsoft) and was ultimately sold for a bigger price. Only Quark remained independent, mostly used by professional designers and typesetters.[al]

In the end, BroadVision paid more for Interleaf than the acquiring companies paid for Aldus, for Frame Technology, or for Ventura. Interleaf had a base of systems customers that was complementary to BroadVision's existing business and was thus particularly valuable to BroadVision. In terms of longevity and the price of its acquisition, one might argue that Interleaf was the most successful of the desktop publishing companies.

6 After Interleaf

BroadVision renamed the Interleaf system as QuickSilver and has continued to support and improve the system for many years.

Interleaf was a good training ground; and, even before the acquisition by BroadVision, people from Interleaf were taking influential or founding entrepreneurial positions in other companies. First stops after Interleaf for various people (or groups of people) were Intuit, Booklink/AOL, Viaweb, Kurzweil Educational Systems, Lotus, and Virtual Ubiquity. In engineering in particular, Interleaf had collected a significantly sized group of excellent-to-world-class computer programmers and strong technical managers and clusters of them moved on to other companies. For instance, nearly a dozen programmers from Interleaf were collected at Boston Light Software which in turn was acquired by Intuit for its people rather than for its product.[42] Later many of those people plus other Interleaf people went to Kayak.[14] Various onetime technical people from Interleaf (and its founders and some other senior managers) went on after Interleaf to serial entrepreneur careers, and several became venture capitalists. Venture capitalists often mentor fledgling entrepreneurs, and one ex-Interleaf programmer cofounded Y-Combinator which provides relatively small amounts of seed funding to a large number of startups.[am] Various middle and senior managers from Interleaf also went on to major management positions in other companies.

A number of artifacts of Interleaf's existence remain (beyond BroadVision's QuickSilver).

- Samples of Interleaf's website may be found at `archive.org`. At archive.org, put interleaf.com in the search window and click Go; this takes you to the archive's Calendar window for `interleaf.com`; there click on Site Map and there click on some of the earlier year numbers and there click on various of the colored circles or arcs.
- There was also an active comp.text.interleaf discussion group and there is a FAQ from that discussion group: `www.faqs.org/faqs/interleaf-faq`

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- For many years, Bob Treitman and Ian Poynter maintained the "interleft" mailing list, which is still active.
- Pulitzer Prize winning author Tracy Kidder had a good bit about Interleaf in his book *A Truck Full of Money*.[14]
- As part of this Interleaf history project, we are putting many documents we have found during out research in an online Interleaf archive at `history.computer.org/annals/dtp/interleaf`—for the benefit of future historians.

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[10]The Boston Globe, 1984-10-12.

[11]Note L of the Interleaf 1989 annual report at `history.computer.org/annals/dtp/interleaf`

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[14]Tracy Kidder, *A Truck Full of Money*, Random House, 2016.

[15]Ralph Alter email of 2019-10-09.

[16]`en.wikipedia.org/wiki/Continuous_integration`

[17]Steve Pelletier email of 2019-11-30.

[18]Joe Mahoney email of 2019-12-02.

[19]Paul English 2020-01-13 email which also notes, "Kimbo Mundy, one of the strongest engineers at the company, was the architect of all of these tools".

[20]Interleaf's mouse was a three-button mouse. Left button marked a selection point; right button extended the selection; and middle button chose a command.

[21]Robert Morris's 1985 overview description of the Interleaf system has much more information than we have presented here, both about the user interface and the overall architecture of the system: `walden-family.com/interleaf/morris-see-enough-interleaf.pdf`

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[41]The stock price varied from 2&7/8 to 88 in 2000.
[42]Karl Berry email of October 27, 2019.

Mark Dionne was with Interleaf from 1983 to 1996. At Interleaf he worked on development of various key projects including filters, document formatting, the equation editor, tables, the Kanji version of the system, the desktop publishing systems, and Cyberleaf. He has also worked at two Kurzweil companies, Partners in Health, and Kayak.

David Walden was a computer programmer, technical manager, and general manager at Bolt Beranek and Newman Inc. Since retirement from business, he studies and writes about computing history and digital typography.

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