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COM TECHNIQUES AND APPLICATIONS AT THE LAWRENCE BERKELEY LABORATORY

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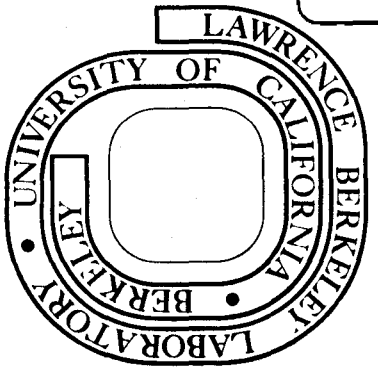
October 9, 1973

Prepared for the U.S. Atomic Energy Commission
under Contract W-7405-ENG-48



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Lawrence Berkeley Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

COM Techniques and Applications at the Lawrence Berkeley Laboratory

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INTRODUCTION

The Lawrence Berkeley Laboratory Computer Output to Microfilm (COM) system was developed as an alternative to hard copy printers for our BKY computer system. We had been operating nine high-speed line printers (5 IBM 1403; 4 CDC 501) for several years as a part of our dual CDC-6600 system. With the arrival of our CDC 7600 it was felt that additional print capacity of the order of 10-15 K lines per minute would be necessary, and in addition we felt that it would be desirable to have a reasonable graphics output facility, as well, and that the capital expense necessary to add ten additional printers and their controllers was absurd.

We therefore investigated the available microfilm equipment and decided to purchase a Stromberg-Datagraphix 4460 microfilm device, along with about 200 (MDI) microfiche viewers, 2 (Bell and Howell) viewer-printers for hard copy, a Kodak Versamat 70 halide reversal processor and a Stromberg fiche cutter. We have always felt that on-line operation was inherently superior to off-line, and, therefore, designed and constructed a hardware interface between the 4460 and a CDC 3000 channel. The 4460 consists of a Honeywell DDP 516 mini-computer, a Stromberg print head, a teletype and two magnetic tape drives. Our on-line interface connects into a DMA channel on the 516. While the hardware and software for our system were being developed, we ran the 4460 off-line and achieved a print speed of about 5000 LPM from tape. The next section of this paper will discuss the user aspects of our on-line system; then we will discuss the operational features of

the system, and lastly we will give the costs of our system.

USER ASPECTS

The computer output on microfilm (COM) system makes it possible to produce miniaturized 'printed' and graphic output on photographic film. Two types of film are available -- individual 4 x 6 inch sheets, called microfiche, and continuous 35 mm strips. A 16mm camera will be added in the future. Microfilm is a convenient and economical way to store and view large quantities of output. One fiche, for example, can hold the images of over 200 printer produced pages, and at less expense. In fact, printing is cheaper only for output of less than about 20 pages. A further advantage of COM is its graphics capability. Graphs, charts, etc., may be made much less expensively than on the Cal Comp plotter, and graphics and printer page images may be intermixed on the same piece of film.

The images on film are, of course, too small to be read without magnification; special viewers exist for that purpose. It is also possible to make full sized hard copy from microfilm.

Computer output on microfilm at BKY is effected by a Stromberg-Datagraphix 4460 microfilm system equipped with a microfiche camera capable of recording 48x or 24x microfiche, a 35 millimeter camera, a teletype for operator communication, two tape drives, and an on-line interface to the 6200 computer. All COM operations are handled in an on-line mode: that is, the data is shipped directly from the 6200 to the SD4460 via the on-line interface.

To produce output on microfilm, a program first creates a file on disk which contains the output data. That file is then routed to

the COM system by means of the DISPOSE control card. Options on this card specify film type, initial data format (which may be changed from within the data), titling, indexing, and routing information. Pages may be ruled if desired.

A fiche may be thought of as divided into a grid of rectangular areas called frames (Fig.1.). The top row of frames is used for titling information, which appears in characters large enough to be read without magnification. Most of the remaining frames are reserved for data. A data frame may contain either a printed page image or graphic output produced by one of several available graphics languages. Data frames are written in column order. The leftmost column of data frames is filled first (top to bottom), then the next, and so on. Two degrees of reduction are available -- 48x and 24x. 48x is recommended for most applications.

Two character sizes are employed in the row of titling frames. The endmost frames contain large numbers indicating, on the left, an internally generated sequence number used by the operator and, on the right, a sequence number for the fiche generated by a particular job (starting with fiche number one). In addition, a copy of the shortened job card and any routing information pertinent to the job are written in microprint at the top of the first frame. The characters used in the remaining frames are half the height of a frame, allowing two rows of titling information. Titling may be specified on the DISPOSE card or in the text stream.

An index to the contents of each fiche is compiled automatically, unless explicitly suppressed, and is appended as the last frame(s) on

line images on the file will be truncated with no error indication. The standard carriage control characters and their actions are:

blank-print the line, then space one line;

0-space a line, print, and then space a line;

1 or 6- eject to a new page, print the line, then space a line;

+-print the line with no space either before or after.

In addition to the above carriage control characters, a new one, $, has been implemented to allow various control functions peculiar to microfilm. Possible functions using the $ are: page, column, or fiche advance; change title; change indexing algorithm; specify an explicit index; write an eye-readable header frame; or change data format.

IGS meta language is a general graphics language using a 4096 x 4096 raster and allowing arbitrary vectors, characters, and film control, specified by character string instructions.

The Stromberg-Datagraphix 4020 microfilm device is a hard-wired microfilm recorder which produces graphic output on a 1024 x 1024 point raster from instructions given by 36 bit words. For simulation of the 4020 output, this raster is mapped onto a 3072 x 3072 point raster, centered within each 4460 frame.

The Vista (CDC 254) microfilm recorder is a microfilm device that operates from the same controller and with the same data format as the Vista (CDC 250) consoles. Plotting is done on a 1024 x 1024 raster from 24 bit instructions. For simulation of the 254 camera, the raster is mapped to a 3072 x 3072 raster centered within the 4460 frame.

the fiche. For each entry, the index supplies the address of the frame from which it was taken. A particular line and character position is defined as the location within a frame from which indexing information is to be extracted. This information may be specified on the DISPOSE card or in the text stream. An index entry will be included even if it is all blanks. Frame addresses consist of a letter (A-M) indicating the row, and a two digit column number. The length of the text entry is determined by the number of frames reserved for indexing as specified by the user on the DISPOSE card.

A job generating 35 millimeter film output will produce a strip of film containing consecutive frames of data. The indexing and titling features are not provided. The data frames will be preceeded and followed by a single frame of identification information, which is the same as the first title frame on microfiche.

Two 35 millimeter film formats are available -- movie and strip. They differ only in the way frames are spaced on the film. With movie film there is a frame every 4 perforations, while on strip film a frame appears every 8 perforations.

Four data formats are currently supported: packed display code, Stromberg-DatagraphixIGS Meta Language, S.D. 4020 language, and CDC 250 (Vista) language. ASCII print will be implemented as soon as a standard is established.

Insofar as is possible, output on microfilm from packed display code files matches printed output on a frame-to-page basis. A print line contains a carriage control character (which will be printed only if it is in error) followed by up to 135 characters of text. Longer

batch of files has been written, and explicitly release (or rerun) each job. However, during normal operation, an operator need not be present - the system will monitor the printhead and the 6200 operator can keep track of the operation. The program will inform the operator of any error conditions, such as film low, and then pause to await operator intervention. Additional commands allow the operator to duplicate a job, interrupt processing at a fiche boundary, search for and run a single specific job from the COM queue, and scan the queue to produce a count and/or a listing of all jobs of a particular film type.

A preliminary version of the system allowing only print files was put into service in January of this year; the complete system was operational in March. We currently produce about two million user data frames of film per month. Between 8 and 15% of our output is graphic, mostly VISTA. About 2% of our output is 24x fiche and 1% is 35mm with the bulk of our output 48x microfiche.

OPERATIONAL FEATURES

The COM system is driven from a central memory program called COMIE running at a control point in the CDC 6200 (our locally written system allows up to 64 control points). COMIE consists of a root containing the general control routines, and special overlays for each of the languages implemented. It uses 7000 (16000B) words of central memory including the longest overlay. Two special PPU programs - one to write the COM on-line interface, and one to print routing labels on a teletype - were required, although neither uses a dedicated PPU. In total, about four thousand lines of central memory coding (3500 in FORTRAN and 500 in COMPASS), eighteen hundred lines of PPU coding, and four hundred lines of DDP 516 coding were required. The code in the 516 does nothing other than transmit previously formatted printhead commands to the printhead, monitor the teletype on the 516 for operator communication messages and transmit status information back to the 6200 for analysis by the central program. When the rest of the 6200 is relatively idle, the COM driver will use most of the CPU and keep about 2 PPU's full, one emptying the output buffer and one filling the input buffer. When the 6200 is relatively idle, COMIE will drive the printhead about 20 per cent faster than the manufacturer thought possible, at about 18-20,000 lines per minute. In fact, we burned out a frame counter on the printhead because we were printing so fast that it could not keep up.

An operator is required at the 4460; he must specify the film type for a run, mount the proper camera, process the film after a

7. COM software costs were 9 months at $2,500 per month at LBL rates.
8. Both hardware and software costs have been spread over 60 months (5 years) for the cost calculation.

COM OPERATING COSTS

1. 105mm film costs $31 per 200 ft roll. LBL gets from 250 to 300 fiche per roll and averages 140-150 user frames per fiche.
2. 35mm film costs are low at LBL as only 20,000 to 30,000frames per month are generated. A roll costs $20 per 400 ft roll and LBL gets about 2800 frames per roll.
3. Developer costs $8 per gallon and LBL uses about 4 gallons per week. Other chemicals used are incidental.
4. Maintenance is done by LBL.
5. Three operators are used to operate COM. The cost per man is $1500 per month at LBL rates.
6. COM hardware costs break down as follows:

Quantity	Item	Cost
	SD4460	$100,000
	105mm camera	20,000
	LBL built interface	30,000
	SD fiche cutter	2,500
	Kodak V70 processor	10,810
200	MDI COM 150 viewers	24,800
30	SD1400 viewers	2,850
20	Realist VII viewers	4,500
2	Bell and Howell Vwr/Prtrs	3,000
		$198,460

PRINTER OPERATING COSTS

1. Printer paper currently comes 2,500 pages per box at $8 per box. Some narrow (8 1/2 inch wide) paper is used for documentation output.
2. Printer ribbons are expensive and 501's eat them. LBL does reink some ribbons.
3. About 10 percent of our paper, or less, is lost due to job separation, dayfiles, etc.
4. Printer maintenance is done by the vendor, (IBM and CDC).
5. Six operators are used to separate and distribute output, and to change ribbons and paper. The cost per man is $1,500 per month at LBL rates.
6. Printer hardware costs break down as follows:

Quantity	Item	Calculation	Cost
5	IBM1403	(5x46,000)	$230,000
5	CDC3458	(5x44,520)	222,600
4	CDC501	(4x47,170)	188,680
4	CDC3256	(4x24,380)	97,520
2	CDC512	(2x47,700)	95,400
2	CDC3555	(2x28,620)	57,240
		Total	$891,440

7. Printer software is not included as most any system has a basic multi-printer driver capability.
8. Hardware costs have been spread over 60 months (5 years) for the cost calculation.
9. LBL averaged 2,109,375 user pages per month over fiscal year 1973.

Item	Calculation	Monthly Cost
105mm film	(2,000,000/140/250)x31	$1,771
35mm film	(30,000/2800)x20	214
chemicals	a good guess	200
maintenance		1,000
operations	(3x1500)	4,500
hardware amortization	(198,460/60)	3,308
software amortization	(22,500/60)	375
	Total 1	$11,368
	Total 2	$ 7,685

$$\text{Cost 1} = \frac{11,368}{2,000,000} = .57¢/\text{user page}$$

$$\text{Cost 2} = \frac{7,685}{2,000,000} = .38¢/\text{user page}$$

Cost 1 includes software and hardware costs spread over 5 years. Cost 2 is the actual current LBL operating cost as the software and hardware is paid for.

SOME ADDITIONAL COMMENTS

A highly skilled senior operator is needed. Highly skilled means camera, film and developing expertise. This is not easy to come by, but the real success of any COM operation will be determined by the skill and motivation of the operators.

Having an easy-to-use film processor (developer) in the COM area is essential to good service and quick turnaround. LBL is able to give 1 hour turnaround on microfiche during prime shift.

Changing from the 105mm camera to the 35mm camera (and back again) is hazardous, as the 105mm camera is bulky, heavy and expensive. You don't want to drop them. LBL is now modifying its 4460 to have up to 3 cameras (105, 35, 16) permanently mounted so that only the flip of a mirror is needed to switch camera types.

We found the SD 1400 viewer quite acceptable although the MDI COM 150 viewer is better.

The Bell and Howell viewer/printers are poor, as they are wet process thus requiring high use to keep them running well. At the moment the 3M dry silver v/p seems the best.

The Kodak processor is quite good but is a half reversal technique. Half (or Halide) reversal leaves a milky green fiche color which slowly darkens with light exposure, leaving a blotchy appearance. Full reversal gives a totally black fiche which users seem to prefer. We are investigating converting our processor to full reversal output.

Many computer users, programmers in particular, still prefer hard copy print output. Most fiche use is for reference output, not

This is calculated as shown below:

$87,000 wide paper

3,000 narrow paper

$90,000

No. of boxes = 90,000/8 = 11,250

No. of pages = 11,250 x 2,500 = 28,125,000

Pages per month = 28,125,000/12 = 2,343,750

User pages per month = 2,343,750 x .9 = 2,109,375

Item	Calculation	Monthly Cost
14 inch paper	(87,000/12)	$ 7,250
8 1/2 inch paper	(3,000/12)	250
Ribbons for 1403	(11,000/12)	917
Ribbons for 501/512	(16,500/12)	1,375
Maintenance	(calculation not shown)	3,329
Operations	(6/1500)	9,000
Hardware amortization	(891,440/60)	14,857
Software	not included	
	Total 1	$36,978
	Total 2	$22,121

$$\text{Cost 1} = \frac{36,978}{2,109,375} = 1.75¢/\text{user page}$$

$$\text{Cost 2} = \frac{22,121 + (288x5)^*}{2,109,375} = 1.1¢/\text{user page}$$

*LBL rents its 5 1403 printers.

Cost 1 includes hardware costs spread over 5 years..

Cost 2 is the actual current LBL operating cost as the hardware is paid for.

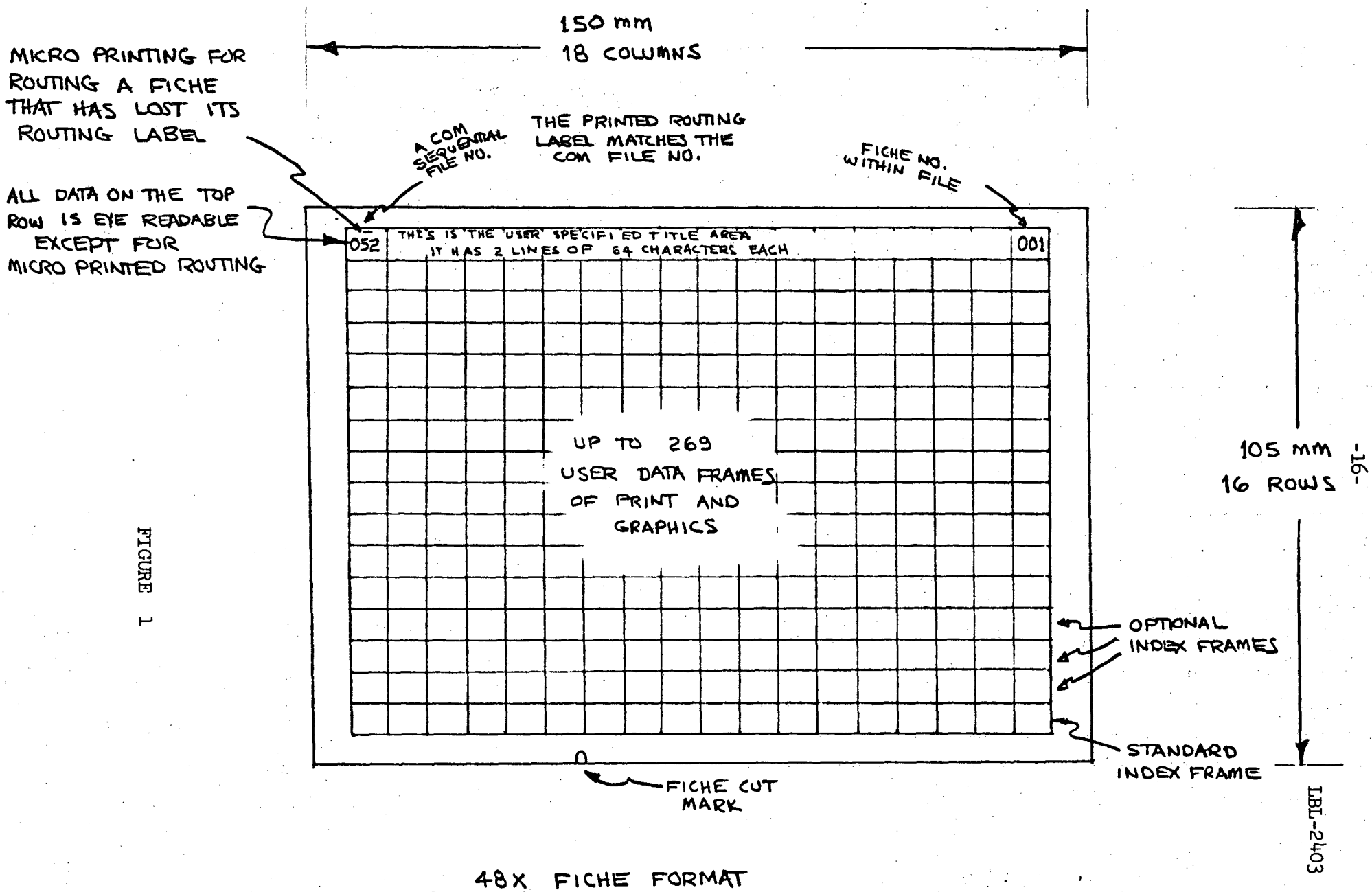

FIGURE 1

48X FICHE FORMAT

working output.

The comparison of COM with printers only considers the use of impact printers. Several non impact (electrostatic) type printers are now available from Versatec, Gould, and Honeywell. At the moment paper costs are high but are coming down.

* * *

This work was done under the auspices of the U.S. Atomic Commission.

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