MATCHING PRINTER TECHNOLOGIES TO YOUR OFFICE NEEDS

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The purpose of this paper is to enlighten the reader on various printer technologies as well as provide some insight to where each of these technologies can be best utilized.

Before this can be effectively accomplished, it is first necessary to discuss four common business printing areas. These areas are:

A) DeskTop Publishing
B) Business Graphics
C) Office Publishing
D) Electronic Data Publishing

A) DESKTOP PUBLISHING

Desktop publishing applications range from the simplest documents (text only) created with electronic typewriters or word processors to documents consisting of any combination of test, graphics, charts, illustrations, photographs and numeric data. Desktop publishers are now producing camera-ready artwork for manuals, newsletters and other formal communication using an integrated page composition system without ever making a trip to the typesetter. During the past 20 years, computers have automated text creation in the office from labor intensive manual methods straight into the twentieth century. Computer systems designed for processing text save time, effort and money: more critically, they give businesses more and more control over all aspects of the appearance and production of their text documents.

Categories Within DeskTop Publishing Include:

Professional Typesetting: - Applications include camera-ready documents, and final drafts for publishing.

Page Composition: - Applications include manuals, press releases, newsletters, price lists and user documentation.

Merged Text & Graphics: - Applications include proposals, technical documents, text printouts from word processing, spreadsheets and database software integrated with graphics and presentation materials.

Sophisticated Word Processing: - Output typically includes contracts, articles, short manuals and external correspondence.

General Word Processing: - Output includes letters, interoffice correspondence, spreadsheets & reports.

B) BUSINESS GRAPHICS

Every day, American offices generate more than 600 million pages of computer printouts. A survey published by Dewar's Career Profile showed that 42% of respondents cited excessive paperwork as the major data processing problem. The information systems of today are capable of generating reams of "timely" data designed to assist with decision making. Business graphics offers a viable alternative to the problem of information overload.

Studies suggest that a person can absorb tables of numbers at 600 to 1200 words per minute. By comparison, a person familiar with reading pictures, charts and graphs can comprehend information at a rate equivalent to 50 to 70 million words per minute. These and other claims for increased efficiency and productivity are verified by the rapid growth occurring in this market.

Business Graphics Applications

Applications in Business Graphics include:

Decision Graphics: - The use of charts for analysis and decision making. Analysis of spreadsheet data, past and present, for example, is used to perform "what if" transformations.

Information Graphics: - The use of graphics for interdepartmental communications and reports. Its primary use is communicating a point more efficiently, rather than serving as an analysis tool.

Presentation Graphics: - The use of graphics to provide visual output during presentations such as overhead transparencies, flip charts or 35mm slides.

C) OFFICE PUBLISHING

Corporate publishing systems are generally found in larger corporations (Fortune 1000 companies) that produce high-quality documents at high volume as a regular part of their business. Typical publications include reports, manuals, annual reports, prospectuses and newsletters. Intended for prospects, clients, and shareholders, these publications must convey a very high quality image. To save money and maintain better control over these publications, many companies often choose to bring publishing systems in house. Such systems also offer corporations many of the same publishing tools which are expensive when using outside typesetting and graphics professionals.

Corporate publishing solutions available on multiuser computer systems integrate mini-computer or mainframe hardware with text, graphics and page composition software. It couples the speed and processing power of a large computer with the ability to link users to a corporate database (as well as provide information from one user to another). High-end laser printers linked to multiuser systems allow for high-speed printing of compound documents. The higher price tags of these laser printers can be offset by increased productivity for a larger number of people.

D) ELECTRONIC DATA PUBLISHING

EDP printers are usually connected directly to mini or mainframe computer systems in an Information System Department. These printers are used for high volume printing jobs and internal correspondence, since most EDP printers have resolutions too low to produce high quality output necessary for for office publishing.

Typical applications for EDP printers include operator technical manuals, accounting output such as large spreadsheets, general ledgers & balance sheets, rough drafts, system dumps, electronic mail messages, printing of pre printed forms, barcoding for shipping and receiving docks and printing of ordinary documents that may need to be archived.

Although EDP printers may have a higher initial cost than office system printers, they typically have a lower cost per page. For example, a 45 page per minute laser printer has a cost of about 1 cent per page, but an 8 page per minute laser printer will have a cost of about 3 cents per page (cost per page based on consumables only, paper was not included).

Duty cycle is another area where EDP printers and office printers differ. EDP printers typically have higher duty cycles; up to about 1 MILLION pages per month. Office system printers have duty cycles of less than 100,000 pages per month. This is why EDP printers are often the computer system's "workhorse", used for large volume printing and the day to day rough drafts.

Now that we have examined the different applications for printers, let's discuss the technologies which dominate the market place today. Raster printing devices like serial dot matrix, line impact dot matrix, inkjet and laser printers provide for most of the office printing needs.

RASTER PRINTERS

The achievement of the mid-seventies toward the advancement of computer graphics was cheap raster graphics based on television technology. In raster displays, the display "primitives" such as lines, characters and solid areas are stored in a refresh buffer in terms of their component points, called pixels or pels (picture elements). The image on the screen is formed from the raster, a set of horizontal raster lines made up of individual pixels.

The concept of raster also applies to raster printing devices. The raster is simply a matrix of pixels covering the entire area, whether a screen or piece of paper. The entire image is scanned sequentially, one raster line at a time, top to bottom.

The storage needed is greatly increased because each pixel must be stored in a refresh buffer as a "bit map" containing only points that map one for one to points on the screen. The development that made raster graphics possible was solid-state memory which provides refresh buffers considerably larger than those of a decade ago at a fraction of the price. All of the pixels in a primitive such as a line or rectangle must be transformed in the buffer to their new coordinates, rather than just the end points of lines, as in vector plotting. Because of the heavy memory demands of graphics applications, much more intelligence is being downloaded into the hardcopy device to relieve much of the computing burden. A number of graphics-oriented printers are more powerful computers than their hosts.

How does all this relate to printing? The first requirement enabling a printer to print bit mapped graphics is a dot matrix form of printing as opposed to fully formed character printing. Normally, the host computer sends the printer a code for a character. The printer has a ROM memory chip called a character generator and the program in this memory establishes the pattern for every character in the set. A printer with provisions for bit-mapped graphics generally recognizes a certain code sent by the computer as an instruction to turn off the character generator and bypass the print logic that controls the printing of individual dots. The printer then interprets the data stream following the turn-off code as explicit orders to print certain dots. This bit mapped control permits the printing of a pattern of dots on the paper to form a picture or graphic image.

Raster printing devices may be categorized by printing technologies, impact or non-impact. Some examples in each category are:

Impact:

* Serial Impact Dot Matrix
* Line Impact Dot Matrix

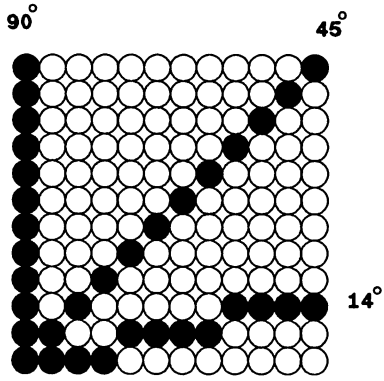
Non-Impact:

* Inkjet
* Thermal
* Laser
* Ion Deposition

PRINT QUALITY

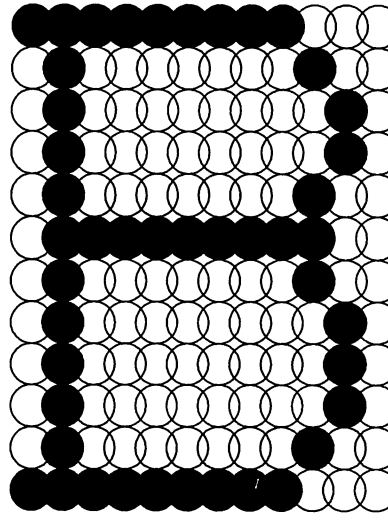
The output from a raster device is an array of dots and the resolution is determined by the number of dots-per-inch (dpi) or points per inch (ppi). These hardcopy devices are usually refereed to as "dot matrix". The term "matrix" refers to this raster pattern and the term "dot" obviously refers to the spots of ink or toner that form this pattern.

The figure below shows a magnified view of raster output. The dots can be darkened or left blank. For comparison, three lines are represented: one at 90 degrees, another at 45 and one at an angle close to the horizontal axis, 14 degrees. Notice how the quality of the line depends on the angle at which it is drawn. The closer to vertical or horizontal, the more obvious the "scalloped" effect becomes.

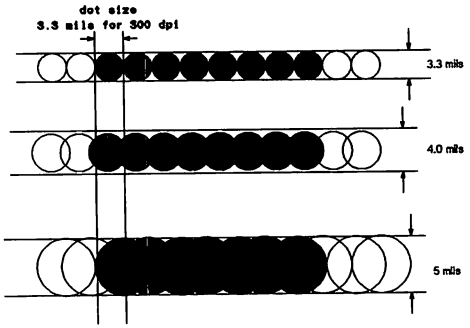


To achieve print quality using a raster device, the scalloped effect must be minimized. This can be accomplished using various techniques. The most straightforward technique is to control the distance between dot centers and thereby controlling the resolution (dpi). Raster hardcopy output devices vary in resolution from under 80 dpi to greater than 400 dpi.

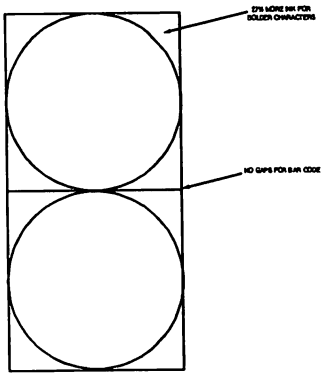
The cell in the following illustration in seven dots wide and nine dots long. Notice that the dots in each row overlap. This is known as "half dot shift". Shifting dots slightly allows for rounder curves and more readable letters.



The second technique for minimizing the scallop is to control the dot size. The dot size determines line width and, depending on dot spacing, how much overlap will occur. Increasing dot size without changing resolution gives more overlap and smoother edges, but also creates a wider line, as illustrated below.



A third technique for minimizing this scallop effect is to alter the shape of the dots from round to square, as determined by the shape of the print stylus. Square dots minimize the scallop effect, providing more readable characters, and better line drawing and bar codes



The combination of resolution, dot size and dot shape are elements in determining the print quality.

THROUGHPUT

Different raster output technologies specify the speed of a raster device in various measurements.

Devices which create characters with a moving head measure speed in characters per second (cps). Those which print one dot row at a time to form characters and graphics specify speed in lines per minute (lpm). Devices which format and print entire pages of text and graphics at one time specify speed in terms of pages per minute (ppm). Devices used primarily for graphics specify speeds in inches per second (ips).

RASTER PRINTING TECHNOLOGIES

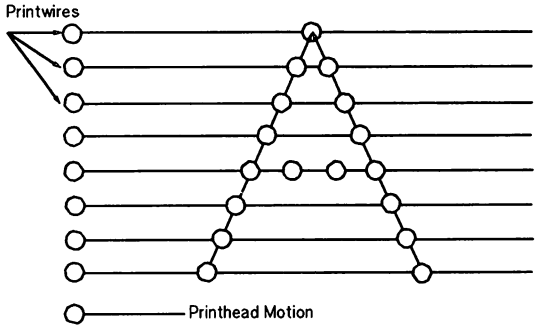
Two types of raster printing technologies will be outlined. Impact printing uses a mechanism that touches the paper and leaves ink on it. Non-impact uses a mechanism that either exposes, charges or sprays the print on the paper without actually striking the paper.

IMPACT

Serial Impact Dot Matrix

The basic method for forming characters with a serial impact dot matrix printer is to move a vertical column of print wires across a line and to strike the paper through an inked ribbon. Each time a wire hits the ribbon, it leaves a dot on the paper. Each wire on the printhead can be driven at over 1000 times per second to form a character within a matrix cell. The printhead uses tungston rids attached at one end to small solenoids and springs. The other end of the wire passes through a wire guide where the wires meet the ribbon and paper. Print quality and formation depend upon the number of wires (usually between 9 and 24), wire speed and the internal control logic of the printer. Speeds on this type of printer ranges from 45 to 360 characters per second and typically the higher the speed the lower the character resolution will become.

Serial impact dot matrix printers are the most common printer in today's office. These printers are normally found printing internal memos, spreadsheets, accounting reports, payroll checks, low resolution graphics, etc. Due to the low resolution of these types of devices, documents generated with serial impact dot matrix printers are rarely used for customer letters, presentation graphics or other uses where a truly polished appearance is necessary.



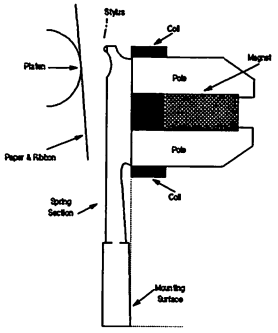
Advantages:	Disadvantages:
Multiple character sets	Lower speeds
Graphics	Noise
Multipart forms	Lower resolution
Low cost per page	
Low initial purchase price	

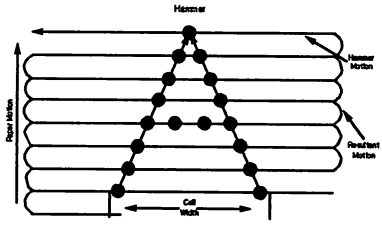
Average Cost:	Monthly Print Volume:
$300 - 1500	100 - 3000 pages

Line Impact Dot Matrix

In line impact dot matrix printers, the print tines or hammers are mounted on a printbar which moves horizontally. The print bar vibrates from side to side to allow one hammer to print from 4 to 16 dots in each horizontal row. A small dot or stylus is mounted on each hammer. The hammer is held back by magnetic force, and when neutralized, is thrown forward by the force of a spring. The hammer impacts the ribbon and paper and is then drawn back to the "loaded" position by magnetic force. Each character is formed one dot row at a time as the paper advances in a smooth motion.

Line impact dot matrix printers range in speed from 300 lines per minute up to 1600 lines per minute. This type of printer is the standard workhorse printer in most datacenters, and more recently, this type of printer can be found as a shared printer on a local area network or as a remote printer in a small department. Printout ranges from EDP reports to barcode labels for inventory control to multipart checks.





Advantages:

- Higher speeds
- Graphics
- Multipart forms
- Low cost per page
- High print volumes

Disadvantages:

- Lower resolution
- Noise
- Pin Feed Paper only

Average Cost:

$4,000 - 26,000

Monthly Print Volume:

3000 - 30,000 pages

NON-IMPACT

Inkjet

Inkjet printing is a broad term describing a form of printing in which drops of ink are projected onto a surface using a variety of techniques. There are two distinct inkjet technologies today, they are: Continuous inkjet and Thermal (sometimes called Drop On Demand) inkjet.

Continuous Inkjet

Continuous inkjet printers will produce a steady stream of magnetically charged ink drops. These drops are passed thru a magnetic field which will either guide the drop on to the paper or into a recycle catch tray. The recycled drops are then passed thru a filter to remove any stray paper dust or other contaminants before they are pumped back thru the inkjet head. Because ink is continuously pumped thru the print head, the small ink nozzles will clog less frequently.

This type of printer is not often found in the office environment. Due to the somewhat high cost per page of this device, this application is better suited for applications where a high volume of paper, but low volume of characters (ex. address printing on envelopes) is required.

Advantages:	Disadvantages:
High resolution depending on drop size Flexible character design Graphics	Pumps can be noisy May require special papers No multipart forms
Average Cost:	**Monthly Print Volume:**
$1,500 - 25,000	Not Available

Thermal Inkjet

In the Thermal Drop on Demand Inkjet printers, ink is held in a small reservoir that is an integral part of the printhead. Capillary action forces ink into tiny channels behind the printhead. When an ink dot is required, an electric current heats up a thermal resistor. The thermal resistor "boils" a drop of ink which squirts onto the paper. Because ink is sprayed only as needed, there is no need for filters or bulky ink pumps. The typical speed for TIJ (Thermal InkJet) printers is between 120 characters per second and 2 pages per minute.

These printers are now capable of producing 300 dot per inch characters and graphics (near laser printer quality). Thermal Inkjet printers are typically found used by a single user in an office where quite printing is a necessity. Typical printout includes: spreadsheets, interoffice correspondence, business graphics, screen dumps and other low volume office printing. These printers usually produce less noise than a normal office conversation (less than 50 dba).

By combining a black printhead with a printhead containing the three primary colors cyan, magenta and yellow, a user can now produce color documents. Today's P/C software packages are just now beginning to merge color in with black and white printing to produce spreadsheets with negative numbers in red. Other packages will allow the company logo to be printed in color, the body of text to be printed in black and the pie chart to be printed in color.

Advantages:	Disadvantages:
High resolution depending on drop size Flexible character design Graphics Color Printing Quiet operation	Limited speed May require special papers No multipart forms
Average Cost:	**Monthly Print Volume**
$ 500 - 2,500	100 - 3000 pages

Laser

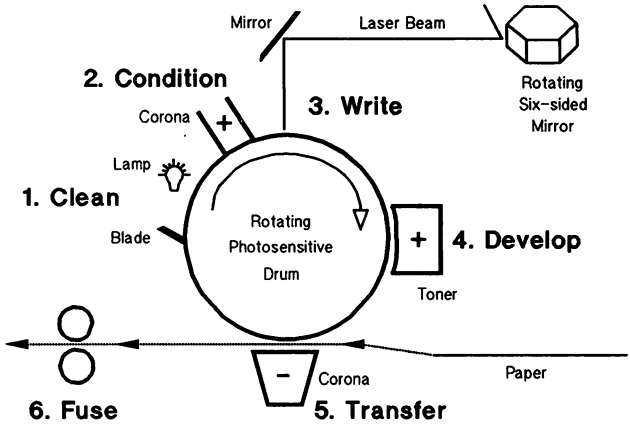
Laser printers are part of a family of non-impact printers which are "electro-photographic". Electrophotography refers to a copying or imaging process in which toner is attracted to portions of a photosensitive plate, drum or other intermediary.

Laser printers use a mechanically deflected beam that has been modulated (turned on or off) with print data to trace the "page" as an electrical image on the drum. In reality, one dot at a time is written as the beam is swept across the face of the photosensitive drum via the polygon mirror. Toner is then attracted to the charged areas of the drum (the areas which were charged by the laser). The toner is then "transferred" to the paper by a large electrostatic charge. The loose toner and paper are then passed thru a fuser which melts the toner into the paper.

Laser printers range in speed from 5 pages per minute to 200 pages per minute. Laser printers are broken up into three different classes: Desktop (5 - 12 pages per minute), Departmental (15 - 30 pages per minute) and EDP / Datacenter (30+ pages per minute). Resolution on laser printers ranges from 180 dots per inch to 600 dots per inch, with 300 dots per inch found in the most common laser printers.

Laser printers perform a wide variety of office printing needs. These printers can be found printing spreadsheets, letter (laser) quality correspondence, business graphics, CAD (Computer Aided Design) graphics, DeskTop Publishing as well as a multitude of other office printing. Due to a higher initial purchase price than most other printers, laser printers are typically shared by two or more users by use of an electronic switchbox (Note: Most laser printer manufacturers do not advocate the use of manual switchboxes as it can cause damage to the internal circuitry of a laser printer), local area network, minicomputers and mainframe computers. Some laser printers work only with cut sheet paper, others work only with continuous forms and a very small portion of laser printers have the ability to be converted from cut sheet to continuous form.

The Laser Process



Advantages:

- Excellent print quality
- Multiple character sets
- Electronic forms
- Graphics
- Quiet operation
- High speed

Disadvantages:

- No Multipart forms
- Higher initial purchase price

Average Cost:

Desktop	$ 2,000 - 10,000
Departmental	$15,000 - 30,000
EDP	$30,000 - 250,000

Monthly Print Volume:

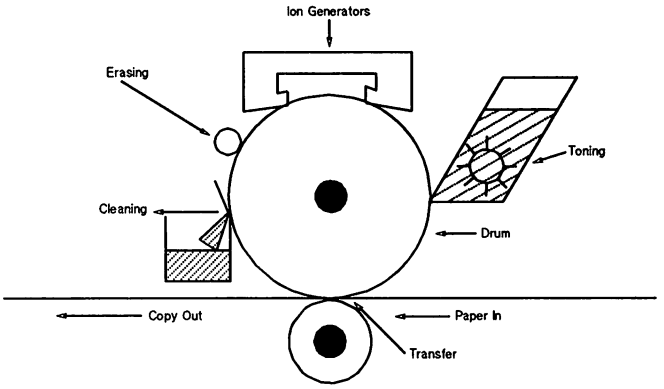
Desktop	4,000 - 12,000 pages
Departmental	10,000 - 100,000 pages
EDP	50,000 - 1,000,000 pages

Ion Deposition

Ion deposition devices are also electrophotographic and place a charge pattern corresponding to the desired image onto the dielectric surface of the drum. The "charging" action is accomplished through a non-contact ion projection cartridge which consist of a multi-plexed matrix of electrodes. The air contained in each cell is ionized when a voltage pulse is placed across the electrodes creating a pool of free ions. An electric field is then used to extract ions from the pool and accelerate them toward the drum. Negatively charged ions are attracted and positively charged ions are repelled from the surface of the drum. As the drum rotates, toner is attracted to the charged pattern on the drum. The image is transferred to the paper and fixed in place by pressing the paper between the image carrying drum and a lower pressure roller. The image is erased from the drum by slightly shaving the

metal drum surface. Currently ALL ion deposition engines are manufactured by one company, Delphax.

Ion deposition printers are utilized in the same areas where departmental and EDP laser printers are found. Ion deposition printers are somewhat lower in cost to produce, but the print quality can be poor. Since the toner is pressure bonded, toner can sometimes be removed from the paper by rubbing or folding the paper.



Advantages:

- High speed
- Flexible character design
- Graphics
- Lower hardware costs
- Cut Sheet paper

Disadvantages:

- Poor durability of print
- "Shiny" print and "fat" characters due to pressure fusing
- No Continuous forms