Portable Document Format (PDF), standardized as ISO 32000, is a file format developed by Adobe in 1992 to present documents, including text formatting and images, in a manner independent of application software, hardware, and operating systems. Based on the PostScript language, each PDF file encapsulates a complete description of a fixed-layout flat document, including the text, fonts, vector graphics, raster images and other information needed to display it. PDF has its roots in "The Camelot Project" initiated by Adobe co-founder John Warnock in 1991. PDF was standardized as ISO 32000 in 2008. The last edition as ISO 32000-2:2020 was published in December 2020.

PDF files may contain a variety of content besides flat text and graphics including logical structuring elements, interactive elements such as annotations and form-fields, layers, rich media (including video content), three-dimensional objects using U3D or PRC, and various other data formats. The PDF specification also provides for encryption and digital signatures, file attachments, and metadata to enable workflows requiring these features.

History

The development of PDF began in 1991 when John Warnock wrote a paper for a project then code-named Camelot, in which he proposed the creation of a simplified version of PostScript called Interchange PostScript (IPS). Unlike traditional PostScript, which was tightly focused on rendering print jobs to output devices, IPS would be optimized for displaying pages to any screen and any platform.

Adobe Systems made the PDF specification available free of charge in 1993. In the early years PDF was popular mainly in desktop publishing workflows, and competed with several other formats, including DjVu, Envoy, Common Ground Digital Paper, Farallon Replica and even Adobe's own PostScript format.

PDF was a proprietary format controlled by Adobe until it was released as an open standard on July 1, 2008, and published by the International Organization for Standardization as ISO 32000-1:2008, at which time control of the specification passed to an ISO Committee of volunteer industry experts. In 2008, Adobe published a Public Patent License to ISO 32000-1 granting royalty-free rights for all patents owned by Adobe necessary to make, use, sell, and distribute PDF-compliant implementations.

PDF 1.7, the sixth edition of the PDF specification that became ISO 32000-1, includes some proprietary technologies defined only by Adobe, such as Adobe XML Forms Architecture (XFA) and JavaScript extension for Acrobat, which are referenced by ISO 32000-1 as normative and indispensable for the full implementation of the ISO 32000-1 specification. These proprietary technologies are not standardized, and their specification is published only on Adobe's website. Many of them are not supported by popular third-party implementations of PDF.

ISO published ISO 32000-2 in 2017, available for purchase, replacing the free specification provided by Adobe. In December 2020, the second edition of PDF 2.0, ISO 32000-2:2020, was published, with clarifications, corrections, and critical updates to normative references (ISO 32000-2 does not include any proprietary technologies as normative references). In April 2023 the PDF Association made ISO 32000-2 available for download free of charge.

File Format

A PDF file is organized using ASCII characters, except for certain elements that may have binary content. The file starts with a header containing a magic number (as a readable string) and the version of the format, for example %PDF-1.7. The format is a subset of a COS ("Carousel" Object Structure) format.

Objects may be either direct (embedded in another object) or indirect. Indirect objects are numbered with an object number and a generation number and defined between the obj and endobj keywords if residing in the document root. Beginning with PDF version 1.5, indirect objects (except other streams) may also be located in special streams known as object streams (marked /Type /ObjStm). This technique enables non-stream objects to have standard stream filters applied to them, reduces the size of files that have large numbers of small indirect objects and is especially useful for Tagged PDF. Object streams do not support specifying an object's generation number (other than 0).

An index table, also called the cross-reference table, is located near the end of the file and gives the byte offset of each indirect object from the start of the file. This design allows for efficient random access to the objects in the file, and also allows for small changes to be made without rewriting the entire file (incremental update). Before PDF version 1.5, the table would always be in a special ASCII format, be marked with the xref keyword, and follow the main body composed of indirect objects. Version 1.5 introduced optional cross-reference streams, which have the form of a standard stream object, possibly with filters applied. Such a stream may be used instead of the ASCII cross-reference table and contains the offsets and other information in binary format. The format is flexible in that it allows for integer width specification (using the /W array), so that for example, a document not exceeding 64 KiB in size may dedicate only 2 bytes for object offsets.

Within each page, there are one or multiple content streams that describe the text, vector and images being drawn on the page. The content stream is stack-based, similar to PostScript.

There are two layouts to the PDF files: non-linearized (not "optimized") and linearized ("optimized"). Non-linearized PDF files can be smaller than their linear counterparts, though they are slower to access because portions of the data required to assemble pages of the document are scattered throughout the PDF file. Linearized PDF files (also called "optimized" or "web optimized" PDF files) are constructed in a manner that enables them to be read in a Web browser plugin without waiting for the entire file to download, since all objects required for the first page to display are optimally organized at the start of the file. PDF files may be optimized using Adobe Acrobat software or QPDF.

Page dimensions are not limited by the format itself. However, Adobe Acrobat imposes a limit of 15 million by 15 million inches, or 225 trillion in^2 (145,161 km^2).

Additional features

a) Logical structure and accessibility

A "tagged" PDF (see clause 14.8 in ISO 32000) includes document structure and semantics information to enable reliable text extraction and accessibility. Technically speaking, tagged PDF is a stylized use of the format that builds on the logical structure framework introduced in PDF 1.3. Tagged PDF defines a set of standard structure types and attributes that allow page content (text, graphics, and images) to be extracted and reused for other purposes.

Tagged PDF is not required in situations where a PDF file is intended only for print. Since the feature is optional, and since the rules for Tagged PDF were relatively vague in ISO 32000-1, support for tagged PDF among consuming devices, including assistive technology (AT), is uneven as of 2021. ISO 32000-2, however, includes an improved discussion of tagged PDF which is anticipated to facilitate further adoption.

An ISO-standardized subset of PDF specifically targeted at accessibility, PDF/UA, was first published in 2012.

b) Optional Content Groups (layers)

With the introduction of PDF version 1.5 (2003) came the concept of Layers. Layers, more formally known as Optional Content Groups (OCGs), refer to sections of content in a PDF document that can be selectively viewed or hidden by document authors or viewers. This capability is useful in CAD drawings, layered artwork, maps, multi-language documents, etc.

Basically, it consists of an Optional Content Properties Dictionary added to the document root. This dictionary contains an array of Optional Content Groups (OCGs), each describing a set of information and each of which may be individually displayed or suppressed, plus a set of Optional Content Configuration Dictionaries, which give the status (Displayed or Suppressed) of the given OCGs.

c) Encryption and signatures

A PDF file may be encrypted, for security, in which case a password is needed to view or edit the contents. PDF 2.0 defines 256-bit AES encryption as the standard for PDF 2.0 files. The PDF Reference also defines ways that third parties can define their own encryption systems for PDF.

PDF files may be digitally signed, to provide secure authentication; complete details on implementing digital signatures in PDF are provided in ISO 32000-2.

PDF files may also contain embedded DRM restrictions that provide further controls that limit copying, editing, or printing. These restrictions depend on the reader software to obey them, so the security they provide is limited.

Even without removing the password, most freeware or open-source PDF readers ignore the permission "protections" and allow the user to print or make copy of excerpts of the text as if the document were not limited by password protection.

Imaging model

PDF graphics use a device-independent Cartesian coordinate system to describe the surface of a page. A PDF page description can use a matrix to scale, rotate, or skew graphical elements. A key concept in PDF is that of the graphics state, which is a collection of graphical parameters that may be changed, saved, and restored by a page description.

a) Vector graphics

As in PostScript, vector graphics in PDF are constructed with paths. Paths are usually composed of lines and cubic Bézier curves, but can also be constructed from the outlines of text. Unlike PostScript, PDF does not allow a single path to mix text outlines with lines and curves. Paths can be stroked, filled, fill then stroked, or used for clipping. Strokes and fills can use any color set in the graphics state, including patterns. PDF supports several types of patterns. The simplest is the tiling pattern in which a piece of artwork is specified to be drawn repeatedly. This may be a colored tiling pattern, with the colors specified in the pattern object, or an uncolored tiling pattern, which defers color specification to the time the pattern is drawn. Beginning with PDF 1.3 there is also a shading pattern, which draws continuously varying colors. There are seven types of shading patterns of which the simplest are the axial shading (Type 2) and radial shading (Type 3).

b) Text

Text in PDF is represented by text elements in page content streams. A text element specifies that characters should be drawn at certain positions. The characters are specified using the encoding of a selected font resource.

A font object in PDF is a description of a digital typeface. It may either describe the characteristics of a typeface, or it may include an embedded font file. The latter case is called an embedded font while the former is called an unembedded font. The font files that may be embedded are based on widely used standard digital font formats: Type 1 (and its compressed variant CFF), TrueType, and (beginning with PDF 1.6) OpenType. Additionally PDF supports the Type 3 variant in which the components of the font are described by PDF graphic operators.

Within text strings, characters are shown using character codes (integers) that map to glyphs in the current font using an encoding. There are several predefined encodings, including WinAnsi, MacRoman, and many encodings for East Asian languages and a font can have its own built-in encoding. (Although the WinAnsi and MacRoman encodings are derived from the historical properties of the Windows and Macintosh operating systems, fonts using these encodings work equally well on any platform.) PDF can specify a predefined encoding to use, the font's built-in encoding or provide a lookup table of differences to a predefined or built-in encoding (not recommended with TrueType fonts). The encoding mechanisms in PDF were designed for Type 1 fonts, and the rules for applying them to TrueType fonts are complex.

For large fonts or fonts with non-standard glyphs, the special encodings Identity-H (for horizontal writing) and Identity-V (for vertical) are used. With such fonts, it is necessary to provide a ToUnicode table if semantic information about the characters is to be preserved.

A text document which is scanned to PDF without the text being recognised by optical character recognition (OCR) is an image, with no fonts or text properties.

Software

a) Printing

Raster image processors (RIPs) are used to convert PDF files into a raster format suitable for imaging onto paper and other media in printers, digital production presses and prepress in a process known as rasterization. RIPs capable of processing PDF directly include the Adobe PDF Print Engine from Adobe Systems and Jaws and the Harlequin RIP from Global Graphics.

In 1993, the Jaws raster image processor from Global Graphics became the first shipping prepress RIP that interpreted PDF natively without conversion to another format. The company released an upgrade to their Harlequin RIP with the same capability in 1997.

Agfa-Gevaert introduced and shipped Apogee, the first prepress workflow system based on PDF, in 1997.

Many commercial offset printers have accepted the submission of press-ready PDF files as a print source, specifically the PDF/X-1a subset and variations of the same. The submission of press-ready PDF files is a replacement for the problematic need for receiving collected native working files.

In 2006, PDF was widely accepted as the standard print job format at the Open Source Development Labs Printing Summit. It is supported as a print job format by the Common Unix Printing System and desktop application projects such as GNOME, KDE, Firefox, Thunderbird, LibreOffice and OpenOffice have switched to emit print jobs in PDF.

b) Viewers and editors

Many PDF viewers are provided free of charge from a variety of sources. Programs to manipulate and edit PDF files are available, usually for purchase.

There are many software options for creating PDFs, including the PDF printing capabilities built into macOS, iOS, and most Linux distributions. Much document processing software including LibreOffice, Microsoft Office 2007 (if updated to SP2) and later, WordPerfect 9, and Scribus can export documents in PDF format. There are many PDF print drivers for Microsoft Windows, the pdfTeX typesetting system, the DocBook PDF tools, applications developed around Ghostscript and Adobe Acrobat itself as well as Adobe InDesign, Adobe FrameMaker, Adobe Illustrator, Adobe Photoshop, that allow a "PDF printer" to be set up, which when selected sends output to a PDF file instead of a physical printer. Google's online office suite Google Docs allows uploading and saving to PDF. Some web apps offer free PDF editing and annotation tools.

The Free Software Foundation were "developing a free, high-quality and fully functional set of libraries and programs that implement the PDF file format and associated technologies to the ISO 32000 standard", as one of their high priority projects. In 2011, however, the GNU PDF project was removed from the list of "high priority projects" due to the maturation of the Poppler library, which has enjoyed wider use in applications such as Evince with the GNOME desktop environment. Poppler is based on Xpdf code base. There are also commercial development libraries available as listed in List of PDF software.

The Apache PDFBox project of the Apache Software Foundation is an open source Java library, licensed under the Apache License, for working with PDF documents.