A Method for Verifying Integrity & Authenticating Digital Media

Supplementary Material

# Metadata

Metadata is a set of data that describes and gives information about other data. If metadata is to be useful it must have structure which implies a formal specification of how the data is to be ordered and interpreted. Metadata can apply to different objects within one instance. For example, an operating system (OS) will hold metadata about a document as a *file* object such as its size or location on the disk. Information about such file attributes will generally be stored externally to the file and may not persist when it is moved or copied to another file system. The *document* itself may also contain internal information which travels with the document such as the number of words it contains and who the author was. An image file will typically contain internal metadata about the *image* object and the *device or software* used to create it; if the device has a Global Positioning System (GPS) enabled, it will also contain data about the *location* where the image was created. The United States National Information Standards Organization [1] has defined three broad functional types of metadata:

* Descriptive metadata such as title or authors are used for activities such as identification and discovery.
* Structural metadata such as chapter structure is used to group compound objects into a single object.
* Administrative metadata such as file type and who can access it are used to manage a resource.

[2] expanded NISO’s definition to five types and provided examples of their various functions. The NISO description and the Baca expansion of it are largely based on practices developed in book cataloguing which is the oldest form of metadata, dating back for over 2000 years [3] and are useful as abstract concepts. They do not, however, easily accommodate the demands of electronic documents and files where metadata requirements do not always readily fit into these traditional categories.

Since the 1990s various attempts have been made to bridge the gap between conventional metadata and electronic media which have resulted in a plethora of metadata structures; [4] has described the metadata movement of that period as “a blooming garden, traversed by crosswalks, atop a steep and rocky road”. [4] differentiate between what they describe as library, archive, and museum (LAM) communities and information industries. Regarding LAMs, they describe a sample list of 15 different metadata structures developed between 1990 and 2005. The first of these, the Dublin Core Metadata Initiative (DCMI), is a typical structure of the period and is still in widespread use, for example in XMP. There has also been a range of metadata systems developed in the electronic information industry. Some leading software companies have developed their own proprietary media data systems such as Microsoft and Adobe.

In regard to image files, the main focus of the work done in this project, an extensive range of image file formats is available with a wide range of disparate structures across different file types. Whereas traditional systems such as the Decimal Dewey Classification for books are designed for direct human use, metadata for electronic metadata in general requires much more detailed and technically defined specifications. In their book on graphics file formats which can still be regarded as authoritative, [5] pointed out that specifications for graphics files like all technical documents, are written by people with varying degrees of literacy, knowledge, and understanding of the subject in question.They went on to conclude that even where formal specifications are available – and even that is not always true – they range from clearly written and helpful to unorganised and confusing and programmers are eventually forced into becoming conversant with what the authors described as “oral tradition” [5]. Although technical specifications are available for the two image formats selected for study (JPEG and PNG), there is a dearth of detailed information on how exactly various operating systems and applications actually implement those specifications; whilst some of this information was available in formal specifications, much of it had to be hunted down as “oral tradition” found through various websites such as StackOverflow. Despite the wide range of graphics files formats that have developed over the last 20 years or so, just three of these file types dominate the market. [6] for example, report JPEG as present on 73% of websites, PNG on 70% and GIF on 41%. Other file types appear on only 1.5% or less of websites. JPEG is also the default image file type for digital cameras including those in mobile phones. [[1]](#footnote-1)

## Joint Photographic Experts Group (JPEG) Files

JPEG files are based upon Tagged Image Files Format[[2]](#footnote-2) (TIFF) which was developed in the 1980s as digital images came into widespread use with the increasing availability of fax machines in general and computerised ones in particular. The TIFF format was cross-platform, running on MS-DOS, Macintosh, Unix and others and was supported by most paint, imaging and desktop publishing programmes [5]. The authors stated that TIFF had garnered a reputation for power and flexibility, but it was also considered complicated and mysterious as well. They put this down to the fact that TIFF had been designed to be very extensible and provide many features and capabilities beyond all other image file formats; it was this very power and extensibility that made it probably the most confusing format to understand and use. The first official specification for TIFF Format was released in 1986 by Aldus, creators of PageMaker, one of the first desktop publishing applications. The specification was labelled Release 3.0 as two draft versions had been previous released and was targeted primarily at desktop scanners which had started to become widespread in recent years with the objective of achieving conformity among manufacturers. The initial standard only handled greyscale images but Release 4.0 in 1987 and Release 5.0 in 1988 introduced RGB colour and LZW compression. The TIFF specification introduced a number of features that provided a foundation for JPEG. It defined itself as a specification for organising and codifying existing practice with respect to the definition and usage of desktop digital data. It was not intended as a printer language or page description language and it was intended to be independent of specific operating systems or hardware. Applications did not have to support all of its features which were designed so that an application could easily ignore any item that it did not understand. It also introduced range of metadata tags covering technical information about the image such as Image Width and ImageLength as well as details of any compression used. It also included general information about the document such as DocumentName and PageNumber in addition to information about the device used to create the image such as Make and Model.

Release 6.0, was issued in 1992 and remains the standard in use today [7]. The copyright passed to Adobe in 1994 when they took over Aldus. The specification is still maintained by Adobe but the TIFF format has substantially declined in popularity having been generally replaced by the JPEG format. Although it is supported by some mid-range and up digital cameras, it is used on less than 0.1% of web sites [6]. JPEG takes its name from the committee who originally created the specification. The first issue only specified the codec which defined how image data is compressed into a stream of bytes and decompressed back, it did not specify the format of the actual file in which it would be stored [8]. Strictly speaking, the name JPEG only applies to the compression codec that is specified in the format’s specification and does not include the file format. There are two different fomats in use - JFIF and Exif and two metadata structures used – IPTC and XMP. All these structures can coexist within a single image file.

## JFIF

JFIF stands for JPEG File Interchange Format and is a specification originally developed by C-Cube Microsystems in cooperation with a number of other companies that facilitates the exchange of JPEG data between different software applications [9]. It defines a single segment to be added to JPEG to provide information missing from the original JPEG specification and was officially added to the specification in 2011 [10]. JFIF is specifically for software applications and is not directly used within digital cameras. An image taken by a camera, however, and later processed using software will contain both JFIF and EXIF and may also contain IPTC or XMP data.

## EXIF

EXIF stands for Exchangeable Image File Format. The specification was originally produced by the Japan Electronic Industry Development Association (JEIDA) which is now the Japan Electronics and Information Technology Industries Association (JEITA), and covers image and sound files used in digital cameras. Since 2009, the standard has been jointly formulated by JEITA and the Camera & Imaging Products Association (CIPA). The latest version is EXIF 2.3 [11]. The standard is based on the TIFF file structure and the JPEG compression codec but as well as including the original TIFF metadata tags, it adds a wide range of new ones relating to various items of interest to photographers and other people dealing with the digital media including ones for GPS. The two organisations also jointly formulated the Design rule for Camera File system (DCF), the current version being 2.0 (CIPA and JEITA 2010). The standard defines the DCF basic main image as an Exif/JPEG file and sets out detailed rules on how this is to be implemented including a range of mandatory tags.

## IPTC

The International Press Telecommunications Council (IPTC) developed the IPTC-IIM (Information Interchange Model) in the early 1990s as an effort to organize, systematize and unify the way information was stored and transported with images among news agencies, photographers, photo agencies, libraries, museums, and other related industries [12]. After the release of XMP by Adobe in 2001, IPTC worked with Adobe to develop a technical implementation of IPTC metadata in XMP format and that led to the issue of *IPTC Core Schema for XMP* in 2005. This was expanded by the *IPTC Extension metadata schema* in 2008. The current version of both schema is 1.2 [13].

## XMP

Extensible Metadata Platform (XMP) was first launched by Adobe in 2001 as an attempt to consolidate the various metadata schemes into an XML structure. Although XMP was originally a proprietary standard, it became an ISO standard [14] in 2012 and is effectively now open source. XMP has been designed to be applied to a wide range of document types and offers a range of schemas including the Dublin Core. Although EXIF/JPEG is the mandatory image format for digital cameras [15]. XMP has an EXIF schema and this often used to copy EXIF data to XMP when a file from a digital camera is edited in a software image processing application.

## PNG Files

An ad-hoc group of computer graphics experts and enthusiasts formed through Internet discussion groups began work on creating the Portable Network Graphics (PNG) in 1995 after problems arose with the raising of patent infringement issues in regard to the Graphics Interchange Format (GIF). That format had been introduced by [17] some 8 years previously. GIF employed the Lempel-Ziv-Welch (LZW) lossless data compression technique and by restricting the colour palette to 256 colours using the 24-bit RGB colour space, could create very small files for the World Wide Web with little or no degradation in the visual quality. GIF quickly became the most widely used format for storing multibit graphics and image data [5]. At the time they launched the GIF format, Compuserve did not realise that the LZW compression technique was patented and in 1994, patent holders Unisys announced that commercial online businesses would have to pay for use of the LZW patent. This caused considerable bad feeling among software developers which resulted in the ad-hoc group being set up to develop an alternative format without LZW compression. Working exclusively through Usenet and email [16], the group successfully produced the first PNG specification. The specification with some minor modifications became an International Standard in 2003 [18]. Since then, PNG has had continuous growth in popularity against a decline in that for GIF and, although the LZW patents relating to GIF expired in 2003 and 2004, GIF files are found on less than 41% of websites today compared to over 71% for PNG [6] although animated GIFs are making something of a comeback for showing short snatches of video, particularly on breaking news stories as well as popular social media sites like Facebook and Tumblr [19]. PNG files have a distinct lack of emphasis on metadata, probably resulting from their background of development with an emphasis on minimal file size. Only 10 metadata tags are included in the specification. Additional custom metadata tags can be added but neither the standard nor custom tags seem to be commonly used in original PNG files. Various applications have significantly different ways of handling existing metadata when converting JPEG files with EXIF data to PNG format.

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1. RAW data is also available on digital cameras but is generally confined to high-end, professional models and requires specialist applications for working with it.
 [↑](#footnote-ref-1)
2. “Tagged” was used in the original specification & remains in popular use even though later specifications and the ISO refers to it as “Tag”. [↑](#footnote-ref-2)