

Dynamic Web File Format Transformations with Grace

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Abstract. Web accessible content stored in obscure, unpopular or obsolete formats represents a significant problem for digital preservation. The file formats that encode web content represent the implicit and explicit choices of web site maintainers at a particular point in time. Older file formats that have fallen out of favor are obviously a problem, but so are new file formats that have not yet been fully supported by browsers. Often browsers use plug-in software for displaying old and new formats, but plug-ins can be difficult to find, install and replicate across all environments that one may use. We introduce Grace, an http proxy server that transparently converts browser-incompatible and obsolete web content into web content that a browser is able to display without the use of plug-ins. Grace is configurable on a per user basis and can be expanded to provide an array of conversion services. We illustrate how the Grace prototype transforms several image formats (XBM, PNG with various alpha channels, and JPEG 2000) so they are viewable in Internet Explorer.

1 Introduction

Data formats for Web-accessible digital content are continually changing. Digital contents that are stored in older or unpopular formats are increasingly in danger of becoming inaccessible to modern web browsers. For example, the XBM image format was properly displayed by Microsoft Internet Explorer (IE) version 4, but IE version 6 is unable to display this format. Older formats like early pkzip, PostScript, and PICT images are no longer accessible or viewable without locating and installing old or special software. Newer digital formats are also likely to be inaccessible through a web browser until wide-spread adoption of the format forces browser makers to support the new format natively. Although the Portable Network Graphic (PNG) format has been around since 1997, its format is still not completely supported by IE 6.

Often it is left to the end user to install plug-ins, software that must be downloaded and installed separately from the web browser, in order to view files with older or unpopular file formats. Installation of this software is not portable; it must be installed at each client browser for the file format to be

properly displayed. For example, the JPEG 2000 image format requires the user to install a plug-in to view .jp2 image files on IE and Netscape. Although a motivated user might install the software on their home computer, they may not have administrative privileges to install the software in a public computer lab. Plug-in software will often age along with the file format it interprets leaving users unable to find up-to-date plug-ins for modern web browsers.

We are in the process of building Grace¹, an http proxy that transparently converts unsupported digital objects into formats that are supported by a user's browser without the installation of any supporting software. The user can create a profile with the Grace system that allows the user to view on-line content in the exact same manner from any web browser. Grace performs format conversion dynamically by using a set of format translation rules that can be customized and personalized by the user.

By using Grace, the accessibility of obsolete file formats like XBM can be stretched over a longer period of time than is currently possible with modern web browsers. New formats like JPG 2000 can be viewed today. Figure 1 illustrates how Grace is able to expand the temporal bubble in which older and newer formats are accessible in modern web browsers.

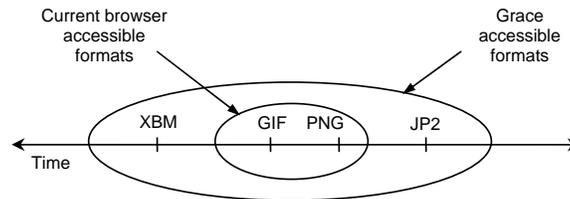


Fig. 1. Expanding time-line of browser-accessible formats using Grace

Grace not only makes accessing web content easier for the end user, it also supports a digital format preservation strategy which relieves the web site operator from the burden of migrating web site content that is stored using obsolete data formats. For example, consider the on-line collection of MPEGs about the Geology of Hydrocarbons². There are 28 videos, each approximately 3 MB. Note the admonition on the web page (Fig. 2) promising new versions of the videos. At the time of this writing, the page was last modified on 2000-03-20. Other formats (e.g., .mov, .wmx, etc.) are still not available, nor are the advanced video interfaces developed by the Open Video Project [9] (e.g., storyboards, fast forwards, etc.). It is unreasonable to expect the National Park Service to pay for the ever-increasing storage demands for new formats or pay for continued programming

¹ Named after the Grace Brothers department store in the BBC Comedy "Are you being served?"

² <http://www2.nature.nps.gov/geology/usgsnps/oilgas/oilgas.html>

development for automatic conversion. This page represents a valuable resource for education, but there is currently no administrative or economic model to update and upgrade the resources to take advantage of the latest formats and interfaces.

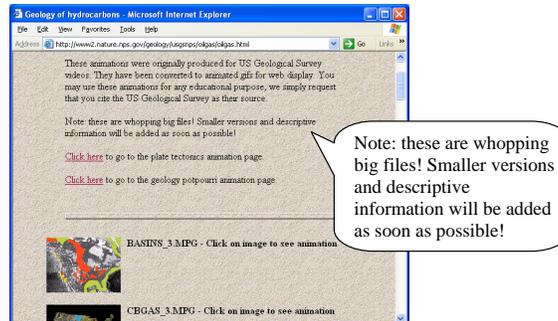


Fig. 2. “Whopping big files” from the US Geological Survey, last modified on 2000-03-20

In this paper we describe how the Grace system can convert a variety of image formats into user-preferred formats. Grace runs as a proxy server and intercepts all web requests by the user. If an image is requested that matches the user’s translation rules, Grace uses ImageMagick [3], an image format converter, to convert the image transparently and return the transformed image to the user. Grace allows additional software to be added internally or externally for additional format conversions.

2 Related Work

The problem of obsolete data formats has been widely recognized for many years. Solutions have primarily fallen into one of two camps: format migration and software/hardware emulation, with the former being the most commonly used approach.

The Typed Object Model (TOM) addresses the problems inherent in accessing data stored in obsolete data formats [10]. TOM provides the ability to explain a data format, interpret the format for proper data extraction, and convert the data to some other format. The TOM Conversion Service [11] was built to demonstrate how file format conversions could be performed using a web interface. It uses third-party software to convert files uploaded by users. The Format Registry Demonstration (FRED) [1] uses TOM to demonstrate how a global digital format registry [2] may be created which provides a central repository

for information on new and obsolete file formats. We are considering using the TOM service for performing external format transformations in Grace. A global format registry could additionally be useful for accessing data on obsolete data formats.

The JSTOR/Harvard Object Validation Environment (JHOVE) project is an attempt to provide a set of services that can be applied to a variety of digital formats [5]. Given a digital object, JHOVE can determine what format the object is stored in, it can determine if the object conforms to a particular data format, and it can provide significant characteristics of the object (i.e. width, height, language, encoding, etc.). JHOVE could be used by Grace for determining the attributes of a web object so that it can be properly converted into another format. For example, if a web server returned a web object with a MIME type of ‘image/gif’, it could be useful for Grace to know which version of GIF the object is using so an appropriate conversion tool could be used if necessary.

The LOCKSS (Lots of Copies Keep Stuff Safe) project is used by many libraries for preserving and making accessible on-line content obtained by permission from a publisher [12]. LOCKSS is a P2P system which crawls a publisher’s website and stores local copies for safekeeping. A web proxy server intercepts requests for these web pages, and if they are no longer available from the publisher’s web site, the proxy server is able to serve a local copy without the user being aware of the exchange. In order to address the possibility of obsolete web formats among the digital content it is preserving, LOCKSS has implemented a proof-of-concept system which converts obsolete image formats into newer ones transparently by the web proxy server [14]. The goal is to create converters which can be preserved along with the web content already being stored in the LOCKSS system. The Grace system is similar to LOCKSS in its desire to serve to the user web content that is transparently converted into other web formats. But Grace is focused on individualized transformations for any web-accessible content. Grace additionally provides accessibility to web content using a variety of web browsers and platforms; the LOCKSS migration facility only works on LOCKSS holdings.

3 Grace Format Conversion

A user can use Grace by configuring their web browser to proxy all http traffic to the Grace Translation Service. All subsequent web accesses will be directed through the Grace system which will return all requested content and translated content to the web browser.

3.1 High Level Design

Figure 3 shows how the Grace Translation Service transforms web content between a client web browser and a web server. Each http request is passed to the Grace Translation Service and then on to the web server which responds with an http response back to the Grace Translation Service. The Translation Rules

Manager uses the returned response's MIME type to see if the user has setup any Transformation Rules. Any matching rules cause the Internal or External Translation Software to convert the content data.

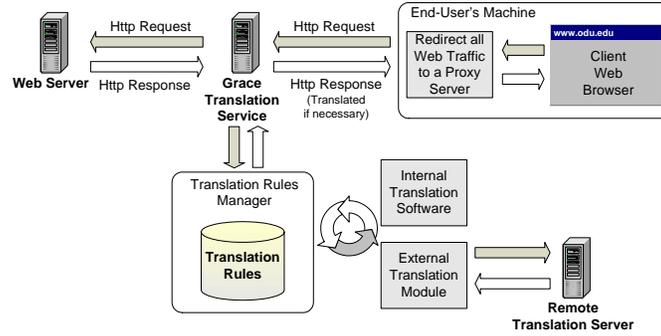


Fig. 3. High-Level Diagram of the Grace Translation Server

ImageMagick [3] is one software package used as Internal Translation Software. ImageMagick can transform over 90 image formats including GIF, JPEG, JPEG-2000, PNG, PDF, TIFF, and DPX. Additional third-party software can be added as needed. An External Translation Module can be used for transforming data formats using remote conversion services like TOM.

Once the content's data is transformed to a new MIME type, the Translation Rules Manager will again search for another matching rule for the new MIME type, and the process will repeat until no more matching rules exist. The transformed content is then returned to the web browser as a new http response encoded with the new MIME type.

3.2 Translation Rules

The Grace Translation Server uses a set of XML encoded translation rules for determining which types of web content to convert. Each user has a profile which contains its own set of translation rules. Figure 4 shows two profiles. The 'dswaney' profile has three translation rules for converting JPG images into GIFs, XBM images into PNGs, and GIF images into BMPs. The 'mln' profile has a translation rule for converting JPEG-2000 images into JPGs and GIFs into PNGs. The rules are from the set of available transformations show in Fig. 5. The user can use a web interface for selecting the desired translation rules.

The Grace Transformation Server uses a list of XML encoded MIME types and conversion software for performing the transformations. As shown in Fig. 5, each transformation defines the MIME type to be transformed (mimetypesource

```

<profile id="dswaney">
  <transform id="001" rule="JPG->GIF" />
  <transform id="002" rule="XBM->PNG" />
  <transform id="003" rule="GIF->BMP" />
</profile>
<profile id="mln">
  <transform id="001" rule="JP2->JPG" />
  <transform id="002" rule="GIF->PNG" />
</profile>

```

Fig. 4. Two user profiles with transformation rules

tag), the target MIME type (mimetytarget tag), and the software to be used to perform the transformation (library tag).

```

<transformations>
  <transform id="JPG->GIF" description="Transform JPG->GIF">
    <mimetypesource>image/jpeg</mimetypesource>
    <mimetytarget>image/gif</mimetytarget>
    <library>TRImageMagick</library>
  </transform>

  <transform id="XBM->PNG" description="Transform XBM->PNG">
    <mimetypesource>image/x-xbitmap</mimetypesource>
    <mimetytarget>image/png</mimetytarget>
    <library>TRImageMagick</library>
  </transform>

  <transform id="JP2->JPG" description="Trans JPEG-2000->JPG">
    <mimetypesource>image/jp2</mimetypesource>
    <mimetytarget>image/jpeg</mimetytarget>
    <library>TRImageMagick</library>
  </transform>
</transformations>

```

Fig. 5. Types of transformations that the Grace Transformation Server can perform

4 Example Transformations

We tested the Grace system on a variety of image formats using three tests:

1. Test formats that are commonly available by most web browsers.
2. Test the PNG format that is improperly displayed by a variety of web browsers.

3. Test the JPEG 2000 format which can only be displayed using a browser plug-in.

We used Microsoft Internet Explorer (IE) 6 (with Service Pack 2) since it is one of the most popular browsers used at the time of writing. All the images transformed by Grace have a watermark at the top-left part of the image to clearly show which images Grace has transformed. The watermark is shown only for testing purposes and can be turned off during production use.

4.1 Common Image Format Test

The web page <http://entropymine.com/jason/testbed/imgfmts/> contains a variety of image formats (GIF, JPEG, PNG, and XBM) with various color palettes and interlace options. As shown in Fig. 6, IE 6 was able to display all the images except the XBM formatted image. Although IE version 4 (circa 1997) was able to display the format, it was abandoned by later versions of the browser. Using the Grace system, the XBM format was converted into the PNG format which was displayed properly in the browser.

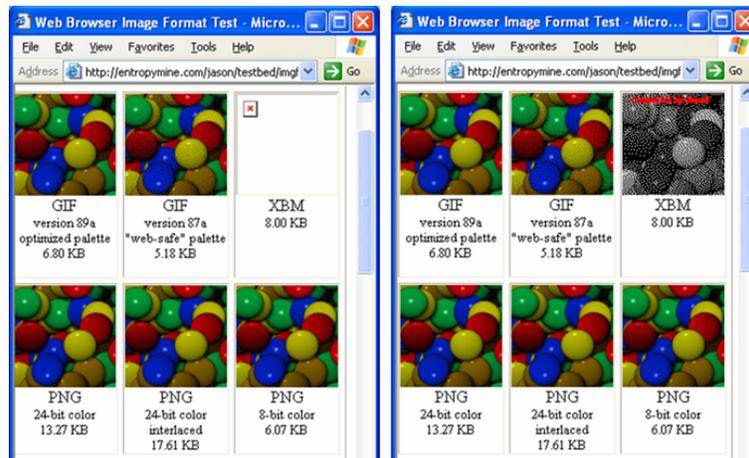


Fig. 6. IE is unable to display the XBM image (left). Grace transforms XBM into PNG image (right)

4.2 PNG Image Test

Although the PNG image format has been incrementally supported by a variety of browsers since its inception in 1997 [13], there are still many browsers that are unable to properly render the various levels of alpha transparency that PNGs use.

The web page <http://www.ecs.soton.ac.uk/~nj198r/png-test/alpha/cmap.html> displays the various deficiencies that browsers have when displaying PNG images. Figure 7 shows an image on the left that is broken into four smaller squares. The three non-black squares all use various levels of transparency. When viewed with IE, the image appears as shown on the right side of Fig. 7. IE is unable to display the transparent levels properly.



Fig. 7. Correct rendering of PNG (left). IE is unable to properly handle various PNG alpha thresholds (right)

Grace was used to convert PNG images into BMP images, a format that IE natively supports. A portion of the transformed web page is shown in Fig. 8. Although it is not clear from a black-and-white rendering of this paper, the image on the left side of Fig. 8 contains different colors because the transparent levels have now been converted to a solid color by Grace. This is because the BMP format is not capable of displaying transparency. In this case, a lossy conversion results in image attributes being lost.



Fig. 8. Grace converts PNG into BMP

4.3 JPEG 2000 Image Test

The JPEG 2000 image format is the successor to the JPEG image format. Being a new format, it is not supported by the major web browsers except with use of a plug-in. Grace is able to transform JPEG 2000 images into JPEG images that

all major web browsers can display. Figure 9 shows how IE can display a web page with two JPEG 2000 images that have been transformed by Grace into two JPEG images.

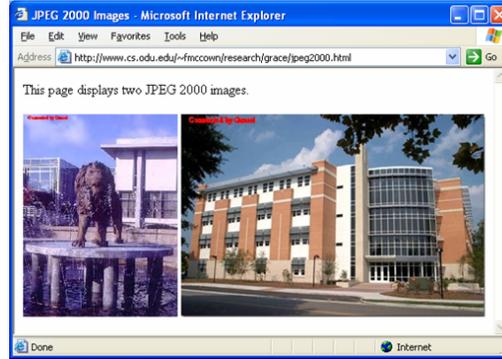


Fig. 9. IE is able to view JPEG 2000 images without a plug-in by using Grace

5 Future Work

The Grace prototype shows how image formats can be dynamically and transparently converted into other formats. There is much work to be done in making Grace perform other types of translations in a time efficient and scalable manner.

5.1 Additional Types of Translations

The Grace prototype currently only translates image formats. Future improvements to Grace will enhance its ability to transform a wide range of data formats using TOM or other conversion services. For example, a Microsoft PowerPoint file could be converted into a PDF or into a series of web pages that can be viewed in any browser.

Other Grace transformations may not focus on the MIME type of a particular resource. Grace could be used to transform an English version of a web page into Spanish using a language translation application, or for stripping out unwanted advertisements or extraneous information that is not desired [8]. Grace could be used in transducing, converting web content into formats that are more easily viewable on small personal devices with limited viewing and bandwidth capabilities [15]. These types of transformations will provide more of a challenge than the digital format conversion illustrated in this paper, but they would allow Grace to be the single framework on which many user interface transformation projects reside.

5.2 Improve File Format Metadata

Currently Grace only works with MIME types which do not provide a level of granularity necessary for all translation rules. For example, a user might want to create a translation rule that converts all Microsoft Word documents earlier than version X into version Y. The MIME type of Word documents is 'application/msword'. Although an optional parameter may also specify the version of the Word document [7], this information is not always given. Therefore a service like JHOVE could be useful for determining the version of a particular Word document in order for Grace to know if the translation rules need to be applied to it.

5.3 Faster Translation of Web Content

Translation of web content at access time is potentially a slow process and may introduce unacceptable delay times for users. Our initial prototype did not suffer from any noticeable time delays, but more rigorous performance testing will be necessary before Grace is ready for wide-spread use. One method we will investigate for improving performance is to cache proxy transformations. After a set of transformations have been applied to a web page, other users requesting the same page need not reconvert the same content. Possibly some transformations can be performed before access: content that is one click away could be transformed while the user is viewing the current web page.

5.4 Scalable Network of Grace Servers

A single Grace server would be prone to a variety of scalability issues. In order for Grace to be scalable, a network of cooperating Grace servers could be used. Servers could communicate with each other using Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) [6], a protocol that is suitable for any scenario that requires periodic updating of XML encoded data. OAI-PMH could be used to transmit transformation capabilities and functionality from one Grace server to another using periodic harvests. This would allow new transformation capabilities to be introduced anywhere within the network and allow new servers to quickly learn of existing transformation capabilities.

5.5 Missing Web Content

Often data stored in obsolete formats are overlooked by web masters that are busy monitoring more up-to-date material on their web sites. These overlooked data files may be inadvertently deleted from a web server. Web pages have been shown to be extremely ephemeral as well which means content being linked to today may be inaccessible a short time later. When web content is missing, Grace could be configured to transparently fetch the latest version of the missing content from the Internet Archive [4]. This type of architecture mimics what LOCKSS does with the content that it crawls and stores locally.

5.6 Translation Rules for Various Browser Capabilities

Grace could be enhanced to perform automatic browser capability checking. For example, Grace could check to see if the browser is capable of displaying PDF documents. If the required plug-in is not found, a translation rule could automatically be applied which converts a requested PDF into a set of web pages. This would make it easier for users who are less technically savvy and may not know what a PDF is or how to install plug-ins. This would also relieve most users from having to manually create translation rules.

5.7 Transformation Metadata

How will a user know if what they are viewing is the original resource or a Grace-transformed resource? If a conversion results in a loss of information (as our PNG to BMP conversion did), how can the user be informed? How can metadata about each transformation be made accessible?

There are many issues which must be addressed in future versions of Grace to allow advanced users access to transformation metadata. Grace is currently configured to place a watermark on top of images that it converts, but the watermark can be distracting and cover vital portions of the image, especially on small images. In order for a user to know that something has been transformed by Grace, it might be better to present a link to transformation metadata at the top of the page or inline with transformed content. This solution will unfortunately alter the look of the web page. Usability studies will need to be performed to determine how best to present this information to users without distracting or annoying them. Most users may not find transformation metadata very useful for casual browsing.

6 Conclusions

We have introduced Grace, an http proxy server that dynamically and transparently converts web accessible content. Grace allows a user to view web content in a consistent manner independent of browser and plug-in software. Grace not only improves the web surfing experience for the end-user, but it also frees the content-provider from the sometimes costly and difficult process of converting existing on-line content into newer/popular data formats. Grace uses a set of translation rules for converting the format of web content on a per user basis. We demonstrated how Grace could be used to allow Internet Explorer version 6 to display several image types (XBM, PNG with various alpha channels, and JPEG 2000) that it is unable to display without the help of plug-ins. Several improvements were offered for expanding the types of translations possible, for improving the speed and quality of translations, and for allowing cooperation among Grace servers.

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