

An Indexing and Querying System for Online Images Based on the PNG Format and Embedded Metadata

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Abstract

In this paper we describe an indexing, querying and browsing system for online images based on the PNG (Portable Network Graphics) image format and its ability to embed structured metadata within the image.

First we describe a Java application which enables the computer-assisted generation and editing of Dublin Core-based metadata descriptions for digital images and the annotation of regions within images. This application integrates an image display window with a graphical user interface and metadata input forms generated from a hierarchical Resource Description Framework (RDF) schema. The schema definition is also used to validate the input descriptions and control the format of the output. At "Save" time, the image is converted from GIF or JPEG to PNG format and the validated metadata which has been input is embedded within the image.

Secondly we describe an image-capable search engine developed through a simple code extension to DSTC's existing HotMeta web-page search engine. HotMeta crawls across the WWW extracting metatags from web pages and storing them in an indexed repository to enable searching. A simple code extension to HotMeta has enabled image search capabilities. Whenever HotMeta encounters a PNG image, it opens the image, extracts the metadata and saves this in the indexed repository.

Finally we describe an improved image browsing method which exploits the metadata embedded in thumbnail PNG images. Clicking on a PNG thumbnail runs a cgi script which opens the thumbnail image, extracts the metadata and displays the full scale JPEG image, with annotated image maps, and other relevant embedded metadata - eliminating the need for backend databases or static web pages.

This prototype system has been developed using digital images of historical photographs from the State Library of Queensland's (SLQ) John Oxley library. In particular, we have used historical photographs of Queensland from the William Boag Photographic Collection from the 1870's.

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1. Introduction

Image libraries have been enthusiastically embracing new digital technologies to increase the accessibility of their collections through online exhibitions on the Internet. Most online image collections are based on either static web pages of browsable GIF thumbnails linked to full-size JPEG images or search interfaces which use cgi-scripts to access proprietary back-end databases containing the libraries' catalogues.

In this paper we describe an indexing and retrieval system for online images based on the ability of the PNG format to embed metadata within the image file.

PNG [[HREF1](#)] is the Portable Network Graphics format, a format for storing digital images. It was designed to be the successor to GIF after Unisys and CompuServe suddenly announced in January 1995 that programs implementing GIF would require royalties because of Unisys's patent on the LZW compression method used in GIF. Apart from its freedom from copyright restrictions, PNG has a number of other advantages over GIF. These include: alpha channels (variable transparency), gamma correction (cross-platform control of image brightness), and two-dimensional interlacing (a method of progressive display). PNG also compresses better than GIF (by around 5-25%) and provides three main image types (truecolor, grayscale and palette-based (8-bit)). However the major advantage of PNG which we aim to exploit in the work described in this paper, is its ability to embed associated metadata within the image.

First we describe *Peggie*, an Image Metadata Generator and Editor application which enables the computer-assisted generation and editing of Dublin Core-based metadata descriptions for both digital images and regions within those images. When the images are saved in the PNG format, the associated metadata is saved within the image file.

This approach then enables existing Dublin Core-based search engines, such as DSTC's HotMeta, to search for images through a fairly simple extension. Whenever the extended HotMeta search engine encounters a PNG image, it opens the file, retrieves the metadata and stores this plus any additional information within its indexed repository enabling image searches.

Finally we describe an image browsing method which exploits the metadata embedded in thumbnail PNG images. Clicking on a PNG thumbnail runs a cgi script which opens the thumbnail image, extracts the metadata and displays the full scale JPEG image with annotated image map and other associated metadata - eliminating the need for backend databases or static web pages.

This prototype system has been developed using digital images of historical photographs from the State Library of Queensland's (SLQ) John Oxley library. In particular, we have used historical photographs of Queensland from the William Boag Photographic Collection from the 1870's [[HREF2](#)].

2. Objectives

Through this work we hope to demonstrate that embedding standardized metadata within images provides the following advantages over existing online image databases:

- Existing Dublin-Core based search engines can easily be made image-capable through a simple code extension;
- Since no back-end databases are required, it's not necessary for search engines understand the protocols of specific databases;
- Broken links between images and pages containing metadata information are no longer a problem. Libraries and cultural institutions can exchange both the image and its metadata within a single file.;
- Modification of the web pages which display the full-size images and associated detailed metadata involves the modification of only a single cgi-script;
- Display of the full-size image and related metadata from a PNG thumbnail, will often be quicker since all of the information is stored locally;

In addition to demonstrating the advantages of the embedded metadata approach to image indexing, as listed above, the project had the following objectives:

- to build a simple efficient metadata editor and generator for images and regions within images, based on Dublin Core [[HREF3](#)] (with image specific qualifiers) and the Resource Description Framework (RDF) [[HREF4](#)];
- to investigate qualifiers for the basic Dublin Core element set that extend its descriptive semantics to the specific characteristics of image objects and enable improved image resource discovery;
- to investigate the utility of the RDF for encoding structured image metadata and for validating image descriptions;
- to investigate how structured metadata, (both for the complete image as well as for contained regions), can be stored within the PNG format;

- to extend an existing Dublin-Core based search engine (DSTC's HotMeta) [[HREF5](#)] to enable image search and retrieval;
 - to demonstrate and test the prototype on images from the John Oxley Library;
 - to increase the global accessibility and retrievability of the John Oxley William Boag Photographic collection;
-

3. Image Metadata Standards

3.1 Existing Image Metadata Standards

A number of organizations have developed or are investigating metadata standards specifically for image resources. These include:

- VRA Core [[HREF6](#)];
- Visual Arts Data Service (VADS) [[HREF7](#)];
- CNI/OCLC Image Metadata Workshop [[HREF8](#)];
- NISO/CLIR/RLG Technical Metadata for Images Workshop [[HREF9](#)];
- DIG2000 Initiative [[HREF10](#)].

Although we are aware of the problems with applying the Dublin Core element set and their qualifiers to resources such as images which often have multiple digital surrogates, we decided to use Dublin Core for the initial prototype for the following reasons:

- The pre-existence of Dublin Core metadata generated by the John Oxley Library cataloguers;
- The fairly simple image resource discovery requirements of the John Oxley Library;
- The ready availability of Dublin Core-based internet search engines and metadata tools (e.g. HotMeta, Reggie);

[Section 3.2](#) below examines some of the problems associated with applying the DC element set to image resources and specific Dublin Core element qualifiers necessary to satisfy our image description requirements.

3.2 Dublin Core Qualifiers for Images

The CNI/OCLC Image Metadata Workshop [[HREF8](#)] highlighted some of the major problems with applying Dublin Core, which was designed for the simple resource discovery of textual documents, to image resources. These include:

- Conflating the metadata descriptions for physical objects and multiple digital surrogates into a single set of DC elements. This is particularly problematic for images which will frequently exist in a variety of forms with complex relationships between them;
- Differentiating between collection-level and item-level descriptions;
- The potentially recursive nature of the *Source* element due to the complex object-surrogate-derivative relationships common to images and the overlap between the *Source* and *Relation* elements;
- The inadequacy of the *Rights* field to monitor the intellectual property rights lineage associated with a typical image's life cycle;
- The overloading of the *Format* element required in order to support the potentially large amount of image capture and rendering information and the overlap with the *Type* element;

Rather than attempt to solve these problems here we simply propose specific element qualifiers which "refine" rather than "extend" the base elements, enabling straight-forward dumbing-down and the most effective simple resource discovery for our image application. These qualifiers are described below.

DC.Date

Date is particularly problematic for images which exist in multiple formats e.g., the original photograph or physical object and multiple digital surrogates. Does it represent the date on which the photograph was taken, scanned or put online? For our application we chose the following representations:

- Date = the date on which the photograph was taken;
- Date.recordCreated = the date on which the metadata record was created;
- Date.placedOnline = the date on which the image was made accessible over the Internet.

DC.Creator, DC.Publisher, DC.Contributor

The DC Agent Working Group [[HREF11](#)] is attempting to resolve the confusion over what to put in each of these fields. With respect to images, is the Creator the creator of the photograph or the person who scanned it to create the digital surrogate or the person who put the digital surrogate online? In which DC term should the names of these contributors go? For our application, the *Creator* is the photographer, 'William Boag' and the *Publisher* is the 'State Library of Queensland'.

DC.Type

This defines the category of the resource. For the sake of interoperability, Type should be selected from a hierarchy of enumerated lists. The most recent report by the DC Type Working Group Type suggests an enumerated list for Type values which includes the *image* type [[HREF12](#)]. We suggest that the 'Image' type be further specified by another hierarchical enumerated list as shown:

- **text**
- **image**
 - **photograph**
 - **slide**
 - **graphic**
 - **map**
 - **painting**
 - **musical Notation**
- **sound**
- **dataset**
- **software**
- **interactive**
- **event**
- **physical object**

DC.Format

This represents the data format of the resource and can be used to identify the software and possibly hardware that might be needed to display or operate the resource. For the sake of interoperability, the unqualified Format element should be selected from the IANA list of Internet Media Types [[HREF13](#)].

Format = IMT mime type e.g. image/gif, image/jpg

For images, the top level description may also have to also provide image-specific information such as file size (Kb), image dimensions/spatial resolution (width and height in pixels), and color information for each version of the image.

Format.filesize = Kb, Mb
Format.colorpalette = RGB, CMYK, Grayscale
Format.colourdepth = 8-bit, 24-bit
Format.dimensions = 1024x768 (spatial resolution)

DC.Relation

DC.Relation can be used to specify the location of different versions of an image resource. For example consider the thumbnail version (myimage.gif) of a full-sized image (myimage.jpg):

For the full-sized image, myimage.jpg, *Relation.hasFormat* = "myimage.gif"
For the thumbnail image, myimage.gif, *Relation.isFormatOf* = "myimage.jpg"

The Relation qualifiers *isPartOf* and *hasPart* can be used to define image items within a collection or to specify spatial regions within an image. For example:

For the full-sized image, myimage.jpg, *Relation.hasPart* = "region1, region2, region3"
For each region, *Relation.isPartOf* = "myimage.jpg"
and *Coverage.polygon* = "x1,y1,x2,y2,x3,y3,..."

DC.Coverage

The recommended and most used qualifiers for Coverage are PeriodName and PlaceName.

However for images, the Coverage qualifiers, Coverage.rect, Coverage.circle, Coverage.point, Coverage.poly can be used to describe the spatial locations and shapes of regions within an image. Given the outline of a region, annotations or descriptions can then be attached to these regions.

```
Coverage.rect="x1, y1, x2, y2"
Coverage.circle="x, y, radius"
Coverage.point = "x, y"
Coverage.poly="x1,y1,x2,y2,x3,y3,x4,y4, ...."
```

When displaying the image and its metadata through a Web browser, image maps can be created from the second-level region metadata. For example:

```
<MAP NAME="MyMap">
<AREA SHAPE="polygon" HREF="Region1_metadata.html" COORDS="131,294 395,294 395,330 171,330">
<AREA SHAPE="circle" HREF="Region2_metadata.html" COORDS="234,349 15">
<AREA SHAPE="point" HREF="Region3_metadata.html" COORDS="234,349">
<AREA SHAPE="rect" HREF="Region4_metadata.html" COORDS="234,349 361,366">
</MAP>
<IMG USEMAP="#MyMap" SRC="MyImage.jpg">
```

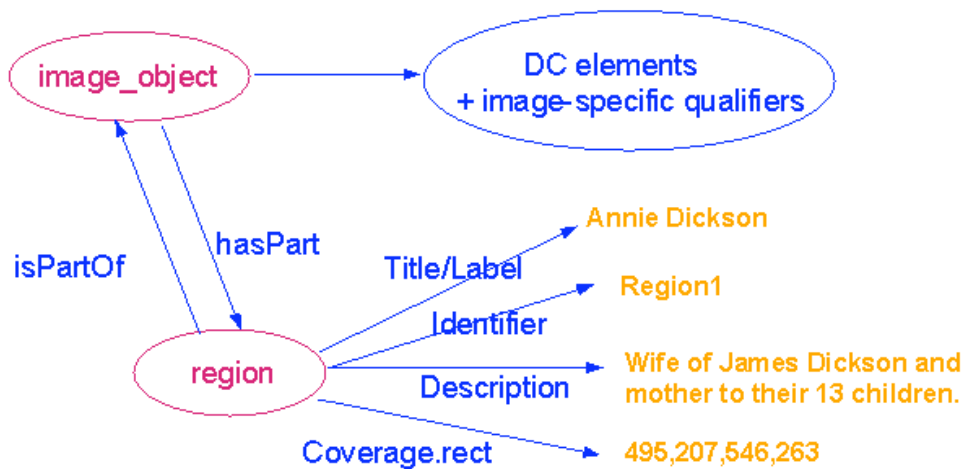
3.3 Metadata Model for Annotated Images

Based on the analyses and requirements described above, the optimum schema for this application consists of:

1. a top-level description applicable to the image as a whole;
2. optional, second-level descriptions (annotations) associated with a number of spatial regions defined within the image.

By top-level metadata, we are referring to the metadata description for the full-sized online master JPEG image. The top level scheme consists of the 15 Dublin Core elements (with certain image-specific qualifiers). The second level region metadata consists of a simple 4 element sub-set of the DC element set. Figure 1 below illustrates the proposed data model for the structured image metadata.

Figure 1: Metadata Model for Annotated Images



3.4 Example Image Description

Consider the image [20248.JPG](#), taken from the William Boag Photograph Collection in the John Oxley library in Brisbane, Qld. It is a digital surrogate of a photograph of a settler family.

An image map has also been created which attaches metadata to a particular spatial region of the image. This has been defined as *Region 1* and is a rectangular region around the head of the woman on the far left of the photograph. Moving the mouse over this region displays the associated region metadata.

Top Level Metadata Description for Complete Image

Title: A selector and his family, probably in the Beenleigh district, 1872
Creator: William Boag

Subject: Photograph collection - Queensland

Description: The difficulties faced by a family in the Queensland bush included poor roads, an unreliable mail service and dense, vine-matted scrub. For many years, a selector's staple diet was salted meat (salt horse) and pumpkins. For several months, a woman and her children might be alone in their stringy-bark hut while her husband went off to split shingles or to earn extra money on a cattle property.

Date.created: 1872

Date.recordCreated: 1996

Date.placedOnline: 1997

Publisher: State Library of Queensland

Type: image.photograph

Format: image/jpg

Format.fileSize: 50.6Kb

Format.dimensions: 672 x 512

Format.colorpalette: grayscale

Identifier: <http://archive.dstc.edu.au/RDU/SLQ/boag/20248.jpg>

Source: BOAG negative no. 906

Language: en

Relation.isPartOf: <http://www.slq.qld.gov.au/jol/boag.htm>

Relation.hasParts: Region1

Relation.hasFormat: <http://archive.dstc.edu.au/RDU/SLQ/boag/20248.gif>

Coverage: Beenleigh region, Queensland, 1872

Rights: <http://www.slq.qld.gov.au/cright.htm>

Secondary Level Metadata for Region1

Identifier: Region1

Title: Annie Dickson

Description: Wife of James Dickson and mother to their 13 children.

Coverage.rect: 495,207,546,263

Relation.isPartOf: <http://archive.dstc.edu.au/RDU/SLQ/boag/20248.jpg>


4. The "Peggie" Image Metadata Editor and Generator

The original idea behind the PNG Image Metadata Editor and Generator was to extend DSTC's Reggie application [[HREF14](#)], a metadata generator and editor for textual documents, to images. A key difference between the Reggie application and the "Peggie" application was the need for an integrated image display window. This enables the user to simultaneously view the image and input or edit the metadata descriptions.

Users can open existing GIF or JPEG images, enter the corresponding metadata and then save the image and metadata together as a PNG file. Alternatively, users can edit existing metadata by opening a previously saved PNG file. When a PNG file is opened, the image is displayed in the image panel and the embedded metadata is displayed in the neighbouring form fields. The input form is generated from an RDF schema which corresponds to the data model in Figure 1. The schema also constrains and validates the user input at *Save* time. Users can also define spatial regions within images and attach metadata to the specified region.

Figure 2 illustrates the user interface of the Peggie application.

Figure 2: Top-level Metadata Input Using the Peggie Application

File	View																																
																																	
<table border="1"> <thead> <tr> <th colspan="2">Image details</th> </tr> </thead> <tbody> <tr> <td>Title</td> <td>Native of Tana, New Hebrides Group [Now Vanuatu] Labourer from</td> </tr> <tr> <td>Creator</td> <td>(SCHEME=LCNAF) State Library of Queensland, Internet Services U</td> </tr> <tr> <td>Subject</td> <td>(SCHEME = LCSH) Photograph collection – Queensland</td> </tr> <tr> <td>Description</td> <td>Carte-de-viste print, stamped on reverse, Messrs Boag & Mills, Au</td> </tr> <tr> <td>Publisher</td> <td>State Library of Queensland</td> </tr> <tr> <td>Contributor</td> <td></td> </tr> <tr> <td>Date</td> <td>1997</td> </tr> <tr> <td>Type</td> <td>Image/photograph</td> </tr> <tr> <td>Format</td> <td>image/png</td> </tr> <tr> <td>Identifier</td> <td>(SCHEME=URI) http://www.slq.qld.gov.au/172000.png</td> </tr> <tr> <td>Source</td> <td>(SCHEME=URI) http://www.slq.qld.gov.au/plate102.htm </td> </tr> <tr> <td>Language</td> <td>(SCHEME=NISOZ39.53) Eng</td> </tr> <tr> <td>Relation</td> <td>(SCHEME=URI) http://www.slq.qld.gov.au/boagphot.htm</td> </tr> <tr> <td>Coverage</td> <td>Foulden Plantation, Mackay district, Queensland, ca. 1874</td> </tr> <tr> <td>Rights</td> <td>(SCHEME=URI) http://www.slq.qld.gov.au/cright.htm</td> </tr> </tbody> </table>		Image details		Title	Native of Tana, New Hebrides Group [Now Vanuatu] Labourer from	Creator	(SCHEME=LCNAF) State Library of Queensland, Internet Services U	Subject	(SCHEME = LCSH) Photograph collection – Queensland	Description	Carte-de-viste print, stamped on reverse, Messrs Boag & Mills, Au	Publisher	State Library of Queensland	Contributor		Date	1997	Type	Image/photograph	Format	image/png	Identifier	(SCHEME=URI) http://www.slq.qld.gov.au/172000.png	Source	(SCHEME=URI) http://www.slq.qld.gov.au/plate102.htm	Language	(SCHEME=NISOZ39.53) Eng	Relation	(SCHEME=URI) http://www.slq.qld.gov.au/boagphot.htm	Coverage	Foulden Plantation, Mackay district, Queensland, ca. 1874	Rights	(SCHEME=URI) http://www.slq.qld.gov.au/cright.htm
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5. The Search Engine

Existing Web-based image search and retrieval systems can be classified into four types:

1. Site-specific search interfaces which access a single or limited number of proprietary backend databases (sometimes via a Z39.50 interface) which represent the image archives from a small number of related organisations or institutions;
2. Large search engines such as Altavista, Infoseek and Lycos which index the ALT text inside IMG tags on Web pages;
3. Specialist image search engines like Scour.Net [[HREF15](#)], Image Surfer [[HREF16](#)] and ditto.com [[HREF17](#)] which have built up a very large image databases from crawling the web looking for image files and extracting keywords from the container web page. With each image they typically store a thumbnail image, the URL of the image file, the type of image (e.g. GIF, JPEG), number of search words matched, keywords used in indexing, URL of the web source, size of the image and the date on which it was last found.
4. Content-based Image Retrieval Systems such as Excalibur Visual RetrievalWare (EVRW)[[HREF18](#)] of Excalibur Technologies, Virage Image Search Engine(VISE) [[HREF19](#)] of Virage, Inc., Query By Image Content(QBIC) [[HREF20](#)] of IBM, VisualSEEK (VSEK)[[HREF21](#)] of Columbia University, and Multimedia Analysis and Retrieval System(MARS)[[HREF22](#)] of University of Illinois at Urbana-Champaign. These systems provide users with either query images or tools to generate queries based on features such as color histograms, color composition, texture, shape or structure and retrieval based on similarity matching.


DSTC's existing HotMeta Search Engine crawls over specified web sites, extracting and indexing metadata from embedded HTML Meta tags and saving it in a metadata repository. A simple extension has been made to HotMeta to enable searching for images. Whenever the search engine encounters a PNG image, it opens it, extracts the metadata (if it exists) and stores it in the indexed metadata repository.

The advantage of the HotMeta PNG image search engine over the image search engines described above is that

it makes detailed metadata, usually only available through site-specific proprietary database access, accessible to wide-scale search engines. This approach can provide much better metadata than is currently available via the ALT tag, to the large search engines.

An online demonstration of the HotMeta PNG version is available [[HREF23](#)]. Figures 3 and 4 below illustrate the Search Interface and Query Results from a simple search for the string 'selector'.

Figure 3: HotMeta Search Interface

Help Feedback 

Find : in :

Turn stemming on Return Results:

[Home](#) [Help](#) [View](#) [Edit](#) [Advanced Search](#) [Feedback](#)

Figure 4: Results of Search on string 'selector'

Search Results – 2 matches

- [1. A selector and his family, probably in the Beenleigh district, 1872](#)


Identifier <http://www.slq.qld.gov.au/plate35.htm>
Subject Photograph collection – Queensland
Description The difficulties faced by a family in the Queensland bush included poor roads, an unreliable mail service and dense, vine-matted scrub. For many years, a selector's staple diet was salted meat (salt horse) and pumpkins. For several months, a woman and her children might be alone in their stringy-bark hut while her husband went off to split shingles or to earn extra money on a cattle property. Then she was left to protect the crop against marauding birds, bandicoots and scrub pademelons (a small forest...
[More Information](#)
- [2. Mrs Robert Veivers near Nerang, 1872](#)


Identifier <http://www.slq.qld.gov.au/plate41.htm>
Subject Photograph collection – Queensland
Description Eliza Veivers had been born in Wicklow, Ireland in 1842. She came to Queensland on the sailing ship Shakamaxon and arrived in Brisbane in December 1859. She lived for a time at Jimboomba station before marrying Robert Veivers in Brisbane ca 1861. Two weeks after the marriage, the couple set out in a small sailing boat for their first home at Nerang. After Veivers' death, Eliza married Henry Smith, a local selector/farmer. In later life, she lived at Ejuncum, her residence on the Thompson Estate at South Brisbane, where she died on 18 September 1929 at the age of...
[More Information](#)

6. The Browse Interface

A browse interface was built which consists of a single web page containing the complete collection as PNG thumbnail images with embedded metadata [HREF24]. Simply clicking on a thumbnail PNG image, runs a cgi script which opens the image, extracts the metadata and dynamically generates a web page displaying the full-sized JPEG image with image maps (if specified) and the associated metadata information.

The advantages of this approach are two-fold:

1. If modifications need to be made to the web pages, then they need only be done once in the cgi-script, not to each and every static web page, corresponding to each image. Dynamically-generated web pages are a much more efficient, scalable approach for large image collections;
2. There is no need for the cgi-script to understand the protocol, query language or fields in the backend database since the metadata is not stored in a database.

Figure 5 is a screen dump of the browse interface for the Boag Photographic collection. Figure 6 shows the dynamically-generated full-size image and associated metadata which is displayed when the user clicks on the PNG thumbnail for Plate 103 of the collection. Plate 35 of the collection includes an example of a dynamically-generated image map.

Figure 5: Browse Interface for the William Boag Photographic Collection

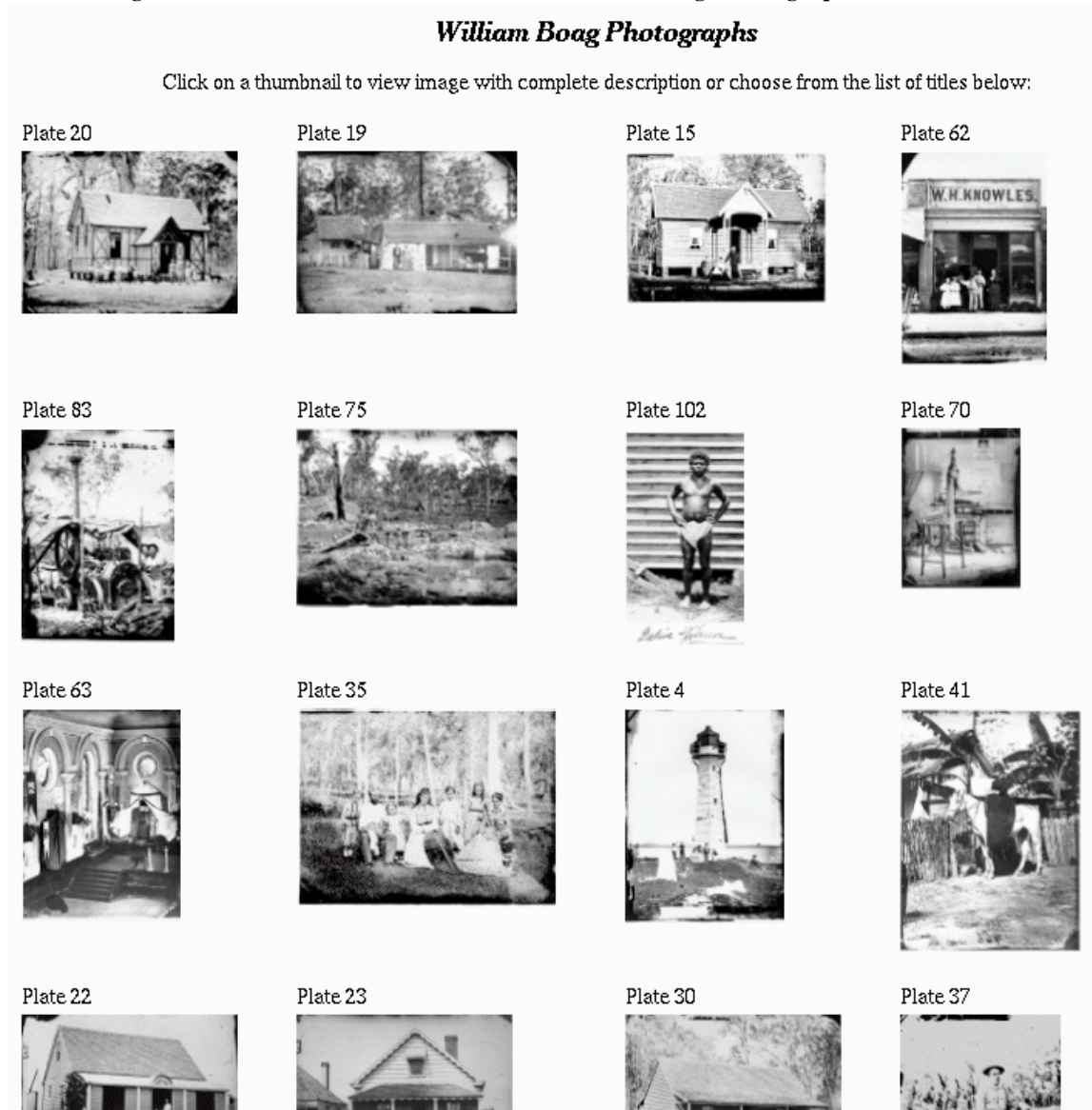


Figure 6: Dynamically-generated Web Page Corresponding to Plate 103

STATE LIBRARY OF QUEENSLAND

[John Oxley Library](#) - [Photograph Collection](#) - [Boag Collection](#)

'Albassoo - the Foulden housekeeper, native of Vanua Land'. Foulden Plantation, Mackay district, ca 1874.



Carte-de-visite print, stamped on reverse, 'Messrs Boag & Mills, Australian Photographic Company.

Copyright held by John Oxley Library [JOL Neg. No. 172009]. Copies of this photograph are available from the John Oxley Library's [photographic service](#).

7. Conclusions and Future Work

We have developed an application which can be used by image librarians to quickly and easily create and store standardized embedded metadata descriptions within their image collections to improve their discovery and retrieval over the WWW. These descriptions can be used by Dublin Core-based Internet search engines to increase the discovery of these images or to dynamically generate webpages displaying full-screen master images and their associated detailed metadata descriptions.

We have demonstrated the following advantages of embedded standardized metadata for the resource discovery of images:

- The application of Dublin-Core based search engines to image retrieval through a simple code extension;
- The advantages of the absence of back-end databases;
- The advantages of combining the image and its metadata within a single file;
- The advantages of generating the full-sized images and metadata dynamically via a cgi-script;

The major disadvantage of this approach is the difficulty associated with performing a batch modification of the metadata for a large collection of images. For example, if the address of the publisher of a large image collection were to change then it would be difficult to perform a blanket change across all of the images. Contrastingly, if the metadata was stored in a database, then this would be a relatively simple procedure.

Future Work includes:

- **Adding support for the JPEG2000 (DIG2000) image format (which includes support for extensive embedded metadata blocks) when the final specification becomes available [[HREF10](#)];**
- **Integrating this work within the Veggie Video Metadata Editor and Generator to enable metadata input and annotation of individual video frames;**

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