Inside Acropolis

A guide to the Research & Education Space for contributors and developers

October 2014 Edition

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Preface

> This book is *deliberately* incomplete. It's an evolving document, licensed under the terms of the *Open Government Licence, v2.0*, and to which we are welcoming contributions. You can fork the repository on GitHub, or e-mail the editor directly if you would like to contribute or have suggestions for changes.

The *Research & Education Space* (RES) is a project being jointly delivered by Jisc, the British Universities Film & Video Council (BUFVC), and the BBC. Its aim is to bring as much as possible of the UK's publicly-held archives, and more besides, to learners and teachers across the UK.

At the heart of RES is *Acropolis*, a technical platform which will collect, index and organise rich structured data about those archive collections published as *Linked Open Data* (LOD) on the Web. The collected data is organised around the people, places, events, concepts and things related to the items in the archive collections—and, if the archive assets themselves are available in digital form, that data includes the information on how to access them, all in a consistent machine-readable form.

Building on the Acropolis platform, applications can make use of this index, along with the source data itself, in order to make those collections accessible and meaningful.

This book describes how a collection-holder can publish their data in a form which can be collected and indexed by Acropolis and used by applications, and how an application developer can make use of the index and interpret the source data in order to present it to end-users in a useful fashion.

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1 An introduction to the Acropolis platform

The Acropolis platform is made of up three main components: a specialised web crawler, *Anansi*, an *aggregator*, *Spindle*, and a public API layer, *Quilt*.

Anansi's role is to crawl the web, retrieving permissively-licensed Linked Open Data, and passing it to the aggregator for processing.

Spindle examines the data, looking for instances where the same digital, physical or conceptual entity is described in more than one place, primarily where the data explicitly states the equivalence, and aggregates and stores that information in an index.

This *subject-oriented* index is the very heart of RES: by re-arranging published data so that it's organised around the entities described by it, instead of by publisher or data-set, applications are able to rapidly locate all of the information known about a particular entity because it's collected together in one place.

Quilt is responsible for making the index available to applications, also by publishing it as Linked Open Data. Because RES maintains an *index*, rather than a complete copy of all data that it finds, applications must consume data both from the RES index and from the original data sources—and consequentially Quilt itself also conforms to the publishing recommendations in this book.

The RES project will not be directly developing end-user applications, although sample code and demonstrations will be published to assist software developers in doing so. RES only indexes and publishes data released under terms which permit re-use in both commercial and non-commercial settings.

For RES to be most useful, holders of publicly-funded archive collections across the UK need to publish Linked Open Data describing their collections (including digital assets, where they exist). Although many collections are already doing so or plan to, the RES project partners will be providing tools and advice to collection-holders in order to assist them throughout the lifetime of the project.

2 Linked Open Data: What is it, and how does it work?

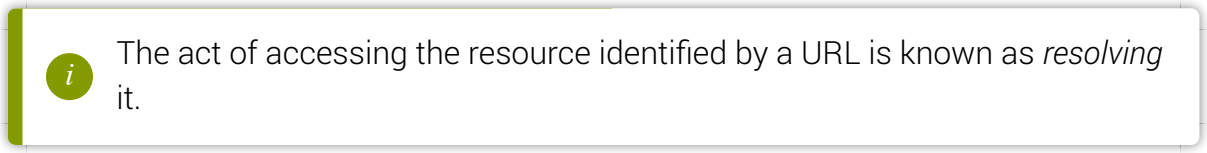
Linked Open Data is a mechanism for publishing structured data on the Web about virtually anything, in a form which can be consistently retrieved and processed by software. The result is a world wide web of data which works in parallel to the web of documents our browsers usually access, transparently using the same protocols and infrastructure.

Where the ordinary web of documents is a means of publishing a page about something intended for a human being to understand, this web of data is a means of publishing data about those things.

2.1 Web addresses, URLs and URIs

Uniform Resource Locators (URLs), often known as *Web addresses*, are a way of unambiguously identifying something which is published electronically. Although there are a variety of kinds of URL, most that you day-to-day see begin with `http` or `https`: this is known as the *scheme*, and defines how the rest of the URL is structured—although most kinds of URL follow a common structure.

The scheme also indicates the communications protocol which should be used to access the resource identified by the URL: if it's `http`, then the resource is accessible using HTTP—the protocol used by web servers and browsers; if it's `https`, then it's accessible using secure HTTP (i.e., HTTP with added encryption).



The act of accessing the resource identified by a URL is known as *resolving* it.

Following the scheme in a URL is the *authority*—the domain name of the web site: it's called the authority because it identifies the entity responsible for defining the meaning and structure of the remainder of the URL. If the URL begins with `http://www.bbc.co.uk/`, you know that it's defined and managed by the BBC; if it begins with `http://www.bfi.org.uk/`, you know that it's managed by the BFI, and so on.

After the authority is an optional *path* (i.e., the location of the document within the context of the particular domain name or authority), and optional *query parameters* (beginning with a question-mark), and *fragment* (beginning with a hash-mark).

URLs serve a dual purpose: not only do they provide a name for something, but they also provide anything which understands them with the information they need to retrieve it. Provided your application is able to speak the HTTP protocol, it should in principle be able to retrieve anything using a `http` URL.

Universal Resource Indicators (URIs) are a superset of URLs, and are in effect a kind of *universal identifier*: their purpose is to name something, without *necessarily* indicating how to retrieve it. In fact, it may be that the thing named using a URI cannot possibly be retrieved using a piece of software and an Internet connection because it refers to an abstract concept or a physical object.

> *i* In other words, while URLs are used specifically to identify digital resources which can be retrieved from a Web server, URIs can be used to identify anything: the URLs we use in our browsers are all URIs, but not all URIs are URLs.

URIs follow the same structure as URLs, in that there is a scheme defining how the remainder is structured, and usually some kind of authority, but there are many different schemes, and many of them do not have any particular mechanism defined for how you might retrieve something named using that scheme.

For example, the `tag:` URI scheme provides a means for anybody to define a name for something in the form of a URI, using a domain name that they control as an authority, but without indicating any particular semantics about the thing being named.

Meanwhile, URIs which begin with `urn:` are actually part of one of a number of *sub-schemes*, many of which exist as a means of writing down some existing identifier about something in the form of a URI. For example, an ISBN can be written as a URI by prefixing it with `urn:isbn:` (for example, `urn:isbn:9781899066100`).

You might be forgiven for wondering why somebody might want to write an ISBN in the form of a URI, but in fact there are a few reasons. In most systems, ISBNs are effectively opaque alphanumeric strings: although there is usually some validation of the check digit upon data entry, once stored in a database, they are rarely interrogated for any particular meaning. Given this, ISBNs work perfectly well for identifying books for which ISBNs have been issued—but what if you want to store data about other kinds of things, too? Recognising that this was a particular need for retailers, a few years ago ISBNs were made into a subset of *Global Trade Information Numbers* (GTINs), the system used for barcoding products sold in shops.

By unifying ISBNs and GTINs, retailers were able to use the same field in their database systems for any type of product being sold, whether it was a book with an ISBN, or some other kind of product with a GTIN. All the while, the identifier remained essentially opaque: provided the string of digits and letters scanned by the bar-code reader could be matched to a row in a database, it doesn't matter precisely what those letters and numbers actually are.

Representing identifiers in the form of URIs can be thought of as another level of generalisation: it allows the development of systems where the underlying database doesn't need to know nor care about the *kind* of identifier being stored, and so can store information about absolutely anything which can be identified by a URI. In many cases, this doesn't represent a huge technological shift—those database systems already pay little attention to the structure of the identifier itself.

Hand-in-hand with this generalisation effect is the ability to disambiguate and harmonise without needing to coordinate a variety of different standards bodies across the world. Whereas the integration of ISBNs and GTINs took a particular concerted effort in order to achieve, the integration of ISBNs and URNs was only a matter of defining the URN scheme, because URIs are already designed to be open-ended and extensible.

Linked Open Data URIs are a subset of URIs which, again, begin with `http:` or `https:`, but do not necessarily name something which can be retrieved from a web server. Instead, they are URIs where performing resolution results in machine-readable data *about* the entity being identified.

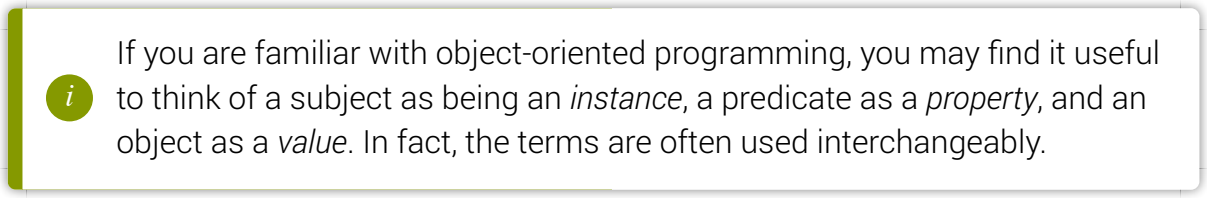
In summary:

Term	Used for…
URLs	Identifying digital resources and specifying where they can be retrieved from
URIs	Identifying *anything*, regardless of whether it can be retrieved electronically or not
Linked Open Data URIs	Identifying anything, but in a way which means that *descriptive metadata* can be retrieved when the URI is resolved

2.2 Describing things with triples

Linked Open Data uses the *Resource Description Framework* (RDF) to convey information about things. RDF is an open-ended system for modelling information about things, which it does by breaking it down into statements (or *assertions*), each of which consists of a *subject*, a *predicate* and an *object*.

The subject is the thing being described; the predicate is the aspect or attribute of the subject being described; and the object is the description of that particular attribute.



For example, you might want to state that the book with the ISBN 978-1899066100 has the title *Acronyms and Synonyms in Medical Imaging*. You can break this assertion down into its subject, predicate, and object:

Subject	Predicate	Object
ISBN 978-1899066100	Has the title	*Acronyms and Synonyms in Medical Imaging*

Together, this statement made up of a subject, predicate and object is called a *triple* (because there are three components to it), while a collection of statements is called a *graph*.

In RDF, the subject and the predicate are expressed as URIs this helps to remove ambiguity and the risk of clashes so that the data can be published and consumed in the same way regardless of where it comes from or who's processing it. Objects *can* be expressed as URIs where you want to assert some kind of reference to something else, but can also be *literals* (such as text, numeric values, dates, and so on).

2.3 Predicates and vocabularies

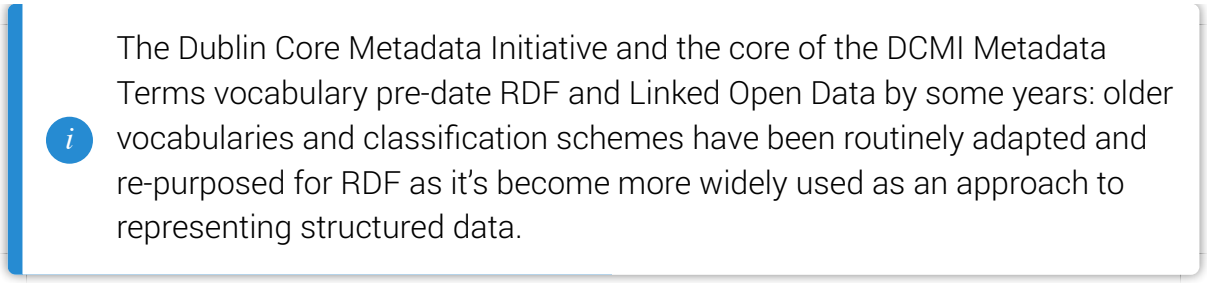
RDF doesn't specify the meaning of most predicates itself: in other words, RDF doesn't tell you what URI you should use to indicate "has the title". Instead, because anybody can create a URI, it's entirely up to you whether you invent your own vocabulary when you publish your data, or adopt somebody else's. Generally, of course, if you want other people to be able to understand your data, it's probably a good idea to adopt existing vocabularies where they exist.

In essence, RDF provides the grammar, while community consensus provides the dictionary.

One of the most commonly-used general-purpose vocabularies is the DCMI Metadata Terms, managed by the Dublin Core Metadata Initiative (DCMI), and which includes a suitable title predicate:

Subject	Predicate	Object
ISBN 978-1899066100	`http://purl.org/dc/terms/title`	*Acronyms and Synonyms in Medical Imaging*

With this triple, a consuming application that understands the DCMI Metadata Terms vocabulary can process that data and understand the predicate to indicate that the item has the title *Acronyms and Synonyms in Medical Imaging*.

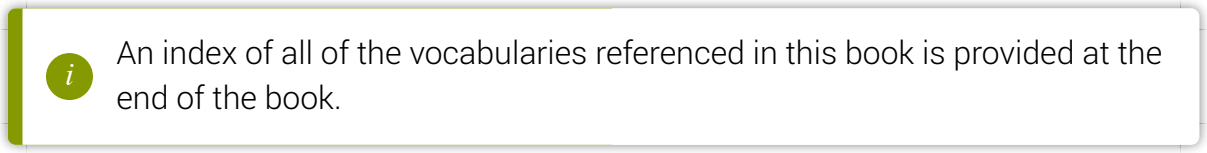


Because `http://purl.org/dc/terms/title` is quite long-winded, it's common to write predicate URIs in a compressed form, consisting of a namespace prefix and local name—similar to the `xmlns` mechanism used in XML documents.

Because people will often use the same prefix to refer to the same namespace URI, it is not unusual to see this short form of URIs used in books and web pages. Some common prefixes and namespace URIs are shown below:

Vocabulary	Namespace URI	Often abbreviated as
RDF Syntax	`http://www.w3.org/1999/02/22-rdf-syntax-ns#`	`rdf:`
RDF Schema	`http://www.w3.org/2000/01/rdf-schema#`	`rdfs:`
DCMI Metadata Terms	`http://purl.org/dc/terms/`	`dct:`
FOAF	`http://xmlns.com/foaf/0.1/`	`foaf:`
Vocabulary of Interlinked Datasets (VoID)	`http://rdfs.org/ns/void#`	`void:`

For example, defining the namespace prefix `dct` with a namespace URI of `http://purl.org/dc/terms/`, we can write our predicate as `dct:title` instead of `http://purl.org/dc/terms/title`. RDF systems re-compose the complete URI by concatenating the prefix URI and the local name.



2.4 Subject URIs

In RDF, subjects are also URIs. While in RDF itself there are no particular restrictions upon the kind of URIs you can use (and there are a great many different kinds — those beginning `http:` and `https:` that you see on the Web are just two of hundreds), Linked Open Data places some restrictions on subject URIs in order to function. These are:

1. Subject URIs must begin with `http:` or `https:`.

2. They must be unique: although you can have multiple URIs for the same thing, one URI can't refer to multiple distinct things at once.
3. If a Linked Open Data consumer makes an HTTP request for the subject URI, the server should send back RDF data describing that subject.
4. As with URLs, subject URIs need to be persistent: that is, they should change as little as possible, and where they do change, you need to be able to make arrangements for requests for the old URI to be forwarded to the new one.

In practice, this means that when you decide upon a subject URI, it needs to be within a domain name that you control and can operate a web server for; you need to have a scheme for your subject URIs which distinguishes between things which are represented digitally (and so have ordinary URLs) and things which cannot; you also need to arrange for your web server to actually serve RDF when it's requested; and finally you need to decide a form for your subject URIs which minimises changes.

This may sound daunting, but it can be quite straightforward—and shares much in common with deciding upon a URL structure for a website that is intended only for ordinary browsers.

For example, if you are the *Intergalactic Alliance Library & Museum*, whose domain name is `ialm.int`, you might decide that all of your books' URIs will begin with `http://ialm.int/books/`, and use the full 13-digit ISBN, without dashes, as the key. You could pick something other than the ISBN, such as an identifier meaningful only to your own internal systems, but it makes developers' lives easier if you incorporate well-known identifiers where it's not problematic to do so.

Because this web of data co-exists with the web of documents, begin by defining the URL to the *document* about this book:

```
http://ialm.int/books/9781899066100
```

Anybody visiting that URL in their browser will be provided with information about the book in your collection. Because the URL incorporates a well-known identifier, the ISBN, if any other pieces of information about the book change or are corrected, that URL remains stable. As a bonus, incorporating the ISBN means that the URL to the document is predictable.

> *i* Of course, the ISBN may have been entered incorrectly (or may be cancelled by the registration authority), and it would be worth planning for that eventuality—but assuming that your collection website's data is based upon information that is used operationally day-to-day, the risk of that needing to occur is kept to a minimum.

Having defined the URL for book pages, it's now time to define the rest of the structure. The Intergalactic Alliance Library & Museum web server will be configured to serve web pages to web browsers, and RDF data to RDF consumers: that is, there are multiple representations of the same data. It's useful, from time to time, to be able to refer to each of these representations with a distinct URL. Let's say, then, that we'll use the general form:

```
http://ialm.int/books/9781899066100.EXT
```

In this case, `EXT` refers to the well-known *filename extension* for the particular type of representation we're referring to.

> *i* Media types (sometimes also called MIME types or content types) are registered with the Internet Assigned Numbers Authority (IANA). The registration document includes the preferred or commonly-used filename extensions for that type. For example, the registration document for HTML can be found on the IANA website.

Therefore, the HTML web page for our book will have the *representation-specific* URL of:

```
http://ialm.int/books/9781899066100.html
```

If you also published CSV data for your book, it could be given the representation-specific URL of:

```
http://ialm.int/books/9781899066100.csv
```

RDF can be expressed in a number of different forms, or serialisations. The most commonly-used serialisation is called *Turtle*, and typically has the filename extension of `ttl`. Therefore our Turtle serialisation would have the representation-specific URL of:

```
http://ialm.int/books/9781899066100.ttl
```

Now that we have defined the structure of our URLs, we can define the pattern used for the subject URIs themselves. Remember that the URI needs to be *dereferenceable*—that is, when a consuming application makes a request for it, the server can respond with the appropriate representation.

In order to do this, there are two options: we can use a special kind of redirect, or we can use fragments. The fragment approach works best where you have a document for each individual item, as we do here, and takes advantage of the fact that in the HTTP protocol, any part of a URL following the "#" symbol is never sent to the server.

Thus, let's say that we'll distinguish our URLs from our subject URIs by suffixing the subject URIs with `#id`. The URI for our book therefore becomes:

```
http://ialm.int/books/9781899066100#id
```

When an application requests the information about this book, by the time it arrives at our web server, it's been turned into a request for the very first URL we defined—the generic "document about this book" URL:

```
http://ialm.int/books/9781899066100
```

> *i* The reason the "fragment" portion of the URI is stripped off the request by the time it arrives at the web server is because the HTTP protocol states that fragments are never sent *over the wire*—that is, they are not included in the protocol exchange between the client and the server. Their original use was to identify a section within a web page and allow a browser to skip straight to it even though it requested and was served the whole page. Fragments in *URLs* are regularly used for this purpose today.

When an application understands RDF and tells the server as much as part of the request, the server can send back the Turtle representation instead of an HTML web page —a part of the HTTP protocol known as *content negotiation*. Content negotiation allows a server to pick the most appropriate representation for something (where it has multiple representations), based upon the client's preferences.

With our subject URI pattern defined, we can revisit our original assertion:

Subject	Predicate	Object
`http://ialm.int/books/9781899066100#id`	`dct:title`	*Acronyms and Synonyms in Medical Imaging*

2.5 Defining what something is: classes

One of the few parts of the common vocabulary which is defined by RDF itself is the predicate `rdf:type`, which specifies the class (or classes) of a subject. Like predicates, classes are defined by vocabularies, and are also expressed as URIs. The classes of a subject are intended to convey what that subject *is*.

For example, the Bibliographic Ontology, whose namespace URI is `http://purl.org/ontology/bibo/` (commonly prefixed as `bibo:`) defines a class named `bibo:Book` (whose full URI we can deduce as being `http://purl.org/ontology/bibo/Book`).

If we write a triple which asserts that our book is a `bibo:Book`, any consumers which understand the Bibliographic Ontology can interpret our data as referring to a book:

Subject	Predicate	Object
`http://ialm.int/books/9781899066100#id`	`rdf:type`	`bibo:Book`
		Acronyms and Synonyms in Medical

http://ialm.int/books/9781899066100#id	dct:title	*Imaging*

2.6 Describing things defined by other people

There is no technical reason why your subject URIs must *only* be URIs that you control directly. In Linked Open Data, the matter of *trust* is a matter for the data consumer: one application might have a white-list of trusted sources, another might have a black-list of sources known to be problematic, another might have more complex heuristics, while another might use your social network such that assertions from your friends are considered more likely to be trustworthy than those from other people.

Describing subjects defined by other people has a practical purpose. Predicates work in a particular direction, and although sometimes vocabularies will define pairs of predicates so that you can make a statement either way around, interpreting this begins to get complicated, and so most vocabularies define predicates only in one direction.

As an example, you might wish to state that a book held in a library is about a subject that you're describing. On a web page, you'd simply write this down and link to it—perhaps as part of a "Useful resources" section. In Linked Open Data, you can make the assertion that one of the subjects of the other library's book is the one you're describing. This works exactly the same way as if you were describing something that you'd defined yourself—you simply write the statement, but somebody else's URI as the subject.

This can also be used to make life easier for developers and reduce network overhead of applications. In your "Useful resources" section, you probably wouldn't only list the URL to the page about the book: instead, you'd list the title and perhaps the author *as well* as linking to the page about the book. You can do that in Linked Open Data, too. Let's say that we're expressing the data about a subject—Roman Gaul—which we've assigned a URI of `http://ialm.int/things/2068003#id`:

Subject	Predicate	Object
http://ialm.int/things/2068003#id	dct:title	*Roman Gaul*
http://bnb.data.bl.uk/id/resource/006889069	rdf:type	bibo:Book
http://bnb.data.bl.uk/id/resource/006889069	dct:title	*Asterix the Gaul*
http://bnb.data.bl.uk/id/resource/006889069	dct:subject	http://ialm.int/things/2068003#id

In this example we've defined a subject, called *Roman Gaul*, of which we've provided very little detail, except to say that it's a subject of the book *Asterix the Gaul*, whose identifier is defined by the British Library.

Note that we haven't described the book *Asterix the Gaul* in full: RDF operates on an *open world principle*, which means that sets of assertions are generally interpreted as being incomplete—or rather, only as complete as they need to be. The fact that we haven't specified an author or publisher of the book doesn't mean there isn't one, just that the data isn't present here; where in RDF you need to state explicitly that something doesn't exist, there is usually a particular way to do that.

2.7 Turtle: the terse triple language

Turtle is one of the most common languages for writing RDF in use today—although there are many others. Turtle is intended to be interpreted and generated by machines first and foremost, but also be readable and writeable by human beings (albeit usually software developers).

In its simplest form, we can just write out our statements, one by one, each separated by a full stop. URIs are written between angle-brackets (`<` and `>`), while *string literals* (such as the names of things) are written between double-quotation marks (`"`).

```
<http://ialm.int/books/9781899066100#id> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://purl.org/ontology/bibo/Book> .

<http://ialm.int/books/9781899066100#id> <http://purl.org/dc/terms/title> "Acronyms and Synonyms in
Medical Imaging" .
```

This is quite long-winded, but fortunately Turtle allows us to define and use prefixes just as we have in this book. When we write the short form of a URI, it's *not* written between angle-brackets:

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix bibo: <http://purl.org/ontology/bibo/> .

<http://ialm.int/books/9781899066100#id> rdf:type bibo:Book .

<http://ialm.int/books/9781899066100#id> dct:title "Acronyms and Synonyms in Medical Imaging" .
```

Because Turtle is designed for RDF, and `rdf:type` is defined by RDF itself, Turtle provides a nice shorthand for the predicate: `a`. We can simply say that our book is `a bibo:Book`:

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix bibo: <http://purl.org/ontology/bibo/> .

<http://ialm.int/books/9781899066100#id> a bibo:Book .

<http://ialm.int/books/9781899066100#id> dct:title "Acronyms and Synonyms in Medical Imaging" .
```

Writing the triples out this way quickly gets repetitive: you don't want to be writing the subject URI every time, especially not if writing Turtle by hand. If you end a statement with a semi-colon instead of a full-stop, it indicates that what follows is another predicate and object about the same subject:

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix bibo: <http://purl.org/ontology/bibo/> .

<http://ialm.int/books/9781899066100#id>
        a bibo:Book ;
        dct:title "Acronyms and Synonyms in Medical Imaging" .
```

> *i* If you end a statement with a comma instead of a semi-colon or full-stop, it means that what follows is another object with the same subject and predicate—in other words, it's a quick way of writing multiple values.

Turtle includes a number of capabilities which we haven't yet discussed here, but are important for fully understanding real-world RDF in general and Turtle documents in particular. These include:

Typed literals

Typed literals: literals which aren't simply strings of text, but can be of any one of the XML Schema data types.

Literal types are indicated by writing the literal value, followed by two carets, and then the datatype URI: for example, `"2013-01-26"^^xsd:date`.

Blank nodes

Blank nodes are entities for which some information is provided, but where the subject URI is not known. There are two different ways of using blank nodes in Turtle: a blank node *value* is one where in place of a URI or a literal value, an entity is partially described.

Another way of using blank nodes is to assign it a private, transient identifier (a blank node identifier), and then use that identifier where you'd normally use a URI as a subject or object. The transient identifier has no meaning outside of the context of the document: it's simply a way of referring to the same (essentially anonymous) entity in multiple places within the document.

A blank node value is expressed by writing an opening square bracket, followed by the sets of predicates and values for the blank node, followed by a closing square bracket. For example, we can state that an author of the book is a nondescript entity who we know is a person named `Nicola Strickland`, but for whom we don't have an identifier:

```
<http://ialm.int/books/9781899066100#id> dct:creator [
        a foaf:Person ;
        foaf:name "Nicola Strickland"
] .
```

Blank node identifiers are written similarly to the compressed form of URIs, except that an underscore is used as the prefix. For example, `_:johnsmith`. You don't have to do anything special to create a blank node identifier (simply use it), and the actual name you assign has no meaning outside of the context of the document—if you replace all instances of `_:johnsmith` with `_:zebra`, the actual meaning of the document is unchanged —although it may be slightly more confusing to read and write as a human.

Multi-lingual string literals

String literals in the examples given so far are written in no particular language (which may be appropriate in some cases, particularly when expressing people's names).

The language used for a string literal is indicated by writing the literal value, followed by an at-sign, and then the ISO 639-1 language code, or an ISO 639-1 language code, followed by a hyphen, and a ISO 3166-1 alpha-2 country code.

For example: `"Intergalatic Alliance Library & Museum Homepage"@en`, or `"grey"@en-gb`.

Base URIs

By default, the base URI for the terms in a Turtle document is the URI it's being served from. Occasionally, it can be useful to specify an alternative base URI. To do this, an `@base` statement can be included (in a similar fashion to `@prefix`).

For example, if a document specifies `@base <http://www.example.com/things/> .`, then the URI `<12447652#id>` within that document can be expanded to `<http://www.example.com/things/12447652#id>`, while the URI `</artefacts/47fb01>` would be expanded to `<http://www.example.com/artefacts/47fb01>`.

For further information on RDF's capabilities and Turtle, be sure to read through the RDF Primer and the Turtle specification.

An example of a Turtle document making use of some of these capabilities is shown below:

```
@base <http://ialm.int/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix bibo: <http://purl.org/ontology/bibo/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

</books/9781899066100#id>
        a bibo:Book ;
        dct:title "Acronyms and Synonyms in Medical Imaging"@en ;
        dct:issued "1997"^^xsd:gYear ;
        dct:creator _:allison, _:strickland ;
        dct:publisher [
                a foaf:Organization ;
                foaf:name "CRC Press"
        ] .

_:strickland
        a foaf:Person ;
        foaf:name "Nicola Strickland" .

_:allison
        a foaf:Person ;
        foaf:name "David J. Allison" .
```

In this example, we are still describing our book, but we specify that the title is in English (though don't indicate any particular national variant of English); we state that it was issued (published) in the year 1997, and that it's publisher—for whom we don't have an identifier—is an organisation whose name is *CRC Press*.

2.8 From three to four: relaying provenance with quads

While triples are a perfectly servicable mechanism for describing something, they don't have the ability to tell you where data is *from* (unless you impose a restriction that you only deal with data where the domain of the subject URI matches that of the server you're retrieving from). In some systems, including Acropolis, this limitation is overcome by introducing another element: a graph URI, identifying the *source* of a triple. Thus, instead of triples, RES actually stores *quads*.

When we assign an explicit URI to a graph in this way, it becomes known as a *named graph*—that is, a graph with an explicit identifier (name) assigned to it.

Turtle itself doesn't have a concept of named graphs, but there is an extension to Turtle, named TriG, which includes the capability to specify the URI of a named graph containing a particular set of triples.

> *i* While Quilt will serve RDF/XML and Turtle when requested, it will also serve TriG: this allows applications to determine the provenance of statements stored in the RES index, allowing them to white– or black-list data sources if needed.

2.9 Why does RES use RDF?

RDF isn't necessarily the simplest way of expressing some data about something, and that means it's often not the first choice for publishers and consumers. Often, an application consuming some data is designed specifically for one particular dataset, and so its interactions are essentially bespoke and comparatively easy to define.

RES, by nature, brings together a large number of different structured datasets, describing lots of different kinds of things, with a need for a wide range of applications to be able to work with those sets in a consistent fashion.

At the time of writing (ten years after its introduction), RDF's use of URIs as identifiers, common vocabularies and data types, inherent flexibility and well-defined structure means that is the only option for achieving this.

Whether you're describing an audio clip or the year 1987, a printed book or the concept of a documentary film, RDF provides the ability to express the data you hold in intricate detail, without being beholden to a single central authority to validate the modelling work undertaken by experts in your field.

For application developers, the separation of grammar and vocabularies means that applications can interpret data in as much or as little detail as is useful for the end-users. For instance, you might develop an application which understands a small set of general-purpose metadata terms but which can be used with virtually everything surfaced through RES.

Alternatively, you might develop a specialist application which interprets rich descriptions in a particular domain in order to target specific use-cases. In either case, you don't need to know who the data comes from, only sufficient understanding of the vocabularies in use to satisfy your needs.

However, because we recognise that publishing and consuming Linked Open Data as an individual publisher or application developer may be unfamiliar territory, and so throughout the lifetime of the project we are committed to publishing documentation, developing tools and operating workshops in order to help developers and publishers work with RDF in general and RES in particular more easily.

3 The RES API: the index and how it's structured

> *i* Because the API is read-only and exposed through HTTP Content Negotiation, there are no API keys or other authentication mechanisms: applications can begin using the API immediately by consuming it as Linked Open Data.

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
OpenSearch	`http://a9.com/-/spec/opensearch/1.1/`	`osd:`
OWL	`http://www.w3.org/2002/07/owl#`	`owl:`
RDF schema	`http://www.w3.org/2000/01/rdf-schema#`	`rdfs:`
RDF syntax	`http://www.w3.org/1999/02/22-rdf-syntax-ns#`	`rdf:`
VoiD	`http://rdfs.org/ns/void#`	`void:`
XHTML Vocabulary	`http://www.w3.org/1999/xhtml/vocab#`	`xhtml:`

At the core of the platform is the *RES index*. This index is available as web pages (to make it easier for application developers to see what's there and how it works), but is primarily published as Linked Open Data. Accessing the index and requesting machine-readable data is the RES platform API.

The RES index takes the form of a `void:Dataset`, and the operations that you might perform against the RES index will often be applicable to other datasets that you might encounter.

Depending upon your application design, it may be desirable to offer the same browse and query capabilities to any dataset that the user navigates to, rather than hard-coding behaviour specific to the RES index.

3.1 Discovering capabilities

As the index is presented as Linked Open Data, discovering information about it is the same process used for obtaining descriptive metadata for anything else: de-reference the entity URI (which in the case of the index is the API root—currently `http://beta.acropolis.org.uk/`), and examine the triples whose subject is that URI.

Capability	Expressed using…

Class partitions (e.g., “all people”, “all places”)	`void:classPartition`
Browse endpoint for everything in the index	`void:rootResource`
Locate an entry from an external URI	`void:uriLookupEndpoint`
Free-form search (complete description document)	`void:openSearchDescription`
Free-form search URL template	`osd:template`
Links to entities contained within the index	`rdfs:seeAlso`
References to original source data about an entity in the index	`owl:sameAs`
Links to first, last, previous and next pages of results	`xhtml:first`, `xhtml:last`, `xhtml:prev`, `xhtml:next`

3.2 Structure of the index

The RES index is made up of a series of *composite* entities which are constructed using the data discovered by the crawler. Each of the composite entities has an `owl:sameAs` relationship with the various source entities used to construct it, a portion of whose data is cached in the index.

If you dereference the URI for the RES index, the result is some metadata about the index itself, including information about how to perform different kinds of query, the different browseable partitions, and some selected sample entities.

When a query is performed against the index (i.e., by adding some query parameters to the URI), the result is a small amount of metadata about the query and the results along with a list of these composite entities.

If you then dereference one of these entities—*drilling down* into it—the document returned will contain both the composite entity, and the cached data about the source entities. If the entity references, or is referenced by other entities, the relevant composite entities are also included.

> *i* An index of the predicates which are used to generate the composite entities and cached alongside them can be found at the end of the book.

3.3 Common API operations

Below is a list of some of the most common kinds of operation an application might wish to perform against the RES index. Note that these operations can apply to *any* dataset.

Operation	Implementation
Determine the	

kind of entity that retrieved data describes	Examine the `rdf:type` properties and compare against the class index.
Locate class partitions	Iterate the `void:classPartition` properties of the index
Find the index entry for a particular entity	Append the encoded entity URI to the value of the `void:uriLookupEndpoint` property
Perform a text query	Populate the template specified in the `osd:template` property (if present), or alternatively the template specified in the `<Url>` element corresponding to the desired data format in the OpenSearch Description document linked via the `void:openSearchDescription` property
Locate the source data for an entity	Once the data for an entity has been retrieved, find the `owl:sameAs` triples which have the entity URI as either the subject or the object
List the items in the dataset or a partition	Retrieve the data either from the URL in the `void:rootResource` property, from one of the `void:classPartition` properties, or a query, then locate all of the `rdfs:seeAlso` properties which have that URL as a subject.
Paginate through a dataset or query results	Follow the `xhtml:prev` and `xhtml:next` properties where available

4 Requirements for consuming applications

Applications built for RES must be able to understand the index assembled by Acropolis, as well as the source data it refers to. Practically, it means that they must be able to retrieve and process RDF from remote web servers and interpret at least the common metadata vocabularies described in this book which are relevant to the consuming application.

4.1 Retrieving and processing Linked Open Data

> *i* Although it's useful to understand the mechanics of consuming Linked Open Data if you are developing applications for it, consumer libraries may exist for your preferred platform and programming language already. A list of some of these is included in an appendix at the end of this book.

In a perfect world, consuming Linked Open Data is as straightforward as:—

- Make a request for the URI you want to get data about, sending an `Accept` HTTP request header containing the MIME types of the formats you support in your application.
- Parse the data in the response using an RDF parser.
- Examine the parsed data to find triples whose subject is the URI that you started with.

While this process is simple, and could be implemented using virtually any HTTP client in common use today, it brings about a few questions. How do you deal with redirects? What happens if the server doesn't return the data in the format that you asked for? Where do you *start*?

This chapter aims to answer all of these questions so that your RES application can be both useful and robust in face of real-world challenges.

4.1.1 Consuming Linked Open Data in detail

As part of the RES project, we are developing a Linked Open Data client library. Although at present this library is currently only available to low-level languages such as C and C++, the process it follows can be implemented in any language. It is intended to be a liberal consumer which can deal with real situations, such as different kinds of redirects and content negotiation failing or being disabled by the publisher.

The algorithm is as follows (implemented in the LOD library in `fetch.c`):—

1. Optionally, check if data about the *request-URI* is present in our RDF model: if so, return a reference to it.
2. Append *request-URI* to *subject-list*.
3. If *request-URI* has a fragment, remove it and store it as *fragment*.

4. Set *followed-link* to `false`, and *count* to 0.
5. If *count* is more than our configured *max-redirects* value, return an error status indicating that the redirect limit has been exceeded.
6. Create an HTTP request for *request-URI*, setting the `Accept` header based upon the data formats supported by the application. Note that RES requires publishers and applications to support at *least* RDF/XML (`application/rdf+xml`) and Turtle (`text/turtle`), but both clients and servers may support other formats which can be negotiated.
7. Perform the HTTP request. Note that this should be a single request-response pair, and not automatically follow redirects.
8. If a low-level error in performing the request occurred (such as the hostname in the URI not being resolveable), return an error status indicating that the request could not be performed.
9. Store the canonicalised form of *request-URI* as the *base*.
10. Obtain the `Content-Type` of the response, if any, and store it in *content-type*.
11. If the HTTP status code is between 200 and 299 and there is a document body:—
    a. If *content-type* is not set, return an error status indicating that no suitable data could be found.

       If the `Content-Type` is not one of `text/html`, `application/xhtml+xml`, `application/vnd.wap.xhtml+xml`, `application/vnd.ctv.xhtml+xml` or `application/vnd.hbbtv.xhtml+xml`, then skip to step 14.
    b. If *followed-link* is true, return an error status indicating that a `<link rel="alternate">` has already been followed.
    c. Parse the returned document as HTML, and extract any `<link>` elements within `<head>` which have a `type` and `href` attributes and a `rel` attribute with a value of `alternate`.
    d. If no suitable `<link>` elements were found, return an error status indicating that no suitable data could be found.
    e. Rank the returned links based upon the application's weighting values (allowing an application to consume a particular serialisation if available in preference to others).
    f. Append the highest ranked link's URI (that is, the value of the `href` attribute) to *subject-list*, set *request-URI* to it, set *followed-link* to `true`, increment *count*, and skip back to step 5.
12. If the HTTP status code is between 300 and 399:—
    a. Set *target-URI* to the redirect target (the `Location` header of the HTTP response). If no target is available, return with an error status indicating that an unsuitable HTTP status was returned.
    b. If the HTTP status code is 303, set *request-URI* to *target-URI*, increment *count* and skip back to step 5.
    c. If *fragment* is set, append it to *target-URI*, replacing any fragment which might be present already.
    d. Push *target-URI* onto *subject-list*, increment *count*, and skip back to step 5.
13. If the HTTP code is not between 200 and 399, return an error status indicating that an HTTP error was returned by the server.

14. Optionally, if *content-type* is `text/plain`, `application/octet-stream` or `application/x-unknown`, attempt to determine a new content type via content sniffing. If successful, store the new type in *content-type*.
15. Parse the document body as *content-type* into our RDF model. If the type is not supported, or parsing fails for any other reason, return an error status.
16. Starting with the first item in *subject-list*:—
    a. Set *subject-URI* to the current entry in the list.
    b. Perform a query against the RDF model to determine whether any triples whose subject are *subject-URI* exist.
    c. If triples were found, return a reference to them.
    d. Otherwise, move to the next item in *subject-list*.
17. Finally, return an error status indicating that no triples were found in the retrieved data.

4.1.2 A starting point: the RES index

Just as an ordinary web browser needs a homepage or an address bar, so too do Linked Open Data applications. Whether your application has a fixed configured starting point or is intended to be an open-ended "data browser", the RES index is intended to be a useful Linked Open Data home for many applications.

Described in more detail in *The RES API: the index and how it's structured*, the index is itself Linked Open Data which can be retrieved and processed using the algorithms described above. The URI for the index is currently `http://beta.acropolis.org.uk`, and this URI can be used as default "homepage" for RES applications.

> ! The URI to the API will change soon as the live version of the platform replaces the current beta.

In the same way that a homepage only provides the starting point for a web browser, the same is true of the RES index: applications can allow users to explore and search the index, but to also follow the onward links to source data and media assets.

For some applications, use the RES index as a starting point won't be appropriate: it may be necessary or useful to implement an intermediary service that provides additional capabilities or a specific curated subset of resources. There is no requirement that RES applications *must* directly use the base of the RES index as their home.

4.2 Editorial Guidelines for Product Developers

What do we mean by "editorial"?

In this context we mean what is *in* the metadata and the associated media, such as text, video or images.

- What does it say and what is it about?
- Is it suitable for all ages to see and hear?

- Are there any limits you would want to set around who could see this material?

When making metadata and media available in to education, it is important to understand the expectations of the audience in terms of what they will see and hear.

These guidelines are intended to help product developers think about these issues as early in the design and development process as possible.

The RES platform is funded with public money and needs to show that it is serving the public interest and behaving responsibly.

- The RES project envisages that in schools and FE colleges it will be teachers who are the primary users of the products built on top of the RES platform, both the catalogue and the assets.
- Teachers will then judge the suitability of the content for particular age ranges and make it available to pupils.
- The pupils and students will therefore be the secondary users of any products, accessing a moderated version of the whole platform.
- Teachers will need to share material with pupils and other teachers and this functionality will be vital.
- Where possible the metadata will include any guidance as to the suitability of the content for particular age groups, for example the BBC would include Guidance warning metadata.
- How this will be displayed to teachers is an important consideration in the design of products and services.
- However where no such information is available, it needs to be clear that this does not mean that the material is necessarily suitable for all ages (so perhaps a “no age range given” tag is appropriate?)
- The RES project will provide teachers with guidelines about the range of material available in RES and hints on how to navigate and mediate such a large volume of metadata and media.
- Teachers will also form their own view of what material is suitable for whom, and their ability to add that information to the metadata and share it is important.
- Every product or service built on the RES platform must have a means of feeding back any concerns about aspects of the assets or the metadata to the provider of the catalogue and assets.

5 Requirements for publishers

Publishers wishing to make their data visible in the Acropolis index and useable by RES applications must conform to a small set of basic requirements. These are:

- The data must be expressed as RDF and published as Linked Open Data;
- the data must be licensed under permissive terms (in particular, it must allow re-use in both commercial and non-commercial applications);
- the licensing terms must be included in the data itself so that consumers can perform automated due diligence before using it;
- the data should use the vocabularies described in this book for best results (although you are free to use other vocabularies too).

Although RES requires that you publish Linked Open Data, that doesn't mean you can't also publish your data in other ways. While human-facing HTML pages are the obvious example, there's nothing about publishing Linked Open Data which means you can't also publish JSON with a bespoke schema, CSV, OpenOffice.org spreadsheets, or operate complex query APIs requiring registration to use.

In fact, best practice generally is that you publish in as many formats as you're generally able to, and do so in a consistent fashion. And, while your "data views" (that is, the structured machine-readable representations of your data about things) are going to be very dull and uninteresting to most human beings, that doesn't mean that you can't serve nicely-designed web pages about them as the serialisation for ordinary web browsers.

5.1 Checklist for data publication

5.1.1 Support the most common RDF serialisations

RDF can be serialised in a number of different ways, but there are two serialisations which RES publishers **must** provide because these are the two serialisations guaranteed to be supported by RES applications:

Name	Media type	Further information
Turtle	`text/turtle`	http://www.w3.org/TR/2014/REC-turtle-20140225/
RDF/XML	`application/rdf+xml`	http://www.w3.org/TR/2014/REC-rdf-syntax-grammar-20140225/

Turtle is increasingly the most common RDF serialisation in circulation and is very widely-supported by processing tools and libraries.

RDF/XML is an older serialisation which is slightly more well-supported than Turtle. RDF/XML is often more verbose than the equivalent Turtle expression of a graph, but as an XML-based format can be generated automatically from other kinds of XML using XSLT.

If you are considering publishing your data as JSON, you may consider publishing it as JSON-LD, a serialisation of RDF which is intended to be useful to consumers which don't understand RDF specifically. JSON-LD isn't currently supported by RES, but may be in the future.

> *i* The RES crawler will request Turtle by preference.

5.1.2 Describe the document and serialisations as well as the item

A minimal RDF serialisation intended for use by RES must include data about three distinct subjects:

Subject	Example
Document URL	`http://ialm.int/books/9781899066100`
Representation URL	`http://ialm.int/books/9781899066100.ttl`
Item URI	`http://ialm.int/books/9781899066100#id`

It is recommended that publishers describe any other serialisations which they are making available as well, but it is not currently a requirement to do so.

A description of the metadata which should be served about the document and representations is included in the Metadata about documents section.

5.1.3 Include licensing information in the data

The data about the document or representation **must** include a rights information predicate referring to the well-known URI of a supported license. See the Metadata describing rights and licensing section for further details.

> ! The RES crawler will discard data which does not include licensing data, because without it, the data cannot be used by RES applications.

5.1.4 Link to the RDF representations from the HTML variant

In your HTML representations, use the `<link>` element (within the `<head>` element) with a `rel` attribute of `"alternate"` in order to link to the other representations of the same document:

```
<link rel="alternate" type="application/rdf+xml" href="/books/9781899066100.rdf">
<link rel="alternate" type="text/turtle" href="/books/9781899066100.ttl">
```

While it's less efficient than content negotiation (see below) for both consuming applications and for your server to access your alternative serialisations this way, linking to them from your HTML provides a useful fall-back capability in the event that content negotiation fails or has to be disabled—for example, if you need to switch your website to be served from a content delivery network which doesn't support negotiation.

It's not the preferred option because consumers must first obtain the HTML, parse it, and then request the RDF. Often, generating the HTML page will also be more expensive than generating the equivalent RDF serialisations.

5.1.5 Perform content negotiation when requests are received for item URIs

If you use fragment-based URIs, this means that your web server must be configured to perform content negotiation on requests received for the portion of the URI before the hash (`#`) sign.

For example, if your subject URIs are in the form:

```
http://ialm.int/books/9781899066100#id
```

Then when your server receives requests for the document:

```
/books/9781899066100
```

It should perform content negotiation and return an appropriate media type, including the supported RDF serialisations if requested.

When sending a response, the server **must** send an appropriate `Vary` header, and should send a `Content-Location` header referring to the representation being served. For example:

```
HTTP/1.0 OK
Server: Apache/2.2 (Unix)
Vary: Accept
Content-Type: text/turtle; charset=utf-8
Content-Location: /books/9781899066100.ttl
Content-Length: 272
…
```

> *i* The Apache web server automatically sends the correct headers when configured to perform Content Negotiation on a set of static files. See the Apache mod_negotiation module documentation for further details on its configuration.

5.2 Editorial Guidelines for Content Providers

What do we mean by "editorial"?

In this context we mean what is *in* the metadata and the associated media, such as text, video or images.

- What does it say and what is it about?

- Is it suitable for all ages to see and hear?
- Are there any limits you would want to set around who could see this material?

When making metadata and media available in to education, it is important to understand the expectations of the users in terms of what they will see and hear.

These guidelines are intended to help content providers think about these issues as early in the process as possible.

The RES platform is funded with public money and needs to show that it is serving the public interest and behaving responsibly.

- Some items in physical collections are only available to certain users.
- How is this information transferred to the online catalogue?
- Are there items in your collections which you believe are not suitable for under-18s?
- How will you help end users know this?
- The RES proposal intends that in schools, the primary users of the products built on the RES aggregator will be teachers.
- But teachers are over-worked and are more likely to use your material if it is easy and quick to identify as relevant to their students.
- If you hold any data or guidance on age suitability you should include this in the data you publish.
- Users will be able to feedback to you about concerns with the metadata or assets, including possible breach of copyright – how will you as an institution manage this?
- Although you will probably already have a mechanism for dealing with feedback and/or requests of either a legal (copyright, data protection etc) or editorial nature, it is worth being aware that RES may expose your material to a wider audience and these requests may therefore increase. Can your existing workflows manage this?
- In sharing data and assets are you comfortable that you are complying with the Data Protection Act.

6 Publishing digital media

The RES platform will not directly consume or publish digital media (audio, video, images, documents) itself. However, it will aggregate data *about* digital media which has been published in a form which can be used consistently by RES applications.

This chapter describes how those media assets can be published in ways which will be most useful to RES applications, while balancing the range of access mechanisms and rights restrictions applicable to users in educational settings.

While this chapter provides guidance on publishing media assets themselves, those assets only become useful to RES and RES applications when they are properly described in accompanying metadata. For more information on publishing data which describes digital media assets, please refer to the chapter *Describing digital assets*.

6.1 Approaches to publication

There are three strategies for publishing media for RES: publishing “raw” media assets, providing embeddable players, and publishing pages which include playback capabilities.

> *i* A media publisher may make use of any or all of these strategies, possibly combined with access-control mechanisms where rights or other legal restrictions require it.

6.1.1 Publishing media directly

Publishing media directly is most suited to situations where the media assets are openly-licensed and can be both downloaded and streamed by RES applications. It is not suitable for media which is rights-restricted to the extent that downloads are not permitted.

Direct publishing allows an application to make use of native playback, viewing, editing, and tagging capabilities, and consequentially offers the greatest level of flexibility to applications and users alike. While it provides no technical barrier to end-users *sharing* downloaded media (in whole or part on its own, or combined into a larger composition), it does not automatically imply that sharing is permitted.

While affording the greatest level of flexibility to the consuming application, publishing media in this way is also the simplest from a technical perspective: the encoded media files are simply uploaded to a web server and then *described in the accompanying metadata*.

Use direct publication where:—

- Licensing allows both streaming *and* download of the media asset.
- If you want to allow snipping or other kinds of editing of the media.
- You want to provide the widest possible range of device support.

For example:—

Property	Value
Media asset URL	//upload.wikimedia.org/wikipedia/commons/a/a4/Claude_Monet_1899_Nadar_crop.jpg
MIME type	image/jpeg
Embeddable?	Yes
Poster image URL	//upload.wikimedia.org/wikipedia/commons/thumb/a/a4/Claude_Monet_1899_Nadar_crop.jpg/18 Claude_Monet_1899_Nadar_crop.jpg
Width	2021px
Height	2694px
Title	Claude Monet 1899 Nadar crop
License	Public domain

6.1.2 Embeddable players

Embeddable players are best suited to situations where media files should not be downloaded by applications and end-users, but the playback capability may be provided in-line with other content by an application.

With an embeddable player, although media assets themselves are published in some fashion, the resource described in accompanying metadata is a web page capable of playing them, typically via an `<iframe>` or equivalent, with the metadata including the preferred dimensions of the frame.

This approach limits the capabilities which can be offered by the RES application to its users: as far as the application is concerned, the contents of the framed web page are completely opaque; it can only assume that the page will provide a suitable player for the media asset, and will have no control over playback.

Use an embeddable player where:—

- Licensing only permits streaming of the asset, but *does* allow its presentation as part of a larger body of content (for example, within in a MOOC).
- Media is only available through a technology which may not be widely supported except through a custom player.
- Your media is published through a third party solution which does not provide ready access to direct media asset URLs.
- As a fall-back option alongside a direct media link (for example, to enable an application to generate the embeddable player code snippet for pasting into a MOOC or social network).

For example:—

Property	Value
Media asset URL	`//player.vimeo.com/video/110040373`
MIME type	`text/html`
Embeddable?	Yes
Poster image URL	`//i.vimeocdn.com/video/494149068_960.jpg`
Preferred width	500px
Preferred height	281px
Title	Mount Piños Astrophotography Time Lapse
Duration	45s
License	Creative Commons 3.0 Unported (CC BY 3.0)

6.1.3 Stand-alone playback pages

Stand-alone playback pages provide the least flexibility to RES applications, and—depending upon presentation—may result in reduced visibility of your media.

With this strategy, an application is not able to embed your media at all, but instead must navigate to the page that you provide in a browser window. The application might provide a thumbnail or text link to your playback page, or it might choose to omit the media altogether if including it would result in a poor user experience.

Use a stand-alone playback page where:—

- Licensing restrictions mean that you're not able to authorise any kind of embedding.
- As a fall-back option alongside an embeddable player or direct media links (particularly if you already publish a playback page for each media asset).

For example:—

Property	Value
Media asset URL	`http://www.bbc.co.uk/iplayer/episode/p0285z2y/horizon-19811982-the-race-to-ruin`
Title	Horizon: 1981-1982: The Race to Ruin
Embeddable?	No
Duration	48m52s

Geographical restriction	UK-only

6.2 Access control and media availability

A key aim of the RES project is to increase the visibility of and access to digital media resources which are available to staff and students of educational establishments within the United Kingdom. While this naturally includes the wealth of resources which are openly-licensed and available to everybody, it also includes digital media which can *only* be accessed at scale by UK educational users.

In order to provide access to this material, publishers typically implement some kind of access control. While the RES platform itself is generally agnostic to media assets and their access-control mechanisms, RES applications require the ability to make user-interface decisions based upon the access restrictions imposed upon the media.

For this reason, RES defines three specific kinds of access-control mechanism, as well as a policy which RES-conformant media must be published according to. Specifically, this policy is that media assets must:—

1. Media must be available either freely or under the terms of a blanket or statutorily-backed licensing scheme available to educational establishments (or licenses may be obtained on their behalf by local authorities or central government).
2. It must be possible to obtain the media without further subscription or other charges, however "value-added" services may be provided which offer additional capabilities (such as archiving, enhanced search), provided those services can be readily subscribed to at an establishment level.
3. The media must be generally available on a long term basis. Media available only for short periods has limited value in education because it prevents the same resources being used again in the future.
4. The technical access-control mechansims must be one or more of those described below.
5. The nature of the access-control mechanism must be described in the metadata accompanying the media.

For example, all of the following conform to the policy:—

- Media published via Wikimedia Commons is available to everybody on a permanent basis without any additional payment or subscritpion.
- Programmes which are part of BBC Four Collections are made available to everybody in the UK on a long-term basis (but may not be embedded). Access control is implemented through geo-blocking.
- Recordings of broadcasts made according to the terms of Section 35 of the Copyright, Designs and Patents Act 1988 (as amended) is may be used by the institution who recorded it (or it was recorded on behalf of), provided their ERA Licence is maintained.

- Services which are authorised by ERA to maintain an archive of Section 35 recordings and make them available to ERA Licence-holders who pay a subscription fee, provided access is through a mechanism described below.
- A consortium of rights-holders who together define a scheme for access to one or more sets of media on an affordable establishment-level subscription basis, provided access is through a mechanism described below.

For more information about describing rights restrictions and access-control mechansims, see *Metadata describing rights and licensing* and *Describing conditionally-accessible resources*.

6.2.1 Geographical restrictions (geo-blocking)

Geo-blocking is the automatic determination of ability-to-access a resource by looking up the end-user's public IP address against a database correlating IP address ranges with countries. For example, the address 132.185.240.10 is part of a range which is within the UK, whereas 192.0.32.8 is part of a range which is within the US.

Geo-location databases and live services are available both for free and on commercial terms, with varying levels of quality and service assurance.

Geo-blocking should generally be applied only where other access-control mechanisms are not applicable: for example, because a media asset is available to everybody within a particular country.

6.2.2 Federated access control using Shibboleth and the UK Access Management Federation

Shibboleth is a federated authentication single sign-on mechanism which is widely used by providers of materials to provide access only to staff and students of educational establishments.

The UK Access Management Federation, operated by Janet, provides the Shibboleth federation for UK institutions.

Shibboleth-protected resources present a sign-in page to users who are not already authenticated, which makes it suitable for use with both the embeddable player and the stand-alone playback page publication approaches described above.

Shibboleth-based access control is the preferred mechanism for use where media should be made available only to educational users.

6.2.3 IP-based access control

IP-based access control is often the simplest mechanism to implement, as it requires only for the publisher to check the end-user's public IP address against a white-list and allow or permit access as required.

However, creating and maintaining that white-list can involve significant administrative burden, particularly on a nation-wide basis, and it does not allow ready access to media to remote-working staff and students without their institution providing additional infrastructure such as remote-desktop services and VPNs.

IP-based access control should generally be employed alongside Shibboleth-based authentication, and only for specific institutions which are not able to participate in the UK Acesss Management Federation.

7 Common metadata

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
RDF syntax	`http://www.w3.org/1999/02/22-rdf-syntax-ns#`	`rdf:`
RDF schema	`http://www.w3.org/2000/01/rdf-schema#`	`rdfs:`
DCMI terms	`http://purl.org/dc/terms/`	`dct:`
FOAF	`http://xmlns.com/foaf/0.1/`	`foaf:`

Dublin Core Metadata Initiative (DCMI) Terms is an extremely widely-used general-purpose metadata vocabulary which can be used in the first instance to describe both web and abstract resources.

In particular, the following predicates are recognised by Acropolis itself and may be relayed in the RES index:

Predicate	Meaning
`dct:title`	Specifies the formal title of an item
`dct:rights`	Specifies a URI for rights information (see Metadata describing rights and licensing)
`dct:license`	Alternative predicate for specifying rights information
`dct:subject`	Specifies the subject of something

The FOAF vocabulary also includes some general-purpose predicates:

Predicate	Meaning
`foaf:primaryTopic`	Specifies the primary topic of a document
`foaf:homepage`	Specifies the canonical homepage for something
`foaf:topic`	Specifies a topic of a page (may be used instead of `dct:subject`)
`foaf:depiction`	Specifies the URL of a still image which depicts the subject

7.1 Referencing alternative identifiers: expressing equivalence

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
OWL	`http://www.w3.org/2002/07/owl#`	`owl:`

Linked Open Data in general, and RES in particular, is at its most useful when the data describing things links to other data describing the same thing.

In RDF, this is achieved using the `owl:sameAs` predicate. This predicate implies a direct equivalence relationship—in effect, it creates a synonym.

You can use `owl:sameAs` whether or not the alternative identifiers use `http:` or `https:`, although the usefulness of URIs which aren't resolveable is limited.

For example, one might wish to specify that our book has an ISBN using the `urn:isbn:` URN scheme [*RFC3187*]:

```
</books/9781899066100#id> owl:sameAs <urn:isbn:9781899066100> .
```

We can also indicate that the book described by our data refers to the same book at the British Library:

```
</books/9781899066100#id> owl:sameAs <http://bnb.data.bl.uk/id/resource/011012558> .
```

> *i* Take care when using `owl:sameAs` to ensure that the subject and the object really are directly equivalent. In particular, make sure that you don't accidentally state that somebody's description of something (be it an HTML page or some other serialisation) is the same as the thing being described.

7.2 Metadata describing rights and licensing

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
DCMI terms	`http://purl.org/dc/terms/`	`dct:`
ODRL 2.0	`http://www.w3.org/ns/odrl/2/`	`odrl:`

The data describing digital assets (including RDF representations themselves) must include explicit licensing data in order for it to be indexed by Acropolis and used by RES applications. Additionally, the RDF data must be licensed according to the terms of a supported permissive licence.

In order to express this, you can use the `dct:rights` or `dct:licence` predicates (at your option). Where the subject is an RDF representation, the object of the statement must be the well-known URI of a supported licence (see below). For other kinds of digital asset, the object of the statement can either be a well-known URI of a supported licence, or a reference to a set of terms described in RDF using the ODRL 2.0 vocabulary.

7.2.1 Well-known licences

The Acropolis crawler discards RDF data which is not explicitly licensed using one of the well-known licenses listed below. Note that the URI listed here is the URI which must be used as the object in the licensing statement.

Licence	URI
Creative Commons Public Domain (CC0)	http://creativecommons.org/publicdomain/zero/1.0/
Library of Congress Public Domain	http://id.loc.gov/about/
Creative Commons Attribution 4.0 International (CC BY 4.0)	http://creativecommons.org/licenses/by/4.0/
Open Government Licence	http://reference.data.gov.uk/id/open-government-licence
Digital Public Space Licence, version 1.0	http://bbcarchdev.github.io/licences/dps/1.0#id
Creative Commons 1.0 Generic (CC BY 1.0)	http://creativecommons.org/licenses/by/1.0/
Creative Commons 2.5 Generic (CC BY 2.5)	http://creativecommons.org/licenses/by/2.5/
Creative Commons 3.0 Unported (CC BY 3.0)	http://creativecommons.org/licenses/by/3.0/
Creative Commons 3.0 US (CC BY 3.0 US)	http://creativecommons.org/licenses/by/3.0/us/

The following example specifies that the Turtle representation of the data about our book is licensed according to the terms of the *Creative Commons Attribution 4.0 International licence*.

```
</books/9781899066100.ttl> dct:rights <http://creativecommons.org/licenses/by/4.0/> .
```

See the Metadata describing documents section for further details on describing representations.

7.2.2 ODRL-based descriptions

This section will be expanded significantly in future editions.

7.3 Describing conditionally-accessible resources

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
Access Control ontology	`http://www.w3.org/ns/auth/acl`	`acl:`

Many kinds of digital asset are not available to the general public but may be accessed by the RES audience: students and teachers affiliated with a recognised educational institution in the UK. This may be because specific exceptions in law allow access when it would not otherwise be possible, or because the rights-holder has elected to make the assets available only to those in education.

In order to support this, and ensure that users of RES applications are able to use to the greatest range of material that they legitimately have access to, the metadata describing those assets which aren't available to the public but are to educational users must describe means by which they are accessed.

> *i* A given asset may be available from multiple sources, each with its own specific constraints applied to who may access it. For example, a recording of a radio programme might be held on behalf of educational users by two separate online services, both requiring that the affiliated institution be a licensee of the relevant ERA licensing scheme, and both operating their own institutional-level subscription schemes. To be most useful, the RES index must aggregate the metadata describing *both* means of access, and the metadata must convey sufficient information so as to allow applications to decide which, if any, should be presented to the end-user.

This section will be expanded significantly in future editions.

8 Describing digital assets

8.1 Metadata describing documents

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
RDF syntax	http://www.w3.org/1999/02/22-rdf-syntax-ns#	rdf:
DCMI terms	http://purl.org/dc/terms/	dct:
DCMI types	http://purl.org/dc/dcmitype/	dcmit:
FOAF	http://xmlns.com/foaf/0.1/	foaf:
W3C formats registry	http://www.w3.org/ns/formats/	formats:

8.1.1 Describing your document

> *i* If the document is actually a data-set, see also the Collections and data-sets section.

Give the document a class of `foaf:Document`:

```
</books/9781899066100> a foaf:Document .
```

Give the document a title:

```
</books/9781899066100> dct:title "'Acronyms and Synonyms in Medical Imaging' at the Intergalatic
Alliance Library & Museum"@en .
```

If the document is not a data-set, specify the primary topic (that is, the URI of the thing described by the document):

```
</books/9781899066100> foaf:primaryTopic </books/12345#id> .
```

Link to each of the serialisations:

```
</data/9781899066100> dct:hasFormat </data/9781899066100.ttl> .
</data/9781899066100> dct:hasFormat </data/9781899066100.html> .
```

8.1.2 Describe each of your serialisations

Use a member of the DCMI type vocabulary as a class:

```
</books/9781899066100.ttl> a dcmit:Text .
```

Where available, use a member of the W3C formats vocabulary as a class:

```
</books/9781899066100.ttl> a formats:Turtle .
```

Use the `dct:format` predicate, along with the MIME type beneath the `http://purl.org/NET/mediatypes/` tree:

```
</books/9781899066100.ttl> dct:format <http://purl.org/NET/mediatypes/text/turtle> .
```

Give the serialisation a specific title:

```
</books/9781899066100.ttl> dct:title "Description of 'Acronyms and Synonyms in Medical Imaging' as
Turtle (RDF)"@en .
```

Specify the licensing terms for the serialisation, if applicable:

```
</books/9781899066100.ttl> dct:rights <http://creativecommons.org/licenses/by/4.0/> .
```

See the Metadata describing rights and licensing section for details on the licensing statements required by RES, as well as information about supported licences.

8.1.3 Example

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dct: <http://purl.org/dc/terms/> .
@prefix dcmit: <http://purl.org/dc/dcmitype/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix formats: <http://www.w3.org/ns/formats/> .

</data/9781899066100>
        a foaf:Document ;
        dct:title "'Acronyms and Synonyms in Medical Imaging' at the Intergalatic Alliance Library &
Museum"@en .
        foaf:primaryTopic </books/12345#id> ;
        dct:hasFormat
                </data/9781899066100.ttl> ,
                </data/9781899066100.html> .

</data/9781899066100.ttl>
        a dcmit:Text, formats:Turtle ;
        dct:format <http://purl.org/NET/mediatypes/text/turtle> ;
        dct:title "Description of 'Acronyms and Synonyms in Medical Imaging' as Turtle (RDF)"@en ;
        dct:rights <http://creativecommons.org/licenses/by/4.0/> .

</data/9781899066100.html>
        a dcmit:Text ;
        dct:format <http://purl.org/NET/mediatypes/text/html> ;
        dct:title "Description 'Acronyms and Synonyms in Medical Imaging' as a web page"@en .
```

8.2 Collections and data-sets

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix

DCMI terms	http://purl.org/dc/terms/	dct:
VoID	http://rdfs.org/ns/void#	void:

8.2.1 Data-set auto-discovery

8.3 Images

8.4 Video

8.5 Audio

9 Describing physical things

> The RES index entry for a physical thing will have a class of crm:E18_Physical_Thing.

10 Describing people, projects and organisations

11 Describing places

The RES index entry for a place will have a class of geo:SpatialThing.

12 Describing events

The RES index entry for an event will have a class of event:Event.

13 Describing concepts and taxonomies

Vocabularies used in this section:

Vocabulary	Namespace URI	Prefix
SKOS	http://www.w3.org/2008/05/skos#	skos:

14 Describing creative works

The RES index entry for a creative work will have a class of frbr:Work.

15 Under the hood: the architecture of Acropolis

This section will be expanded significantly in future editions.

Appendix I: Tools and resources

Guides

- *RDF 1.1 primer*
- *Linked Data Patterns*
- *Linked Data - The Story so Far* (PDF)
- *Cool URIs don't change*
- *Cool URIs for the Semantic Web*

Tools for consuming Linked Open Data

- *EasyRDF* is a PHP library for consuming and producing RDF
- *RDFLib* is a suite of libraries and tools for working with RDF in Python
- *node-rdf* is a suite of libraries and tools for working with RDF in ECMAScript (JavaScript), and in particular with Node.js
- *libcurl* is an extensible multi-protocol file transfer library with bindings for many high-level languages
- *Redland (librdf)* is a set of libraries for parsing, serialising and processing RDF
- *libxml2* is a very capable and widely used XML and HTML parsing library
- *liblod* is a Linked Open Data client library developed by the RES project, and which uses the capabilities of libcurl, librdf and libxml2

Tools for processing RDF and publishing Linked Open Data

- *D2RQ* is a system for transforming data in relational databses to RDF
- *Twine* is an engine developed by the RES project for transforming data and pushing it into an RDF quad-store
- *Quilt* is a FastCGI application developed by the RES project for publishing the contents of an RDF quad-store as Linked Open Data

Technical standards

- *RDF 1.1 Turtle*
- *RDF 1.1 TriG*
- *RDF 1.1 XML Syntax (RDF/XML)*
- *RFC 7230: Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing*
- *RFC 7231: Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content*

Appendix II: Codecs & container formats

Video codecs

Kind	Usage	Properties	Examples
Preservation	Long-term archive storage	Lossless compression, typically 2:1	DNG sequence, Motion JPEG 2000 lossless, VC2 (Dirac) lossless
Intermediate (mezzanine)	Fine-cut editing	Visually lossless, typically 4:1–6:1	VC2 (Dirac), VC3 (DNx), Apple ProRes
Delivery	Distribution through a broadcast chain or publishing on physical media	Output format, constrained by bandwidth, typically 10:1–40:1	H.262 (MPEG-2 Part 2), H.264 (MPEG-4 Part 10, AVC)
Browse	Lightweight, streamable, viewing proxy	Output format, constrained by bandwidth, typically in excess of 50:1	H.262 (MPEG-2 Part 2), H.264 (MPEG-4 Part 10, AVC), WebM (VP8+), Theora (VP3+), VP6

Codec	Kind	Authority	Lossy/lossless	Depth	Chroma	Notes
SMPTE VC-2 (Dirac)	Video	SMPTE/BBC	Both	8, 10, 12	4:2:0, 4:2:2, 4:4:4	Currently limited support
SMPTE VC-3 (DNx)	Video	SMTPE/Avid	Lossy	8, 10	3:1:1, 4:2:2, 4:4:4	Max 1080i59.94
H.262 (MPEG-2 Part 2)	Video	ISO/MPEG	Lossy	8	4:2:0, 4:2:2, 4:4:4	Considered legacy
H.264 (MPEG-4 Part 10, AVC)	Video	ISO/MPEG	Lossy	8, 10	4:2:0, 4:2:2, 4:4:4	Widely supported
Apple ProRes	Video	Apple	Lossy	10, 12	4:2:2, 4:4:4	Proprietary intermediate codec
Apple Intermediate	Video	Apple	Lossy	8, 10	4:2:0	Considered

Codec						legacy
Ogg Theora/VP3	Video	Xiph	Lossy	8	4:2:0, 4:2:2, 4:4:4	
VP6	Video	Google/Adobe	Lossy	8	4:2:0	Classic Flash video codec
WebM/VP8+	Video	Google	8	4:2:0	Limited support	
Motion JPEG 2000	Video	ISO/JPEG	Both	8, 10	Various	Particularly suited to preservatior

Audio codecs

Kind	Usage	Properties	Examples
Preservation	Long-term archive storage	Lossless compression, typically 2:1	Raw PCM, FLAC, ALAC, Dolby TrueHD
Intermediate (mezzanine)	Fine-cut editing	Audibly lossless, typically 4:1–6:1	Raw PCM, FLAC, ALAC, AAC (MPEG-2 Part 7, MPEG-4 Part 3), Dolby TrueHD
Delivery	Distribution through a broadcast chain or publishing on physical media	Output format, constrained by bandwidth, typically 7:1	AAC (MPEG-2 Part 7, MPEG-4 Part 3), MP3 (MPEG-1 Part 3, MPEG-2 Part 3), Dolby AC-3, Dolby TrueHD
Browse	Lightweight, streamable, proxy	Output format, constrained by bandwidth, typically in excess of 11:1	AAC (MPEG-2 Part 7, MPEG-4 Part 3), MP3 (MPEG-1 Part 3, MPEG-2 Part 3), Dolby AC-3

Codec	Kind	Authority	Lossy/lossless	Notes
Raw PCM	Audio	Various	Uncompressed	Typically wrapped in AIFF or RIFF (WAV)
FLAC	Audio	Xiph	Lossless	Limited hardware support
Apple Lossless (ALAC)	Audio	Apple	Lossless	Limited support

Dolby TrueHD	Audio	Dolby	Lossless	
Dolby AC-3	Audio	Dolby	Lossy	Widely supported in professional applications
AAC (MPEG-2 Part 7, MPEG-4 Part 3)	Audio	ISO/MPEG	Lossy	Widely supported
MP3 (MPEG-1 Part 3, MPEG-2 Part 3)	Audio	ISO/MPEG	Lossy	Very widely supported
Ogg Vorbis	Audio	Xiph	Lossy	Adopted as audio codec for WebM
Opus	Audio	IETF	Lossy	Currently being trialled, particularly by radio broadcasters

Image codecs

Kind	Usage	Properties	Examples
Preservation	Long-term archive storage, editing & composition	Lossless compression, typically 2:1	Adobe DNG (RAW), JPEG 2000 (ISO/IEC 15444) lossless, TIFF, PNG
Delivery	Distribution through a broadcast chain or publishing on physical media	Output format, constrained by bandwidth, typically 10:1-40:1	JPEG 2000 (ISO/IEC 15444) lossless, TIFF, PNG
Browse	Lightweight viewing proxy/thumbnail	Output format, constrained by bandwidth, typically in excess of 30:1	JPEG (ISO/IEC 10918), JPEG 2000 (ISO/IEC 15444) lossless, PNG

Codec	Kind	Authority	Lossy/lossless	Depth (BPC)	Chroma	Notes
Adobe DNG	RAW image	Adobe	Lossless	Arbitrary		Derived from TIFF
DPX	Processed image	SMPTE	Lossless	8-64 log		
TIFF	ISO/Adobe	Both	Arbitrary	4:4:4, 4:2:0	Supports HDR, alpha	

OpenEXR	Processed image	Disney-Pixar	Both	16		Supports HDR
JPEG 2000 (ISO/IEC 15444)	Processed image	ISO/JPEG	Both	8, 10	Various	Supports sequences with Motio JPEG 200(
JPEG (ISO/IEC 10918)	Processed image	ISO/JPEG	Lossy	8	4:2:0	
PNG (ISO/IEC 15948)	Processed image	W3C	Lossless	8bpp, 8bpc		Supports alpha
WebP	Processed image	Google	Both	8	4:2:0	Derived from WebM/VP8

Container formats

Container	Authority	Seekable?	Multiple tracks?	Multiple programs?	Notes
Transport Stream (MPEG-2 Part 1)	ISO/MPEG	No	Yes	Yes	Used by DVB, ATSC, ARIB, Apple HLS, modified for use by Blu-Ray and AVCHD
Program Stream (MPEG-2 Part 1)	ISO/MPEG	Yes	Yes	No	Used by DVD-Video (VOB), HD-DVD (EVO)
QuickTime	Apple	Yes	Yes	No	Now harmonised with and extends Base Media
Base Media (MPEG-4 Part 12)	ISO/MPEG	Yes	Yes	No	Derived from QuickTime .mov
MP4 (MPEG-4 Part 14)	ISO/MPEG	Yes	Yes	No	Derived from Base Media
FLV	Adobe	Yes	Yes	No	Derived from Base Media
3GP & 3G2	3GPP	Yes	Yes	No	Derived from Base Media
					Transport Stream

AVCHD/Blu-Ray MTS/TOD	Various	Yes	Yes	No	packets prefixed with a 32-bit timecode
Elementary Stream (ES)	ISO/MPEG	No	No	No	Raw codec data
Packetized Elementary Stream (PES)	ISO/MPEG	Yes	No	No	Elementary Stream split into packets with an added header
MXF	SMPTE	Yes	Yes	No	Forms the basis of the Digital Production Partnership (DPP) UK broadcasting delivery specification
AIFF	Apple	Yes	No	No	Typically used as a lightweight single-essence container
AAF	AMWA	Yes	Yes	No	Derived from Microsoft (OLE) Structured Storage as used by legacy Microsoft Office
Matroska	Matroska	Yes	Yes	No	Not well-supported
JP2 (ISO 15444-12)	ISO/JPEG		No	No	Derived from Base Media; profiled for JPEG 2000 (and Motion JPEG 2000) essence
WebM	Google	Yes	Yes	No	Derived from Matroska; only used to carry WebM audio & video essence
RIFF	Microsoft	Yes	Yes	No	WAV and AVI are both RIFF formats
ASF	Microsoft	Yes	Yes	No	Considered legacy; WMA and WMV are both ASF formats
Ogg	Xiph	Yes	Yes	No	De facto container for Vorbis audio and Theora video

Metadata formats

Container	Authority	Extensibility	Standalone?	Embedded in	Notes
Exif	Unmaintained	Controlled	No	JPEG, TIFF, JPEG 2000, PNG	Largely superseded by XMP; contains IPTC IIM
Adobe XMP	Adobe	Arbitrary (URIs)	Yes	TIFF, JPEG 2000, PDF	XMP is a subset of RDF/XML; widely-used
ID3v2	Various	Consensus	No	MP3, AIFF, MP4	Considered legacy, but widely-used
Ogg	Xiph	Controlled	No	Ogg	
MP4	ISO/MPEG	FourCC registry	No	Base Media and derivatives	
MPEG-7	ISO/MPEG	Controlled	Yes	Base Media	XML-based; describes relationships between components
MPEG-21	ISO/MPEG	Controlled	Yes	Base Media	Includes rights expression
TV-Anytime	Unmaintained	Controlled	Yes	Base Media	Considered legacy but used in broadcast applications
Turtle (RDF)	W3C	Arbitrary (URIs)	Yes		Not currently widely-used as a media metadata container; can be generated from RDF/XML
RDF/XML	W3C	Arbitrary (URIs)	Yes		Generally considered legacy, superseded by Turtle; basis of Adobe XMP

Packaging formats

Package	Authority	Metadata formats	Container formats	Multiple programs?	Notes
AVCHD	Sony/Panasonic		MTS/TOD	Yes	Derived from Blu-Ray
DVD-Video	DVD Forum		Program Stream (MPEG-2 Part 1)	Yes	
Blu-Ray	BDA		MTS/TOD	Yes	
CinemaDNG	Adobe	XMP	MXF, DNG	No	Intended to package losslessly-encoded media
Digital Production Partnership (DPP)	DPP	DPP XML	MXF	No	Intended for delivery of complete programmes to broadcasters

Streaming formats

Format	Authority	Manifest format	Container formats	Notes
IIS Smooth Streaming	Microsoft	XML	MTS/TOD	HTTP-based adaptive streaming for Silverlight clients
RTSP & RTP	IETF	SDP		
RTMP	Adobe	Protocol exchange		Adaptive streaming for Adobe Flash; considered legacy but remains widely-used, often alongside HLS
Apple HLS	Apple/IETF	Extended playlist (m3u8)	Transport Stream (MPEG-2 Part 1)	Particularly well-supported on mobile devices

Adobe HDS	Adobe	XML	FLV	Considered legacy; Adobe is transitioning to HLS for streaming media

Vocabulary index

Vocabulary	Namespace URI	Prefix	Section
Access Control ontology	http://www.w3.org/ns/auth/acl	acl:	*Describing conditionally-accessible resources*
Basic geo vocabulary	http://www.w3.org/2003/01/geo/wgs84_pos#	geo:	*Describing places*
Creative Commons Rights Expression Language	http://creativecommons.org/ns#	cc:	*Metadata describing rights and licensing*
CIDOC CRM	http://www.cidoc-crm.org/cidoc-crm/	crm:	*Describing physical things*
DCMI Metadata Terms	http://purl.org/dc/terms/	dct:	*Common metadata, Metadata describing rights and licensing, Collections and data-sets*
DCMI Types	http://purl.org/dc/dcmitype/	dcmit:	*Metadata describing documents, Collections and data-sets*
Event ontology	http://purl.org/NET/c4dm/event.owl#	event:	*Describing events*
FOAF	http://xmlns.com/foaf/0.1/	foaf:	*Common metadata*
FRBR Core	http://purl.org/vocab/frbr/core#	frbr:	*Describing creative works*
GeoNames Ontology	http://www.geonames.org/ontology#	gn:	*Describing places*
Media RSS	http://search.yahoo.com/mrss/	mrss:	*Publishing digital media, Describing digital assets*
ODRL 2.0	http://www.w3.org/ns/odrl/2/	odrl:	*Metadata describing rights and licensing*
OpenSearch	http://a9.com/-/spec/opensearch/1.1/	osd:	*The RES API: the index and how it's structured*
			The RES API: the index and how it's

OWL	http://www.w3.org/2002/07/owl#	owl:	*structured, Referencing alternative identifiers: expressing equivalence*
RDF schema	http://www.w3.org/2000/01/rdf-schema#	rdfs:	*The RES API: the index and how it's structured, Common metadata*
RDF syntax	http://www.w3.org/1999/02/22-rdf-syntax-ns#	rdf:	*The RES API: the index and how it's structured, Common metadata*
SKOS	http://www.w3.org/2008/05/skos#	skos:	*Describing concepts and taxonomies*
VoID	http://rdfs.org/ns/void#	void:	*The RES API: the index and how it's structured, Collections and data-sets*
W3C formats registry	http://www.w3.org/ns/formats/	formats:	*The RES API: the index and how it's structured, Metadata describing documents*
XHTML Vocabulary	http://www.w3.org/1999/xhtml/vocab#	xhtml:	*The RES API: the index and how it's structured*

Class index

The following RDF classes are applied to entries in the RES index by the aggregator, based upon the class they are evaluated as belonging to:—

Class	Description	Section
foaf:Agent	Agents (i.e., things operating on behalf of people or groups).	*Describing people, projects and organisations*
dcmitype:Collection	Collections	*Collections and data-sets*
skos:Concept	Concepts	*Describing concepts and taxonomies*
frbr:Work	Creative works	*Describing creative works*
void:Dataset	Datasets	*Collections and data-sets*
foaf:Document	Digital assets	*Describing digital assets*
event:Event	Events (time-spans)	*Describing events*
foaf:Organization	Organizations	*Describing people, projects and organisations*
foaf:Person	People	*Describing people, projects and organisations*
crm:E18_Physical_Thing	Physical things	*Describing physical things*
geo:SpatialThing	Places (locations)	*Describing places*

Predicate index

This section lists the predicates which are specifically recognised by the RES aggregation engine, whether they are cached (against the original subject URI from the data in which they appear), and whether they can relayed in the composite entity generated by the aggregator.

Predicate	Entity kind	Cached?	Relayed?
`rdf:type`	Any	Yes	Yes, but also mapped to pre-defined classes
`rdfs:label`	Any	Yes	Yes
`foaf:givenName` and `foaf:familyName`	People	Yes	Yes, as `rdfs:label`
`foaf:name`	Agents	Yes	Yes, as `rdfs:label`
`gn:name`	Places	Yes	Yes, as `rdfs:label`
`gn:alternateName`	Places	Yes	Yes, as `rdfs:label`
`dct:title`, `dc:title`, `foaf:name`, `skos:prefLabel`	Any	Yes	Yes, as `rdfs:label`
`foaf:depiction`	Any	Yes	Yes
`crm:P138i_has_representation`	Any	Yes	Yes, as `foaf:depiction`
`dct:subject`	Creative works, collections, digital assets	Yes	Yes
`geo:lat`	Places	Yes	Yes
`geo:long`	Places	Yes	Yes
`dct:rights`, `dct:license`, `cc:license`	Any	Yes	No
`skos:inScheme`	Concepts	Yes	Yes
`skos:broader`	Concepts	Yes	Yes
`skos:narrower`	Concepts	Yes	Yes