Syntax for the
Digital Object Identifier

Abstract: Defines the order and composition of the Digital Object Identifier (DOI) used to identify intellectual property in the digital environment.

Contents

Foreword

This standard defines "the composition and order of components of the DOI^{SM} (Digital Object Identifier), a character string used to identify intellectual property in the digital environment." The DOI was developed by the International DOI Foundation (http://www.doi.org/) on behalf of the publishing industry, to provide a framework for managing intellectual content including activities such as linking users with content owners, facilitating electronic commerce, and enabling automated copyright management. *Note:* DOI and DOI.ORG are registered service marks of the International DOI Foundation, Inc.

Some history on the development of this standard is needed to understand how and why the standard appears in its present form.

DOI System Background

The Internet is a new environment for information transactions and it requires new enabling technologies to provide services and to protect intellectual property. Systems must be developed to identify, authenticate, and protect content to ensure that what the user is requesting is what is being delivered. At the same time, the rights owner of the information must have assurances that copyright in content is respected and protected.

In considering the new systems required, international publishers realized that a first step would be the development of an identification system to be used for intellectual property in the digital environment. Such a system was launched at the Frankfurt Book Fair in October 1997: the Digital Object Identifier (DOI) System. The System provides a unique identification mechanism for content in all media, and a way to link users of the materials to the rights holders or their agents to facilitate automated digital commerce.

The DOI in Context (DOI System, Handle System®, IDF)

The DOI System is an implementation of the Handle System®, developed by the Corporation for National Research Initiatives (CNRI). The Handle System® is a distributed computer system that stores names, or handles, of digital items. It can quickly resolve those names into the information necessary to locate and access the items. It was designed by CNRI as a general purpose global system for the reliable management of information on networks such as the Internet over long periods of time and is currently in use in a number of projects. The Library of Congress, the Defense Technical Information Center, the International DOI Foundation, and the National Music Publishers' Association are implementing the Handle System®.

The DOI System is managed by the International DOI Foundation, which sets policies, appoints service providers, and ensures the successful operation of the System. The IDF has issued a document outlining the DOI issues entitled "Guidelines for the Issuance and Use of DOI" (the most current version will be available at http://dx.doi.org/10.1000/25).

Basis of the DOI System

In the CNRI Handle System® the term "DOI" is used instead of "Handle" to describe the identifiers. Handle and therefore DOI is in conformance with IETF RFC 1737 Functional Requirements for Uniform Resource Names. (http://www.ietf.org/rfc/rfc1737.txt)

The Handle System web site (www.handle.net) includes an overview of the technology; protocol specifications, and a discussion of Handle System Scalability. The Handle System is an open specification described in two IETF Internet-Drafts: "Handle System Overview," July 1999, (http://www.ietf.org/internet-drafts/draft-sun-handle-system-04.txt), and "Handle System Namespace and Service Definition," July 1999, (http://www.handle.net/draft-sun-handle-system-def-01.txt).

These documents are in conformance with Section 10 of RFC2026. Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). The list of current Internet-Drafts can be accessed at http://www.ietf.org/ietf/1id-abstracts.txt. The list of Internet-Draft Shadow Directories can be accessed at http://www.ietf.org/shadow.html. An overview of the Handle System is available at http://www.handle.net/overviews/hs-version4.html

Resolution

The DOI System enables resolution of the DOI. A resolution system takes a URN and returns a list of services or instances of the information identified by the URN, commonly one or more URLs. Resolution is here used to mean the act of submitting an identifier to a network service and receiving in return one or more pieces of current information related to the identifier. In the case of the Domain Name System (DNS), as an example, the resolution is from domain name, e.g., www.doi.org, to a single IP address, e.g., 132.151.1.146, which is then used to communicate with that Internet host. In the case of the Handle System, the resolution is from a handle, e.g., 10.1000/140, to one or more pieces of typed data, e.g., three URLs representing three copies of the object.

DOI and Metadata

From the earliest development of the Digital Object Identifier (DOI), one of the most widely discussed issues has been whether or not the identifier string of which the DOI is composed should be meaningful. The syntax of this string, as defined by this standard, contains a set of components with very limited meaning.

• Each DOI string begins with a code indicating that within the Handle System of the Corporation for National Research Initiatives (CNRI) the string will be resolved by the Local Handle System reserved for the DOI.

• The next component of the DOI string notes the number assigned to the registrant who originally created the DOI. It should be noted that this number provides no information about current ownership of the object that the DOI string references.

• The DOI suffix string contains an unspecified identifier.

The elements within the DOI string do not include information about the object identified. The Committee recognized that the lack of descriptive information would limit the usefulness of the DOI string. It was agreed that accompanying information that describes the object would be necessary to make the string meaningful. Such information is called "metadata." This metadata may be aggregated into databases together with the DOI string and used for specific purposes.

The following recommendations are accordingly included here:

1. No DOI string should be registered without an accompanying set of metadata describing the object being referenced in the syntax string.

2. The Maintenance Agency listed in Appendix B should provide the latest information about the relevant metadata schemas and any databases that aggregate metadata about DOI referenced objects.

NISO Involvement and Role of the International DOI Foundation (IDF)

The ongoing management of the DOI System is done by the International DOI Foundation, a not-for-profit, membership-based organization with offices in the United States and Geneva, Switzerland. The Foundation is responsible for licensing Directory Managers/Registration Agencies and technology providers, for setting policy for the system, and for encouraging development of the related enabling technologies to build the infrastructure for electronic transaction systems such as copyright management.

Though the DOI System was originally developed by the publishing industry, it was recognized that the DOI system would have a broader scope and that it should work with established standards bodies as much as possible. NISO participation was requested in early 1998 to develop a standard for the syntax of the DOI identifier string, in order to maximize the broad potential use of a digital object identifier.

Goals of the Syntax Committee

The NISO DOI Syntax standards committee (SC AR) was established with the following goals:

• To formalize the syntax for the DOI identifier string to enable DOI registration. It has been possible to register DOIs since 1998 but there has been concern that the syntax has not been conclusively set.

• To determine the elements of the DOI identifier string. Several proposals to add elements to the DOI identifier string had been made and the committee was charged with determining which ones should be included in the string.

• To limit the scope of the standard to the DOI identifier string. The DOI System is made up of a number of parts including the identifier string, the resolution mechanism, and the Directory. This standard addresses only the syntax for the identifier string.

While limiting itself to the DOI identifier string, the Syntax committee took into account the wider context of the DOI System, the Handle System®, the International DOI Foundation, and the Internet. This Foreword and the Appendixes provide important information and references for understanding the DOI System, how the DOI is being used, how it relates to other standards and the Internet, and where to get more information.

This standard was processed and approved for submittal to ANSI by the National Information Standards Organization. It was balloted by the NISO Voting Members July 15, 1999 - September 15, 1999. It will next be reviewed in 2005. Suggestions for improving this standard are welcome. They should be sent to the National Information Standards Organization, 4733 Bethesda Avenue, Suite 300, Bethesda, MD 20814. NISO approval of this standard does not imply that all Voting Members voted for its approval. At the time it approved this standard, NISO had the following Voting Members:

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Acknowledgment

Syntax for the Digital Object Identifier

1. Introduction

1.1 Purpose

This standard defines the syntax for a character string called the Digital Object Identifier (DOI).

1.2 Scope

This standard is limited to defining the syntax of the DOI character string. Policies governing the assignment and use of DOIs are determined by the International DOI Foundation (IDF) and are outside the scope of this document.

2. Standards and References

Referenced standards are those that need to be used to construct a DOI. Secondary standards and references include citations to documents that can be of use in conjunction with the DOI. See Appendix D for related standards and references.

2.1 Referenced Standard

Unicode Consortium "The Unicode Standard Version 3.0" ISBN: 0-201-61633-5 (http://www.unicode.org/).

3. Definitions

Deposit. The act of entering into the Directory a DOI and associated information necessary for the DOI to be used.

Digital Object Identifier (DOI). A character string used in a System conforming to the rules of, and deposited in the Directory administered by, the IDF.

Directory. A repository in which DOIs are deposited and attendant locations are maintained.

Directory Manager. The organization that manages the Directory on behalf of the IDF.

DOI prefix . The Directory and the Registrant codes issued by the Registration agency to a Registrant for use as the prefix in the DOIs allocated by that Registrant.

DOI suffix. The character string assigned by a Registrant. The suffix shall be unique within the set of DOIs specified by the DOI prefix held by the Registrant.

International DOI Foundation (IDF). The body set up to support the needs of the intellectual property community in the digital environment by establishing and governing the DOI System, setting policies for the System, appointing service providers for the System, and overseeing the successful operation of the System.

Registrant. An organization or entity that has requested and been allocated one or more DOI prefixes by a Registration Agency.

Registration. The act of allocating the DOI prefix to a Registrant by the Registration Agency.

Registration Agency [DOI Registration Agency]. An organization appointed by the International DOI Foundation to register and allocate DOI prefixes to Registrants, and which subsequently accepts DOIs being deposited by Registrants. A Registration Agency may also be a Directory Manager.

4. Format and Characteristics of the DOI

The DOI is composed of the *prefix* and the *suffix.* Within the prefix are the Directory Code <DIR> and the Registrant Code <REG>. The suffix is made up of the DOI Suffix String <DSS>.

The syntax of the DOI string is:

<DIR>. <REG> /<DSS>

There is no limit on the length of a DOI string, or any of its components.

4.1 DOI Character Set

Legal characters are the legal graphic characters of Unicode. Reserved characters, if any, are listed in the following descriptions of the prefix and suffix.

4.2 Prefix

<DIR> Directory Code (required)

See Appendix A for all valid values for the Directory Code. The Maintenance Agency is responsible for updating the list of valid values.

<REG> Registrant's Code (required)

Separated from <DIR> by ".". This is assigned to the Registrant by the International DOI Foundation.

DOI Prefix Character Set

Any character within Unicode. <DIR> <REG> are assigned by the International DOI Foundation.

4.3 Suffix

<DSS> DOI Suffix String (required)

This is assigned by the Registrant.

DOI Suffix Character Set

Any character within Unicode. The Suffix cannot start with */ where * is any single character. This is reserved for future use. The DSS is case sensitive.

5. Maintenance Agency

The Maintenance Agency designated in Appendix B shall review suggestions for new data elements, interpret the rules prescribed by this standard, and maintain a listing of inquiries and responses that may be used for potential future enhancement of this standard. Questions concerning the implementation of this standard and requests for information should be sent to the Maintenance Agency.

APPENDIX A
DOI Specifications

(This appendix is not part of the American National Standard Syntax for the Digital Object Identifier, ANSI/NISO Z39.84-2000. It is included for information only.)

This appendix provides information on aspects of the DOI system beyond syntax which are determined by the International DOI Foundation and which will not change the DOI syntax defined in this standard.

Valid values for Directory Code (See Section 4.1), Persistance and Character Encoding

<DIR> <REG> is assigned by the International DOI Foundation. The prefix is numeric.

Valid value for <DIR> = 10

DOIs are persistent, as defined in IETF RFC 1737. Functional Requirements for Uniform Resource Names. (http://www.ietf.org/rfc/rfc1737.txt) : "It is intended that the lifetime of a URN be permanent. That is, the URN will be globally unique forever, and may well be used as a reference to a resource well beyond the lifetime of the resource it identifies or of any naming authority involved in the assignment of its name."

UTF-8 encoding is mandated by the Handle System. Therefore, all Unicode characters must be encoded using UTF-8.

The Handle System used as the basis for the DOI system allows an unlimited length for the DOI string. However it is recommended that the suffix (<DSS>) be kept as short as possible to allow for human readability and ease of use in systems where size may be a consideration (e.g., watermarking).

This information is maintained by the DOI Maintenance Agency (see Appendix B).

APPENDIX B
Designation of Maintenance Agency

(This appendix is not part of the American National Standard Syntax for the Digital Object Identifier, ANSI/NISO Z39.84-2000. It is included for information only.)

The functions assigned to the Maintenance Agency as specified in Section 5 will be administered by The International DOI Foundation (http://www.doi.org/). Questions concerning the implementation of this standard and requests for information should be sent to:

E-mail: n.paskin@doi.org
Web site: www.doi.org

The International DOI Foundation
PO Box 233
Kidlington, Oxford
OX5 1XU, U.K.
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The International DOI Foundation
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50 F Street, N.W., 4th Floor
Washington, DC 20001
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The International DOI Foundation
c/o International Publishers Association
3, avenue de Miremont
CH-1206, Geneva, Switzerland
Phone: 41-22-830-1080
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E-mail: doi@worldcom.ch

APPENDIX C
Examples of Digital Object Identifiers
(This appendix is not part of the American National Standard Syntax for the Digital Object Identifier, ANSI/NISO Z39.84-2000. It is included for information only.)

DOI registrants can use a variety of strings for the DSS including private identifiers and existing standards such as SICI (Serial Item and Contribution Identifier). The following are examples of Digital Object Identifiers:

DOI for the Authors' Licensing and Collecting Society's Byline service:
    10.054/1418EC1N2LE
    └─────┘ └──────────┘
    Prefix   Suffix

DOI (incorporating a SICI) from an article in the *Journal of the American Society for Information Science,* published by John Wiley & Sons:
    10.1002/(SICI)1097-4571(199806)49:8<693::AID-ASI4>3.0.CO;2-O
    └─┘└───┘ └──┘
    DIR REG   DSS

DOI for an article from JAMA, the *Journal of the American Medical Association:*
    10.1001/PUBS.JAMA(278)3,JOC7055-ABST:
    └─────┘ └──────────────────────────┘
    Prefix   Suffix

DOI for the article "ABO Blood Group System" from *Encyclopedia of Immunology Online,* 2nd edition, published by Academic Press:
    10.1006/rwei.1999.0001
    └─┘└───┘ └────────────┘
    DIR REG   DSS

APPENDIX D
Related Standards and References

(This appendix is not part of the American National Standard Syntax for the Digital Object Identifier, ANSI/NISO Z39.84-2000. It is included for information only.)

Standards for item identification have been proliferating in recent years. The standard cited in Section 2 is required for the construction of the DOI syntax. This appendix includes secondary standards and references to standards in development, citations that may be useful with DOIs. Other references provide additional information on the DOI.

When American National Standards cited below are superseded by a revision, the revision shall apply.

Secondary Standards

ANSI X3.4:1986 American National Standard for Information Systems – Coded Character Sets – 7-bit American National Standard Code for Information Interchange (7-bit ASCII) New York: ANSI, 1986.

ANSI/NISO Z39.9-1992, International Standard Serial Numbering (ISSN). Bethesda, MD: NISO Press, 1992.

ANSI/NISO Z39.23-1997, Standard Technical Report Number. Bethesda, MD: NISO Press, 1997.

ANSI/NISO Z39.56-1996, Serial Item and Contribution Identifier (SICI). Bethesda, MD: NISO Press, 1996.

ISO 2108:1992 Information and Documentation — International Standard Book Numbering (ISBN). Geneva: ISO, 1992.

ISO 3297:1998 Information and Documentation — International Standard Serial Numbering (ISSN). Geneva: ISO, 1998.

ISO 3901:1986 Information and Documentation — International Standard Recording Code (ISRC). Geneva: ISO, 1986.

ISO 10957:1993 Information and Documentation —International Standard Music Number (ISMN). Geneva: ISO, 1993.

Uniform Resource Identifiers
http://info.internet.isi.edu:80/in-notes/rfc/files/rfc2396.txt

References to Standards in Development

NISO Book Item and Component Identifier (Draft released for comment January 6, 2000- April 7, 2000)

ISO/TC 46/SC9 ISO/DIS 15706, Information and Documentation — International Standard Audiovisual Number (ISAN)

ISO/TC 46/SC9 ISO/DIS 15707, Information and Documentation — International Standard Work Code (SIWC) — Part 1: Musical Works

Other References

Guidelines for the Issuance and Use of DOI Version 3.1
http://dx.doi.org/10.1000/25

Document Object Model
http://www.w3.org/DOM/

Dublin Core Metadata Initiative
http://purl.oclc.org/dc/

Handle System
http://www.handle.net/

Publisher Item Identifier
http://www.elsevier.nl/homepage/about/pii

"UTF-8, A Transform Format for Unicode and ISO10646", RFC2044, October 1996, Yergeau, Francois - http://www.normos.org/ietf/rfc/rfc2044.txt

APPENDIX E
Application Issues

(This appendix is not part of the American National Standard Syntax for the Digital Object Identifier, ANSI/NISO Z39.84-2000. It is included for information only.)

Except for the specific requirements imposed by this standard (such as use of Unicode and reserved characters), no restrictions are imposed or assumptions made about the characters used in DOIs. Appendix E discusses some encoding issues that arise when using DOIs in specific application contexts like URLs and with the HTTP protocol. Other application contexts in which DOIs are used may have similar types of requirements or restrictions. However, such requirements for encoding or restrictions on the use of particular characters only apply when DOIs are used within those particular application contexts. They are not part of the DOI syntax itself as defined by this document.

UTF-8 Encoding

The Handle System specifies UTF-8 as the encoding for DOI strings. ASCII characters are preserved under UTF-8 encoding. No changes need to be made to ASCII characters to comply with UTF-8 encoding. The default encoding of Unicode is that each character consists of 16 bits (2 octets). UTF-8 is a variation of the Unicode encoding that allows characters to be encoded in terms of one to six octets. UTF-8 encoding plays a role when non-ASCII characters are used. For example, the Japanese word "nihongo" is written as:

日 本 語

The Unicode sequence representing the Han characters for "nihongo" is:
   65E5 672C 8A9E

These may be encoded in UTF-8 as follows:
   E6 97 A5 E6 9C AC E8 AA 9E

For further information on UTF-8 see "UTF-8, A Transform Format for Unicode and ISO10646", RFC2044, October 1996.

Encoding Recommendations When Used in URLs

Current practice is to imbed DOIs within URLs for transmission via HTTP to be resolved. The URL currently used for the resolution of DOIs is http://dx.doi.org/. A DOI inside a URL would be:
   http://dx.doi.org/10.1006/rwei.1999.0001

DOIs are also primarily used in HTML pages. The DOI *10.1006/rwei.1999".0001* as a link in an HTML page would be:

<A HREF=”http://dx.doi.org/10.1006/rwei.1999%22.0001">10.1006/
rwei.1999%22.0001</A>

Note that ” has been encoded (see next section) to distinguish the DOI in the URL from the surrounding text. The DOI is displayed in its encoded form since users may type the DOI directly into their browsers.

Encoding Issues

There are special encoding requirements when a DOI is used with HTML, URLs, and HTTP. The syntax for Uniform Resource Identifiers (URIs) is much more restrictive than the syntax for the DOI. A URI can be a Uniform Resource Locator (URL) or a Uniform Resource Name (URN).

Hexadecimal encoding must be used for characters in a DOI that are not allowed, or have other meanings, in URLs or URNs. Hex encoding consists of substituting for the given character its hexadecimal value preceded by percent. Thus, # becomes %23 and http://dx.doi.org/10.1000/456#789 is encoded as http://dx.doi.org/10.1000/456%23789. The browser does not now encounter the bare #, which it would normally treat as the end of the URL and the start of a fragment, and so sends the entire string off to the DOI network of servers for resolution, instead of stopping at the #. *Note:* The DOI itself does not change with encoding, merely its representation in a URL. A DOI that has been encoded is decoded before being sent to the DOI Registry. At the moment the decoding is handled by the proxy server http://dx.doi.org/. Only unencoded DOIs are stored in the DOI Registry database. For example, the number above is in the DOI Registry as “10.1000/456#789” *and not* “10.1000/456%23789”. The percent character (%) must always be hex encoded (%25) in any URLs.

There are few character restrictions for DOI number strings per se. When DOIs are embedded in URLs, they must follow the URL syntax conventions. The same DOI need not follow those conventions in other contexts.

Mandatory and Recommended Encoding for DOI Deposit and URLs

Tables 1 and 2 summarize the encoding guidelines for DOI. URLs have the most restricted set of characters. Table 1 lists the characters that should always be hex encoded. Table 2 lists additional characters where it is recommended that characters be replaced by hex-encoding. The distinction between the lists is between practical experience with current web browsers and the more formal specification of URL syntax. In the DOI Directory all characters represent themselves.

Table 1: Mandatory Encoding

Character	Encoding
%	(%25)
"	(%22)
#	(%23)
SPACE	(%20)

Table 2: Recommended Encoding

Character	Encoding
<	(%3c)
>	(%3e)
{	(%7b)
}	(%7d)
^	(%5e)
[	(%5b)
]	(%5d)
'	(%6o)
|	(%7c)
\	(%5c)