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ISO/TC 46 / SC 9

Title

Information and documentation – Identification and description

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P-members of the technical committee or subcommittee concerned have an obligation to vote. Comments from O-members and liaison organizations are also invited.

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English title

Information and documentation — Digital Object Identifier (DOI)

French title

Information et documentation — Identificateur des objets numériques (DOI)

Reference language version: ☒ English   ☐ French   ☐ Russian

Introductory note

CD 26324 specifies the syntax, description and resolution functional components of the Digital Object Identifier (DOI®) system and the general principles for the creation, registration and administration of DOI names. .
A DOI name may be used to identify objects of any material form (digital, physical) as well as abstractions (such as textual works).

It is important to note that a DOI name is not intended as an alternative for an identifier from another scheme, such as those of ISO TC46/SC9 (ISBN, ISSN, ISAN, ISRC, etc.), or other commonly recognised identifiers..

For objects that are identified by another ISO standard identifier, the character string of that ISO identifier would be incorporated into the DOI name in most circumstances. Refer to Annex C for additional information.

A document outlining the disposition of comments at the Working Draft stage is available in the TC46/SC9 document register as SC9 document N 474.

CD 26324 was developed within TC46/SC9 Working Group 7 under the direction of Dr. Norman Paskin of the International DOI Foundation.

ISO TC 46/SC 9 N 475

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Information and documentation — Digital Object Identifier (DOI)

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 26324 was prepared by Technical Committee ISO/TC 46, *Information and documentation*, Subcommittee SC 9, *Identification and description*.

Introduction

The Digital Object Identifier System provides an infrastructure for persistent unique identification of entities (here termed "objects"). In this standard the term "Digital Object Identifier" refers to the system defined in this standard unless otherwise stated. DOI[®1] is an acronym for Digital Object Identifier. The DOI System does not specify the context of its application but is designed to work over the internet. A DOI name is permanently assigned to an object, to provide a persistent link to current information about that object, including where the object, or information about it, can be found on the internet.

Information about an object can change over time, including where to find it, but its DOI name will not change. Applications include but are not limited to: managing content location and access; managing metadata; facilitating electronic transactions; persistent unique identification of any form of any data; commercial or non-commercial transactions. The DOI system provides resolvable, persistent, semantically interoperable identification of entities in a networked environment, and so enables the construction of automated services and transactions.

A DOI name can, within the DOI system, be resolved to values of one or more types of data relating to the object identified by that DOI name, such as a URL, an e-mail address, other identifiers, and descriptive metadata.

The content of an object associated with a DOI name is described unambiguously by DOI metadata, based on a structured extensible data model that enables the object to be associated with arbitrarily precise metadata to support description and services. The data model supports interoperability between DOI applications.

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[1] DOI® is a registered trademark of the International DOI Foundation, Inc. See 8.2.

Information and documentation — Digital Object Identifier (DOI)

1   Scope

This International Standard specifies the syntax, description and resolution functional components of the Digital Object Identifier System (DOI®) system) and the general principles for the creation, registration and administration of DOI names.

A DOI name may be used to identify objects of any material form (digital, physical) as well as abstractions (such as textual works). "DOI" is construed as "digital identifier of an object" (not "identifier of a digital object").

A DOI name is not intended as an alternative for an identifier from another scheme, such as ISBN, ISSN, ISAN, ISRC, etc., or other commonly recognised identifiers. For objects already identified with another ISO standard identifier, the character string of the other ISO identifier (unless the relevant Registration Authority of that standard identifier indicates otherwise, or an integration mechanism cannot be agreed between the relevant Registration Authorities) is integrated into the DOI name.

The scope of the DOI System is not defined by reference to the type of content (format, etc), but by reference to the functionalities it can provide and context of use. The DOI System provides, within networks of DOI applications, for unique identification, persistence, resolution, metadata and semantic interoperability.

This standard does not prescribe specific technologies to deliver these functionalities, which are separately specified by the ISO registration authority for the standard.

This standard also describes how the DOI System may be used with existing ISO identification systems, including to provide additional functionality (such as resolution) where this is not already available.

2   References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Unicode Consortium. *The Unicode^{TM} Standard*[2].

3   Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
DOI application profile
set of DOI names that share some common characteristics. A DOI Application Profile is a grouping mechanism for DOI names; the functional specification of the application profile includes a set of metadata,

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2 Available at: www.unicode.org. Unicode is a trademark of Unicode, Inc. The Unicode Standard imposes additional constraints on implementations of ISO/IEC 10646:2003, Information technology - Universal Multiple-Octet Coded Character Set (UCS) to ensure that they treat characters uniformly across platforms and applications.

comprising the kernel metadata and additional information applicable to that particular genre of object and functional requirements. Each DOI name is associated with one or more Application Profiles.

3.2
DOI metadata
specific metadata associated with a referent within the DOI system, based on a structured data model that enables the referent of the DOI name to be associated with arbitrarily precise metadata to support description and services.

3.3
DOI name
the string that specifies a unique object (the *referent*) within the DOI System. Names may consist of alphanumeric characters in a sequence prescribed by the DOI syntax.

NOTE – The terms "identifier" and "number" are sometimes but not always used in the same sense and are to be avoided where ambiguity might arise. The unqualified use of "DOI" alone may also be ambiguous: the term should instead always be used in conjunction with a specific noun (DOI name, DOI system, etc).

3.4
DOI registration agencies
bodies appointed by the ISO Registration Authority to provide allocation of DOI names prefixes, registering DOI names and providing the necessary infrastructure to allow registrants to declare and maintain metadata.

3.5
DOI resolution
process of submitting a DOI name to a network service and receiving in return one or more pieces of current information related to the identified object. e.g., a location (URL) of the object or metadata. This may involve one or more intermediate mapping operations. The resolution may or may not return an instance of the object. *Multiple resolution* is the simultaneous return as output of several pieces of current information related to the object, in defined data structures.

3.6
DOI resource metadata declaration (RMD)
form of message designed specifically for the exchange of metadata between DOI registration agencies to support their service requirements. It is developed by two or more registration agencies in accordance with format and schema specifications established by the Registration Authority.

3.7
DOI syntax
rules for the form and sequence of characters comprising any DOI name, specifically the form and character of a prefix element, separator, and suffix element.

3.8
DOI system
functional deployment of DOI names as the application of identifiers in computer sensible form through assignment, resolution, referent description, administration, etc. as prescribed by this standard.

3.9
object
entity within the scope of the DOI system; the entity may be abstract, physical or digital, as any of these forms of entity may be of relevance in content management (e.g. people, resources, agreements). A particular object identified by a specific DOI name is the *referent* (q.v.) of that DOI name.

3.10
persistent
existing, and able to be used in services outside the direct control of the issuing assigner, without a stated time limit.

3.11
referent
particular object identified by a specific DOI name.

3.12
unique identification
the specification by a DOI name of one and only one referent.

4 DOI syntax

4.1 General

A DOI name is the string that specifies a unique object (the referent) within the DOI System. The DOI syntax prescribes the form and sequence of characters comprising any DOI name. The DOI syntax shall be made up of a prefix element and a suffix element separated by a forward slash.

There shall be no defined limit on the length of the DOI name, or of its prefix or its suffix elements.

The DOI name shall be case insensitive and may incorporate any printable characters from the Unicode Standard.

The combination of a unique prefix element (assigned to a particular DOI registrant) and a unique suffix element (provided by that registrant) is unique, and so allows the de-centralized allocation of DOI numbers.

The DOI name is an opaque string for the purposes of the DOI system. No definitive information should be inferred from the specific character string of a DOI name. In particular, the inclusion in a DOI name of any Registrant code allocated to a specific organization does not provide evidence of the ownership of rights or current management responsibility of any intellectual property in the referent. Such information can be asserted in the associated DOI metadata.

4.2 DOI prefix

The DOI prefix shall be composed of a Directory indicator followed by a Registrant code. These two components shall be separated by a full stop (period).

EXAMPLE 1   10.1000

The Directory indicator shall be "10". The Directory indicator distinguishes the entire set of character strings (prefix and suffix) as Digital Object Identifiers within the resolution system.

The second element of the DOI prefix shall be the Registrant code. The Registrant code is a unique alphanumeric string assigned to an organization that wishes to register DOI names. The Registrant code is assigned through a DOI Registration Agency. Once a DOI name is assigned the string shall not be changed, including its Registrant code element, regardless of any changes in the ownership or management of the referent object. The original registrant may no longer have any role in maintaining a DOI name and its associated records even though its Registrant code remains a permanent element of that DOI name.

The Registrant code may be further divided into sub-elements for administrative convenience if desired. Each sub-element of the Registrant Code shall be preceded by a full stop. Such sub-division implies no hierarchical relationship; each prefix string, whether subdivided or not, has equal status in the DOI system. However sub-divided prefixes may have technical resolution implications: registrants should consult the Registration Authority for further information before allocating sub-divisions.

EXAMPLE 2   10.1000.10

4.3   DOI suffix

The DOI suffix shall follow the prefix element and shall be separated from it by a forward slash. It shall consist of an alphanumeric character string of any length chosen by the registrant. Each suffix shall be unique to the prefix element that precedes it:

EXAMPLE 3   Showing a DOI name with the prefix element "10.1000" and the suffix element "123456":

10.1000/123456

The unique suffix may be a sequential number, or it may incorporate an identifier generated from or based on another system used by the registrant (e.g. ISBN, ISSN, ISTC).   In such cases, the existing system may specify its own preferred construction for such a suffix.

EXAMPLE 4:   Showing a DOI suffix using an ISSN:

To construct a DOI suffix using an ISSN, precede the ISSN (including the hyphen) with the lowercase letters "issn" and a period, as in the hypothetical example shown below of a DOI for the electronic version of Nature.

10.1038/issn.1476-4687

NOTE − This example iillustraties syntax only. *Nature* has not assigned a DOI at the journal level.

Once a DOI is assigned the DOI string is considered to be opaque (i.e., no meaning should be read into the number) for the purposes of the DOI System.

For further information on the incorporation of existing identifier numbers, see Annex C.

4.4   Visual presentation and other representation of DOI name

When displayed on screen or in print, a DOI name shall be preceded by a lowercase "doi:" unless the context clearly indicates that a DOI name is implied.

EXAMPLE 5: the DOI name 10.1006/jmbi.1998.2354 is displayed as doi:10.1006/jmbi.1998.2354.

The use of lowercase string "doi" follows the IETF specification for representation as a URI (Uniform Resource Identifier), such as "ftp:" and "http:".

When displayed in web browsers the DOI name itself may be attached to the address for an appropriate proxy server, to enable resolution of the DOI name via a standard web hyperlink. The ISO Registration Authority shall maintain a list of approved proxy servers (e.g. http://dx.doi.org/ resolves DOIs in the context of web browsers using the Handle System resolution technology). To resolve a DOI via a standard web hyperlink, the DOI name itself should be appended to the address for the proxy server:

EXAMPLE   6:   the   DOI   name   10.1006/jmbi.1998.2354   would   be   made   an   active   link   as http://dx.doi.org/10.1006/jmbi.1998.2354.

DOI names so represented in a URL and transported by the HTTP protocol are constrained to follow standard IETF guidelines for URI representations. The syntax for URIs is more restrictive than the syntax for DOIs; some characters are reserved and will need encoding. The ISO Registration Authority shall provide current information on appropriate encoding of characters in the User Manual.

Certain client or server software may be able to handle DOIs using native resolution technology (i.e. *doi:10.1006/jmbi.1998.2354* would be interpreted by the browser and automatically resolved without the addition of the proxy server address). The ISO Registration Authority shall provide current information on resolution technology in the User Manual.

DOI names may be represented in other forms in certain contexts (e.g. in the info URI schema).   The Registration Authority shall maintain a list of such representations, which may be modified from time to time, and shall provide this as part of the User Manual.

5 Assignment of DOI name

5.1 Scope of DOI name

A DOI name may be assigned to any object of any form whenever there is a functional need to distinguish it as a separate entity. Registration Agencies may specify more constrained rules for the assignment of DOI names to objects for DOI-related services. Where specified, these rules shall be compatible with the overall DOI system specification and shall not form part of this ISO standard. Rules for assignment of DOI names may include a functional definition of scope based on appropriate metadata through a DOI application profile.

The principal focus of assignment shall be to content-related entities exemplified by, but not limited to: text documents; data sets; sound carriers; books; photographs; serials; audio, video and audiovisual recordings; software; abstract works; artwork, etc., and related entities in their management, e.g. licences, parties.

However, a DOI name is not intended as an alternative for other ISO identifier schemes such as ISBN, ISSN, ISAN, ISRC, and other commonly recognised identifiers. See 5.6 and Annex C for further details.

5.2 Granularity

A DOI name may be assigned to any entity, regardless of the extent to which it may be a component part of some larger entity. DOI names may be assigned at arbitrary levels of granularity or abstraction.

EXAMPLE 7: separate DOI names may be assigned to: a novel as an abstract work; a specific edition of that novel; a specific chapter within that edition of the novel; a single paragraph; a specific image or quotation; as well as to each specific manifestation in which any of those entities are published or otherwise made available, or any other level of granularity which a registrant deems to be appropriate.

5.3 Description

Assignment of a DOI name shall require the Registrant to record metadata describing the entity to which the DOI name is being assigned. The metadata shall describe the entity to the degree that is necessary to distinguish it as a separate entity within the DOI system. In certain cases (which shall be defined in the User Manual) it shall be allowable for no metadata declaration to be made.

5.4 Uniqueness

Each DOI name shall specify one and only one referent in the DOI system. A referent may be specified by more than one DOI name, though it shall be recommended practice that each referent has only one DOI name: thus where multiple DOI names are assigned to the same referent, e.g. through assignment of DOI names by two different registration agencies, the Registration Authority shall encourage registration agencies to collaborate in provide a unifying record for that referent.

5.5 Persistence

No time limit for the existence of a DOI name shall be assumed in any assignment, service or application.

A DOI name and its referent are unaffected by changes in the rights associated with the referent, or changes in the management responsibility of the referent object.

To aid persistence of identification, the Registration Authority shall publish in the User Manual rules which include (but need not be limited to) rules for transfer of management responsibility between Registration Agencies, requirements placed on Registration Agencies for maintenance of records, default resolution services, and technical infrastructure resilience.

The DOI system is not a means of archival preservation of identified entities. The DOI system provides a means to continue interoperability through exchange of meaningful information about identified entities and initiated actions between different systems through at minimum persistence of the DOI name and description of the referent.

5.6   Other identifier schemes

A DOI name is not intended as an alternative for an identifier from another identifier scheme, but when used with them may enhance the identification functionality provided by those systems with additional functionality, such as resolution. Such identifiers include the ISBN, ISSN, ISAN and ISRC, and other commonly recognised identifiers. The guiding principles for referencing other identifier schemes within the DOI System are to maximise utility to potential users, and to maximise efficiency among registration agencies.

If an object or class of objects is already within the scope of another ISO standard identifier, the DOI registration authority shall consult with the registration authority of the other ISO identifier to agree a mechanism for the inclusion of the character string of the identifier within the DOI syntax. The character string of the other ISO identifier shall be integrated into the DOI syntax, unless the relevant Registration Authority of that standard identifier indicates otherwise, or an integration mechanism cannot be agreed.

EXAMPLE 8:   A possible incorporation of an ISBN into a DOI prefix and suffix:

ISBN: 978-86-123-4567-8.

The corresponding DOI incorporating this : 10.978.86123/45678

(note: other agreed syntaxes for an integration are also possible)

EXAMPLE 9:   Showing a DOI suffix using an ISSN:

10.1038/issn.1476-4687

The DOI registration authority, or its agencies as appropriate, shall take all reasonable steps to agree upon such a mechanism and to ascertain whether such an identifier has been assigned before a new DOI name is created. In the absence of any agreement being reached between the relevant registration authorities, there shall be no obligation to include the other ISO standard identifier in the syntax.

Further details are given in Annex C.

6   Resolution of DOI name

6.1   General

Resolution is the process of submitting a specific DOI name to the DOI system and receiving in return the associated values held in the DOI resolution record for one or more types of data relating to the object identified by that DOI name. This may include, but is not restricted to, types of data such as a location (URL), an e-mail address, another DOI name, and descriptive metadata. The referent objects referred to by a particular DOI name may be of various types (e.g. abstract "works", physical "manifestations", performances) that may or may not be directly accessible in the form of a digital file or other manifestation; hence the resolution may or may not return an instance of the object. Resolution may involve one or more intermediate mapping operations.

DOI resolution records may include one or more URLs, where the object may be located, and other information provided about the entity to which a DOI name has been assigned, optionally including but not restricted to: names, identifiers, descriptions, types, classifications, locations, times, measurements, and relationships to other entities.

6.2   Functionality

The technology deployed to manage the resolution of the DOI name shall support the functions listed in a) through l) below:

a)   *Internet compatible*: transmission via the global information system that is logically linked by a globally unique address space and communications..

b) *First class naming*: identifiers resolved by the system shall have identity independent of any other entity.

c) *Unique identification*: the specification by an identifier string of one and only one referent.

d) *Functional granularity*: it shall be possible to separately resolve an entity whenever it needs to be distinguished.

e) *Data typing*: the extensible definition of constraints placed upon the interpretation of certain data entries in a resolution record, such that data values with similar constraints may be grouped and treated in the same way (e.g. for application profile definition).

f) *Multiple resolution*: the simultaneous return as output of several pieces of current information related to the object, in defined typed data structures. Resolution requests should be capable of returning all associated values of current information, individual values, or all values of one data type.

g) *Designated authority*: the administrator of an identifier shall be securely identified, and capable of transfer.

h) *Appropriate access to resolution records*: changes to a resolution record shall be recorded and capable of providing access to the data on which the administrator depends, and privacy and confidentiality from those who are not dependent on it.

i) *DNS independent but compatible*: not reliant on the Domain Name System (DNS), but capable of working with DNS domain naming and resolution services.

j) *Granularity* of administration divisible per name.

k) *Scalable*:

  1) Efficient and infinitely scalable protocol.

  2) No limitations on absolute number of identifiers assigned or length of identifier string.

l) Unicode compliant.

The technologies to deploy the DOI System resolution functionality shall be selected by the ISO Registration Authority for the DOI System. The ISO Registration Authority for the DOI System will ensure that any change of selected technology to meet the functional needs at any point will be compatible with earlier DOI applications.

An exemplar resolution technology is the Handle System. Further information on the Handle System is provided in Annex A.

7 DOI metadata

7.1 General

The object is described unambiguously and precisely by DOI metadata, based on a structured data model that enables the referent of a DOI name to be associated with arbitrarily precise metadata to support description and services associated with a referent. This is designed to:

a) promote interoperability within networks of DOI users by enabling independent systems to exchange information and initiate actions from each other in transactions involving DOI names. Since DOI names may be assigned to any type of entity, such interoperability can be across different types of content (e.g. audiovisual, music and text);

b) ensure minimum standards of quality of administration of DOI names by registration agencies, and facilitate the administration of the DOI system as a whole.

7.2 Functionality

The technology deployed to manage the DOI metadata should support the functions listed in a) to e) below.

a) a generic mechanism to handle complex metadata for all different types of intellectual property.

    EXAMPLE: Instead of treating sound carriers, books, videos and photographs as fundamentally different things with different (if similar) characteristics, they are all recognised as creations with different values of the same higher-level attributes, whose metadata can be supported in a common environment.

b) interoperability across:

    1) media (such as books, serials, audio, audiovisual, software, abstract works, visual material).

    2) functions (such as cataloguing, discovery, workflow and rights management).

    3) levels of metadata (from simple to complex).

    4) semantic barriers.

    5) linguistic barriers.

c) functional granularity: it should be possible to identify an entity whenever it needs to be distinguished.

d) designated authority: the source of an item of metadata should be securely identified.

e) appropriate access to metadata: rule implementation to define access to metadata, and privacy and confidentiality for metadata.

The technologies to deploy the DOI System metadata functionality shall be selected by the ISO Registration Authority for the DOI System. The ISO registration authority for the DOI System will ensure that any change of selected technology to meet the functional needs at any point will be compatible with earlier DOI applications.

An exemplar metadata technology is the Contextual Ontology Architecture resulting from development of the indecs analysis, deployed for creating data dictionaries in a number of current applications including the ISO MPEG 21 Rights Data Dictionary specified in ISO/IEC 21000-6. Compatibility with this data dictionary provides semantic interoperability between DOI metadata and the metadata element sets used by other systems similarly mapped through that data dictionary. Further information on the contextual ontology architecture is provided in Annex B.

7.3 Registration of DOI metadata

7.3.1 Assignment of a DOI name shall require the Registrant to record metadata describing the entity to which the DOI name is being assigned.

7.3.2 The DOI Registration Authority shall publish the DOI Kernel Metadata Declaration which specifies the metadata that each DOI Registration Agency shall ensure is recorded for each DOI name for which it is responsible. Further information on the DOI Kernel Metadata Declaration is contained in Annex B.

7.3.3 A DOI registration agency shall be responsible for collecting from each registrant metadata about the entity to which a DOI name is being assigned and shall ensure that such metadata is recorded promptly and accurately. This metadata shall meet the minimum requirements of the DOI Kernel Metadata Declaration.

A DOI registration agency shall also provide output metadata to support the services of the DOI system.

There are no restrictions on the form and content of a registration agency's input and service metadata declarations, other than input metadata must support the minimum requirements of the DOI Kernel Metadata Declaration. DOI registration agencies should specify their own metadata schemes and messages, or use any existing schemes in whole or part for their input and service metadata declarations, in compliance with a

DOI Resource Metadata Declaration developed in accordance with format and schema specifications established by the DOI Registration Authority.

7.3.4   The Registration Authority shall provide a Data Dictionary as the repository for all data elements and allowed values used in DOI metadata specifications, to facilitate interoperability across selected existing schemes.

See also Annexes B and F.

8   Administration of the DOI system

8.1   General

The Registration Authority for this International Standard shall be the International DOI Foundation (IDF)[3]. The DOI system shall be administered by the International DOI Foundation, and by DOI registration agencies appointed by the International DOI Foundation, in accordance with the specifications in Annex D.   The Registration Authority shall make available a User Manual to registration agencies, which shall specify implementation details in conformance with this standard.

8.2   Trademark

DOI® is a registered trademark of the International DOI Foundation, Inc. ("International DOI Foundation"). This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the validity or geographical scope of the trademark rights, or of the product named. The International DOI Foundation authorizes persons who create software or other products or services that comply with the DOI® System to use the mark DOI® free of charge in truthfully stating that their products or services comply with ISO 26324 and in references to the DOI® System and DOI® names, provided (i) that they identify DOI® as a trademark of IDF and (ii) that they place the superscript symbol "®" following the letters "DOI" in any printed or electronic document at its first occurrence, with the exception that when expressed as a URL or similar syntactic string "doi" forms part of the presentation of the DOI Name and need not be so identified.

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[3]   International DOI Foundation. E-mail: info@doi.org. Web site: www.doi.org.

Annex A
(normative)

Roles within administration of the DOI System

A.1 Registration Authority

A.1.1   The DOI system shall be administered by a Registration Authority, the International DOI Foundation, and by appointed DOI registration agencies providing services to registrants, in accordance with the specifications outlined in A.1.2 below.

A.1.2   The Registration Authority shall perform the functions and provide the services described in a) to k) below.

a)   Promote, co-ordinate and supervise the DOI system in compliance with the specifications of this International Standard.

b)   Appoint appropriate organizations as DOI registration agencies and revoke such appointments as necessary.

c)   Supply, or appoint appropriate organizations to supply, technology and infrastructure for resolution, metadata and registration functionality in compliance with the specifications of this International Standard, and which may be modified from time to time in order to ensure effective deployment of the functionality. The ISO Registration Authority for the standard will ensure that any selected technology to meet the functional needs at any point will be compatible with earlier DOI applications. Exemplar technologies that provide such functions are illustrated in the informative annexes of this standard.

d)   Allocate unique DOI prefixes to registrants via registration agencies and maintain an accurate register of the registration agencies and DOI prefixes that have been assigned.

e)   Secure the maintenance of DOI names and associated DOI resolution records through the maintenance of a single logical directory of all registered DOI names, the DOI Directory.

f)   Enable the registration and mapping of DOI metadata through the maintenance of, or agreed use of, an appropriate data dictionary, data model and associated policies for the DOI system, to promote the interoperability of DOI information and transactions among independent systems within networks of DOI users, and ensure minimum standards of quality of administration of DOI names by registration agencies, and facilitate the administration of the DOI system as a whole.

g)   Develop, implement, monitor and enforce policies and procedures governing the operations of DOI registration agencies and the process of DOI registration by those agencies, including rules to aid persistence of DOI names and interoperability within networks of DOI users, rules for the transfer of records and data, transfer of management responsibility between Registration Agencies, requirements placed on Registration Agencies for maintenance of records, default resolution services, and technical infrastructure resilience.

h)   Review and decide on appeals of decisions made by DOI registration agencies in such matters as rejection of DOI applicants and disputes concerning the appropriateness of assignments of DOI names.

i)   Develop, maintain and make available documentation for users of the DOI system, including the provision of a User Manual to registration agencies which shall specify implementation details in conformance with this standard.

j) Review relevant technology developments and maintain current information on appropriate syntax character encoding, resolution software implementations, etc.

k) Where multiple DOI names are assigned to the same referent, e.g. through assignment of DOI names by two different registration agencies, the Registration Authority shall encourage registration agencies to collaborate in provide a unifying record for that referent.

A.2 DOI registration agencies

A.2.1 A DOI registration agency shall perform the functions and provide the services described in a) to f) below.

a) Provide services for the initial registration and subsequent maintenance of DOI names and associated metadata declarations in conformance with, and subject to, the rules of the Registration Authority, using the DOI resolution system and data management policies specified by the Registration Authority.

b) Support the verification of a participant in the DOI system. This verification may comprise capturing and verifying the participant's credentials. The credentials may comprise a username and password.

c) Allocate unique DOI prefixes to registrants and maintain an accurate register of the DOI names/prefixes that have been assigned by those registrants.

d) Support the distributed deployment of any default resolution service(s) specified by the Registration Authority.

e) Enable the production of a DOI Kernel Metadata Declaration for each DOI name issued.

f) Where multiple DOI names are assigned to the same referent through assignment of DOI names by two different registration agencies, collaborate with the registration authority in provide a unifying record for that referent.

A.2.2 If a registration agency chooses to maintain its own directory for DOI names assigned by the registrants to which it has allocated a DOI prefix, the registration agency shall mirror that service in the single logical directory of all registered DOI names maintained by the Registration Authority, the DOI Directory, so as to ensure that resolution information for every DOI name issued is available in the DOI Directory maintained by the Registration Authority.

A.2.3 If a registration agency chooses to operate its own data dictionary or maintain a mirrored copy of the Registration Authority's data dictionary, such service shall at a minimum perform the same functions as the public DOI data dictionary and shall comply with the policies and procedures specified by the Registration Authority regarding the maintenance and safekeeping of DOI metadata.

A.2.4 Metadata exchanged between registration agencies to support DOI services should be exchanged using an agreed DOI Resource Metadata Declaration for the Resource or Service type. Proprietary terms (data elements and values) used by registration agencies in Kernel and Resource Metadata Declarations should be registered in the Registration Authority's Data Dictionary.

A.3 Registrants

Each DOI registrant shall perform the functions listed in a) to c) below:

a) ensure that each suffix element assigned within their Registrant code is unique, thereby ensuring that each DOI name is unique within the DOI system.

b) ensure that each referent they register is assigned only one DOI name.

c) ensure that each DOI suffix/name they assign is registered with the required Metadata Declaration in the DOI resolution system, following the specifications established by the International DOI Foundation and any further rules of the appropriate Registration Agency.

A.4 Validation of DOI registrations and metadata

Each DOI registration and its associated metadata may be subject to verification at intervals determined by the relevant DOI registration agency. Verification shall include actions to determine the outcome and validity of a resolution request performed on a DOI name.

Registration agencies shall also be responsible for validating information on registrants and participants in the DOI system, which may comprise the capture and verification of credentials such as a user name and password.

Registration agencies shall ensure that the outcome of any verification checks is accurately reflected in the resolution record and/or metadata associated with a specific DOI name in the DOI system.

Annex B
(normative)

DOI metadata specifications

B.1 Data Dictionary

The Registration Authority shall provide a Data Dictionary as the repository for all data elements and allowed values used in DOI metadata specifications.   Further details shall be provided in the User Manual. The Data Dictionary shall enable the definition within an ontology of all metadata elements to be available to all registration agencies, and provide the mappings to support metadata integration and transformations required for data interchange between registration agencies.

If an RA wishes to consolidate metadata provided by several other registration agencies for a specific service, the Data Dictionary will provide the data mappings required to enable the registration agency to present the consolidated metadata as if from a single set. The Data Dictionary shall also contain mappings of other relevant schemes, as determined by the registration authority (such as ONIX, the ISO/IEC 21000-6 Rights Data Dictionary, and the ISO codes for territories, currencies and languages).

All allowed values used by a registration agency in its Kernel Metadata, and all data elements used by a registration agency when mapping to a DOI Resource Metadata Declaration RMD, shall be registered in the Data Dictionary.

B.2 DOI Kernel Metadata Declaration

Table 1 shows the basic descriptive elements in a DOI Kernel Metadata Declaration, also known as the DOI Kernel. The formal specification of the DOI Kernel Metadata Declaration is given in an XML schema maintained and published by the DOI Registration Authority. In order to be coherent, the definitions in such a list of elements must be based on one specific scheme. The list here is based on the exemplar COA model (see Annex B); should another technology be selected for DOI metadata deployment the ISO Registration Authority shall define and publish any changes necessary to support these definitions so as to be compatible with earlier DOI applications.

Kernel element(s)	Comment
DOI name	Specific DOI name allocated to the identified referent.
resourceIdentifier(s)	Other identifier commonly referencing the same referent (e.g. ISBN, ISRC, ISSN).
resourceName(s)	Name by which the referent is usually known (e.g. title).
principalAgent(s), agentRole(s)	Entity that is principally responsible for the creation or publication of the referent, with specification of that agent's role(s).
structuralType	Specification of type of fixation, expression or abstraction (e.g. physical fixation, digital fixation, performance, abstract work), from a set of allowed values specified by the Registration Authority.
Character(s)	Specification of fundamental character of the content of the referent (eg music, language, visual, other).
mode(s)	Specification of medium of expression of the referent (e.g. audio, visual, audiovisual, abstract), from a set of allowed values specified by the Registration Authority.
referentType	Specification of type of referent (e.g. an audio file, scientific journal,

	musical composition, dataset, serial article, eBook, pdf etc), from a set of allowed values specified by the Registration Authority.

Table 1 – Descriptive elements of the DOI Kernel Metadata Declaration

Table 2 shows the basic administrative elements in a DOI Kernel Metadata Declaration. These elements relate to the issuance of the DOI name and to the registration record itself.

Kernel element	Comment
RegistrationAgency	Name of the registration agency which issued this DOI name.
IssueDate	Date when this DOI name was issued.
IssueNumber	Number or other designation associated with the specific version identified.

Table 2 – Administrative elements of the DOI Kernel Metadata Declaration

The Registration Authority shall specify the Kernel elements that will be used in common by all DOI registration agencies and shall issue prescribed sets of allowed values for such elements. For other elements and sub-elements, DOI registration agencies may develop and use their own choice of values as needed. However, each DOI registration agency shall register such value sets in the data dictionary specified by the Registration Authority in order to facilitate the integration of DOI data from different sources by a common application.

B.3 DOI Resource Metadata Declaration

A DOI Resource Metadata Declaration (RMD) is a form of message designed specifically for the exchange of metadata between DOI registration agencies to support their service requirements. It is developed by two or more registration agencies in accordance with format and schema specifications established by the Registration Authority. In order to be coherent, the definitions in such a list of elements must be based on one specific scheme.   Further information is provided in Annex F.

Annex C
(normative)

The DOI system in relation to other identifiers for content entities

C.1 Principles

The DOI name is not intended as an alternative for an identifier from another sscheme for content entities, but when used with them may enhance the identification functionality provided by those systems with additional DOI system functionality.

The guiding principles for referencing other identifier schemes within the DOI System are to maximise utility to potential users, and to maximise efficiency among registration agencies.

If an existing identifier scheme is referenced within a DOI name and/or DOI metadata, the registration authority for each identifier scheme shall retain its autonomy and take precedence in determining rules for its application and usage within its own system.

If an object or class of object is within the scope of another ISO standard identifier, the DOI registration authority shall consult with the registration authority of the other ISO identifier to reach mutual agreement so that existing services are not disrupted.

C.2 Incorporation of an existing identifier into a DOI name.

If an object or class of object is within the scope of another ISO standard identifier, the DOI registration authority shall consult with the registration authority of the other ISO identifier to agree a mechanism for the inclusion of the character string of the identifier within the DOI syntax. The character string of the other ISO identifier shall be integrated into the DOI syntax, unless the relevant Registration Authority of that standard identifier indicates otherwise, or an integration mechanism cannot be agreed. The existing identifier(s) shall also be indicated in the DOI metadata field "resourceIdentifier(s): Other identifier commonly referencing the same referent".

If an object or class of object is within the scope of another non-ISO standard identifier, the DOI registration authority may consult with the registration authority of the other identifier to agree a mechanism for the inclusion of the character string of the identifier within the DOI syntax. The character string of the other identifier may be integrated into the DOI syntax, unless the relevant Registration Authority of that standard identifier indicates otherwise, or an integration mechanism cannot be agreed. The existing identifier(s) may also be indicated in the DOI metadata field "resourceIdentifier(s): Other identifier commonly referencing the same referent".

If a DOI application is envisaged for entities for which there is no existing scheme available or in widespread use, the DOI system may be used to create new actionable identifiers.

EXAMPLE: The CrossRef application used (from 2000 onwards) DOI names with a variety of otherwise incompatible numbering schemes from different publishers to refer to textual abstractions at the article level, and to make these schemes interoperable within the CrossRef service.

C.3 Expressing the relationship of DOI names to other identifier schemes within the DOI system.

Where the referent of a DOI name also has an existing identifier (or identifiers) within a commonly recognised scheme or schemes, one or both of the following methods shall be used to express the relationship(s):

a) other existing identifier(s) shall be indicated in the DOI metadata field "resourceIdentifier(s): Other identifier commonly referencing the same referent", irrespective of whether such an identifier is incorporated into the syntax of the DOI name; and/or

b) an existing identifier may be incorporated as an explicit part of the DOI name for the referent.

If an object is identified with another ISO standard identifier, both are required (see C.2 and B.2 Table 1); for non-ISO schemes the selection of an appropriate practice will depend upon agreement between the appropriate registration authorities. The appropriate registration authorities may share or compare the values and updating processes for accompanying metadata.

Where syntax rules are agreed to incorporate an existing identifier as part of the DOI name, such rules shall be compatible with the overall DOI system specification; shall be compatible with the standard specification of the existing identifier; and shall not form part of this ISO standard. In such cases attention is drawn to the following points:

a) The Registration Agency shall ensure that the same referent is denoted by both the DOI name and the included identifier string, to the degree that is necessary to distinguish it as a separate entity within each system

b) Within the DOI system itself, the DOI name is an opaque string. No definitive information relating to the other identifier system should be inferred from the specific character string used for a DOI name, and the DOI name is not guaranteed to be usable in any non-DOI applications designed for the other identifier scheme (though automated parsing to facilitate this is encouraged).

c) The existence of multiple (third, fourth etc) identifiers should be recognised in the DOI metadata field "resourceIdentifier(s): Other identifier commonly referencing the same referent" by multiple values, rather than by incorporation in the DOI name.

C.4 Additional functionality

The DOI system functionality may be offered in addition to, or parallel to, other identifier services which are available through other parties e.g. for the resolution of identifiers in a variety of contexts. Services using an identifier may be offered by multiple providers: rules of certain identifier systems may necessitate the use of only specified preferred service providers; in such cases the application of the identifier shall follow the rules of the relevant registration authority. Each registration authority for an identifier scheme shall retain autonomy and precedence in determining rules for usage within its own scheme or community.

Annex D
(informative)

Exemplar resolution technology: The Handle System

D.1 General

The technologies to deploy the DOI System resolution functionality shall be selected by the ISO Registration Authority for the DOI System. The ISO registration authority for the DOI System will ensure that any change of selected technology to meet the functional needs at any point will be compatible with earlier DOI applications.

An exemplar technology, currently in use, is the Handle System as defined in RFC 3650, RFC 3651 and RFC 3652 of the Internet Engineering Task Force (IETF). Information on the Handle System is available at http://www.handle.net

D.2 General description of the Handle System

The DOI system currently uses an implementation of the Handle System for the resolution of DOI names. The Handle System is a comprehensive system for assigning, managing, and resolving persistent identifiers, known as "handles," for digital objects and other resources on the Internet. Handles can be used as Uniform Resource Names (URNs). Handles resolve to typed data. The software has a public license, similar to an open source license, in order to enable broader use of the technology

The Handle System includes an open set of protocols, a namespace, and a reference implementation of the protocols. The protocols enable a distributed computer system to store names, or handles, of digital resources and resolve those handles into the information necessary to locate, access, and otherwise make use of the resources. That information can be changed as needed to reflect the current state and/or location of the identified resource without changing the handle. This allows the identification of the item to persist over changes of its location and other associated information. Each handle may have its own administrator(s) and administration of these handles can be done in a distributed environment. The name-to-value bindings may also be secured, allowing handles to be used in trust management applications.

Implementation of the Handle System consists of Local Handle Services, each of which is made up of one or more sites which provide the servers that store specific handles. The Global Handle Registry® is a unique Local Handle Service which stores information on the naming authorities within the Handle System and can be queried to find out where specific handles are stored on other Local Handle Services within this distributed system.

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D.3 Deployment of Handle System functionality

Handle clients can be embedded in end user software (e.g. a web browser) or in server software (e.g. a web server).   The choice is one of embedding functionality in individual clients (which puts it closer to the end user,

and simplifies the architecture, but means that you have to deploy and maintain the software using plug-ins etc.) versus simpler maintenance of a centralized piece of middleware (which means that the users must all then talk to that middleware). Handle client software libraries in both C and Java are freely available. In the Java API all strings are Unicode and are only encoded into UTF-8 when they are stored as bytes; i.e. each Unicode character is encoded into its UTF8 representation for storage and communication.

Examples of Handle system functional deployment are available at http://www.doi.org/tools.html, http://www.doi.org/doi_proxy/index.html and http://www.handle.net/ . These include:

a) The CNRI Handle URI . Resolver, a web browser extension, or plug-in, that enables selected browsers to recognize the handle protocol and communicate directly with the Handle System to resolve handles to their associated URLs, available at http://www.handle.net/other_software.html. Without the plug-in, web browsers may be directed to a proxy server, a client software that understands the handle protocol, to resolve the handle to a URL. Attaching a handle to a proxy URL will permit any browser to use the client to resolve that handle. CNRI maintains proxy client servers including "hdl.handle.net" and "dx.doi.org"; a public DOI proxy client is available at: http://dx.doi.org.

b) CNRI proxy server system, a collection of web servers that understands the handle protocol and how to talk to the Handle System. Many implementations of the Handle System intended to help manage web content use handles embedded in URLs on web pages, and for the convenience of their customers, use the proxy server (or a similar implementation) for resolution. A growing ecology of other tools for handles is developing, both from CNRI and from outside parties.

c) The Handle Plug-in for Adobe Acrobat® and Acrobat Reader® is an extension that adds functionality to PDF documents with embedded handles. When a PDF with embedded handles is opened, the plug-in resolves the handles and performs tasks based on the expected standard data types and values returned from the Handle System. The plug-in has a modular design so that support for new data types can be added incrementally as the need arises. When installed, the plug-in may add buttons to the Toolbars, or open windows or display alerts, depending on the type of data stored with the handles that are embedded in the document. Its utility depends on an agreed upon set of functions and an agreed upon set of handle type/value pairs corresponding to those functions.

Annex E
(informative)

Exemplar metadata technology: the Contextual Ontology Architecture

E.1 General

The technologies to deploy the DOI Metadata functionality shall be selected by the ISO Registration Authority for the DOI System. The ISO registration authority for the DOI System will ensure that any change of selected technology to meet the functional needs at any point will be compatible with earlier DOI applications.

An exemplar technology currently in use is the COA (Contextual Ontologyx Architecture).

E.2 General description of Contextual Ontologyx Architecture

The COA (Contextual Ontologyx Architecture) is a metadata framework that supports integrated, extensible systems development and interoperability between systems and standards. It is a generic ontology-based metadata framework comprised of defined types of entity and attribute, and the relators that link them within a contextual model structure (where context is defined as an intersection of *time* and *place*, in which *entities* may play roles).

Applications of COA were initially in the media and rights domains, in a number of current applications (including the ISO MPEG 21 Rights Data Dictionary specified in ISO/IEC 21000-6), but the architecture is generalized and in principle may be applied to any domain or system. Its primary purpose is to facilitate machine-to-machine communication when using terms drawn from different schemes - different systems within the same organisation or between one organisation and another - without losing or changing the meaning of the metadata being communicated. This enables re-expressing a complex communication from one "view" to another - for example, from a flat, "descriptive" view to an event-based "contextual" view

The ontology uses a framework of prescriptive terms and relationships. Terms can have any number of relationships with other terms, and any number of defined types of relationship from which meaning may be inherited. The ontology also contains sets of rules that will determine relative to a specific community what must or must not be present in a particular set of circumstances.

Everything in the COA may ultimately be expressed in terms of "when", "where", "what" and "how". All definitions in the COA originate from these concepts, their defined inter-relationships, and critically the "Context" in which they inter-relate. Context is defined as "an entity at the intersection of Time and Place, in which other entities may play Roles".

The Context Model is based on the assumption that Time and Place are primitive and universal entities. Times and Places may combine to form particular Contexts, within which the roles of other entities are established and all meaning defined.

The framework is extensible and can accommodate any level of granularity required by a community to express its meaning.

Meaning within the framework is prescriptive, and the framework is highly generalised and fully integrated. Therefore it is always possible to express an unambiguous relationship between terms in a way that enables machine to machine communication.

COA is highly configurable and so it is possible to create structures that are as simple as required whilst ensuring that they conform to a coherent overall structure.

E.3 COA status

The COA is the framework used in ontologies developed by Ontologyx Ltd.   The COA MetaModel is a proprietary model which has its immediate origins in the development of the <indecs> metadata framework (1998-2000). The subsequent development of COA has been advanced by, and has in turn influenced, a number of other metadata and identifier schemes and projects, some of which are now supported by ontologies based on the COA. Some of these applications may have further IP associated with them.

The Contextual Ontologyx Architecture builds on a patent held by the CONTECS:DD consortium, declared as part of International Standard ISO/IEC 21000-6 (Information technology - Multimedia framework (MPEG-21) - Part 6: Rights Data Dictionary) which is available under license under reasonable and non-discriminatory terms.

Intellectual property rights in the COA are owned by Ontologyx Ltd. Ontologyx Ltd is committed to make available a document describing the key building blocks of the COA (the "COA MetaModel") that can be used to re-create the COA for the internal use of communities' subject only to the ensuing work not being exploited commercially.

Annex F
(informative)

DOI Resource Metadata Declaration

The ISO Registration Authority shall establish format and schema specifications for the DOI Resource Metadata Declaration (RMD). A DOI Resource Metadata Declaration (RMD) is a form of message designed specifically for the exchange of metadata between DOI registration agencies to support their service requirements. It is developed by two or more registration agencies in accordance with format and schema specifications established by the Registration Authority. In order to be coherent, the definitions in such a list of elements must be based on one specific scheme. The Declaration here is based on the exemplar COA model (Annex E); should another technology be selected for DOI metadata deployment the ISO Registration Authority shall define and publish any changes necessary to support these definitions so as to be compatible with earlier DOI applications.

The RMD uses a generic metadata structure of basic data element classes, developed from the COA MetaModel. The COA MetaModel was designed to incorporate all types of Resource metadata in a structured and flexible way. Table 3 shows the eleven RMD basic elements, and those to which class each of the more specialized Kernel elements belong. Specific data elements within an RMD may be established for individual registration agencies or defined application profiles, thereby allowing the same RMD to be used flexibly within a broad community of interest.

Any RMD shall be available for use by any registration agency, and any registration agency may contribute to the editorial development of a RMD.

RMD element class	Comments	Includes RMD Kernel elements
identifier	Unique name(s) by which the referent is known	DOI name, resourceIdentifier
name	Non-unique name(s) by which the referent is known	resourceName
annotation	Description of, or comment about, the referent	
quantity	Numeric measurement of an aspect of the referent	
category	Type, class, quality or subject of the referent	structuralType, resourceType, mode
flag	A Boolean (true/false) classification of the referent	
context	Specific event or state involving the referent	
agent	Person or organization who performed a specific action in relation to the referent	primaryAgent, agentRole
Time	Time (point-in-time or period) in relation to which a specific event or state occurred involving the referent	
Place	Location (geographical or virtual) in relation to which a specific event or state involving the referent occurred	
resource	Other referent(s) related to the identified referent	

Table 3 – RMD basic element classes

RMDs may incorporate data elements, allowed values, codes, etc. from any other standard or proprietary message or metadata schemes (e.g. ONIX, MARC, etc). ISO codes and formats for languages, territories, currencies, measures, dates and times shall be used where applicable.

All element types and allowed values for an RMD shall be registered in the Data Dictionary specified by the Registration Authority. A registration agency that wishes to make use of a RMD shall register the corresponding data elements and values in its own database to ensure reliable mapping by other RAs.

Registration agencies may use existing standards to communicate metadata between them when appropriate (e.g. if two registration agencies are providing services requiring ONIX metadata, they may agree to communicate with each other using the ONIX message format).

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