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Digital Object Identifier (DOI) System: An Overview

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Abstract: *A Digital Object Identifier (DOI) is an internationally accepted standard that provides unique identification or a permanent link consisting of an alphanumeric string assigned to digital objects such as articles, books, databases, and multimedia files to identify and locate them on the internet. The aims of this paper are to describe the concept of the Digital Object Identifier (DOI), the history of DOI, an outline of the DOI system, the features of DOI, and its benefits.*

KeyWord: *Digital Object Identifier (DOI), DOI Agency, DOI system, Crossref.*

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Understanding of Digital Object Identifier (DOI)

A digital object identifier (DOI) is a character string used to uniquely identify an electronic document or other object. DOI is a tool for the location and identification of digital information published on the Internet. It is an advanced tool that provides unique identification or permanent links to identify specific journal articles and other information resources on the web. The DOI is typically located on the first page of an electronic document, near the copyright notice, and on the database landing page for the document (American Psychological Association, 2018). Developed by a group of international publishers, the DOI system provides a way to guarantee that digital copies of articles can remain accessible even if a journal changes its domain name or ceases publishing. (Hume-Pratuch, 2014).

Digital object identifiers have been compared to barcodes because they are persistent identifiers that catalogue content and track movement (Ye, 2007). DOI is specifically in online contents. The contents that have been identified by DOI so far are journals and journal articles, books and book chapters, conference proceedings, technical reports, working papers, preprints, standards, theses and dissertations, components (e.g., graphs, figures), and reviews (CrossRef, 2017). Higgins (2017) noted that the versatility of DOIs means they can be assigned to journal articles, datasets, supplemental material, and addenda; to audio, video, streaming media, and 3D objects; to theses, dissertations, technical reports, visualizations, and pre-prints of articles. Even though the DOI system does not provide a central search capability, as stressed by Tiliute (2016), most web search engines will show DOI names in the results of a search by title, by name, or by topic or related terms, while the reverse will also work.

In another development, DOls as a tool can be employed in some studies relating to Altmetrics and Bibliometric (Hausten, Costal, and Lariviere, 2015). Altmetrics are social web metrics foracademic publications incorporating a number of variables like downloads, view count, andcomments, so as to measure the impact of articles (Galligan and Dyas-Correia, 2013). Kasdorf (2012) opine that it is high time to make DOIs as indispensable to scholarly books, conference proceedings, reports, and datasets as they are to journals. More so, that citation counts andcitation metrics are increasingly depending on DOIs, hence scholarly materials that do not have.

DOIs can be ignored by the systems which generate these important metrics. Thereby, giving rise to underestimation of the impact of such academic publication. Interestingly, all major publications within any given scientific field now use a digital identifier which is DOI for each electronic published document noticed either on the electronic version of the paper either on theprinted version or both (Tiliute, 2016).

The term "Digital Object Identifier" is construed as "digital identifier of an object," rather than "identifier of a digital object": the objects identified by DOI names may be of any formdigital, physical, or abstractas all these forms may be necessary parts of a content managementsystem. The DOI system is an abstract frameworkwhich does not specify a particular context of its application,but is designed with the aim of working over theInternet. (Khan, 1999)

A DOI name is permanently assigned to an object, toprovide a persistent link to current information about thatobject, including where it, or information about it, can befound. The principal focus of assignment is to contentrelatedentities; that term is not precisely defined but isexemplified by text documents; data sets; sound carriers;books; photographs; serials; audio, video, and audiovisualrecordings; software; abstract works; artwork, etc., andrelated entities in their management, for example,licenses or parties. A DOI name is not intended as areplacement for other identifier schemes, such as thoseof ISO TC46/SC9, ISBN, ISSN, ISAN, ISRC, etc., or other commonly recognized identifiers: if an object isalready identified with another identifier string, the characterstring of the other identifier may be integrated intothe DOI name syntax, and/or carried in DOI metadata, foruse in DOI applications. (ISO)

A DOI name may be assigned to any object wheneverthere is a functional need to distinguish it as a separateentity. Registration agencies may specify more constrainedrules for the assignment of DOI names to objectsfor DOI-related services (e.g., a given registration agencymay restrict its activities to one type of content or onetype of service). (Paskin, 2009)

History

The DOI system was the result of a publishing industryinitiative in the late 1990s, which recognized the need touniquely and unambiguously identify content entities, ratherthan refer to them by locations, and commissioned a study tospecify an appropriate technical solution, selected, if possible, from one or more existing technologies rather than developinga new system. The International DOI Foundation wasincorporated in 1998 to develop the system with the aim to provide a framework of managing intellectual contents, like customers with publishers facilitate electronic commerce and enable automated copyright management. The first DOI registrationagency began in 2000. The most widely known application of the DOIsystem is the Crossref cross-publisher citation linking servicewhich allows a researcher link from a reference citationdirectly to the cited content on another publisher's platform,subject to the target publisher's access control practices. The development of the DOI system has proceededthrough three parallel tracks:

- An initial implementation of persistent naming: a single redirection from a DOI name to a digital location (URL) of the entity or information about it.
- The development of more sophisticated means of management such as contextual resolution, where the result of a redirection is also a function of some additional information such as local holdings information.
- Collaboration with other standards activities in the further development of tools for managing entities in a digital environment. (Paskin, 2009)

DOI System: Outline

DOI is an acronym for Digital Object Identifier. The DOI system provides for unique identification, persistence, resolution, metadata, and semantic interoperability of content entities ("objects"). Information about an object can change over time, including where to find it, but its DOI name will not change. The DOI system brings together

- A syntax specification, defining the construction of a string (a DOI name)
- A resolution component, providing the mechanism to resolve the DOI name to data specified by the registrant
- A metadata component, defining an extensible model for associating descriptive and other elements of data with the DOI name
- A social infrastructure, defining the full implementation through policies and shared technical infrastructure in a federation of registration agencies

The DOI system operates through a tiered structure:

- The International DOI Foundation is the umbrella organizationdefining the rules and operation of the system.It is a non-profit member-funded organization.
- Registration agencies are all members of the International DOI Foundation, and have a contractual arrangement with the Foundation including a license to operate the DOI system. They provide defined services in specific sectors or applications. DOI registration is normally only a part of the service such an organization offers, since assignment of an identifier is usuallydone for the purpose of a specific initial service or application. An example is the CrossRef registration agency, [8] which provides services to publishers for linking reference citations in articles based on DOI identified articles. Registration agencies may collaborate, or remain relatively autonomous.
- DOI names are registered by clients via a registration agency (e.g., in the case of the CrossRef agency, individual publishers are clients using the CrossRef service). Part of

this process may be undertaken by the registration agency, as part of its service offering. If a suitable registration agency cannot be found for a certain sector, the International DOI Foundation will seek to appoint one.

DOI is a registered trademark of the International DOI Foundation, Inc. (abbreviated to IDF). The preferred usage, to avoid ambiguity, is with a qualifier to refer to either specific component of the DOI system (e.g., "DOI name": the string that specifies a unique referent within the DOIsystem); or the system as a whole ("DOI system": the functional deployment of DOI names as the application of identifiers in computer-sensible form through assignment, resolution, referent description, administration, etc.) (Paskin, 2009).

Structure of a DOI

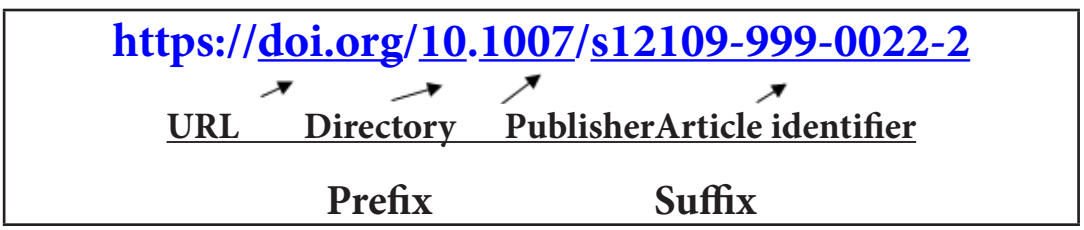
DOI stands for "Digital Object Identifier" which is a persistent identifier used to uniquely identify digital objects such as journal articles, books and databases. The DOI syntaxprescribesthe form and sequence of characters comprising any DOI name. A DOI is composed of two components: a prefix and a suffix separated by a forward slash (/).There is no defined limit on the length of the DOI name,or of its prefix or its suffix elements.

Prefix: The prefix identifies the organization responsible for managing the DOI.

The Prefix of a DOI consist of three elements: the ULR, directory code and publisher's code (its fixed for a publisher) and each elements prefix separated by a forward slash (/). The most common DOI prefix is "10".

Suffix: The suffix identifies the specific digital object. The suffix is one element. After the slash of prefix, the article identifier code is placed. This identifier is set by the publisher to identify each published article. The suffix can include letters, numbers and special charters.

Example: DOI: https://doi.org/10.1007/s12109-999-0022-2



International DOI Foundation (2015) mentioned functionalities and Benefits of implementing the DOI systems:

Functionalities:

1. Persistence, if material is moved, rearranged, or bookmarked;
2. Interoperability with other data from other sources;
3. Extensibility by adding new features and services through management of groups of DOI

names;

4. Single management of data for multiple output formats (platform independence);
5. Class management of applications and services; and
6. Dynamic updating of metadata, applications and services.

Benefits of implementing the DOI systems are:

1. Facilitating internal content management.
2. Enabling faster, more scalable product development, by delivering four key advantages in making it easier and cheaper. (Fasae and Oriogu, 2018).

DOI Registration Agency and the Registrant

DOIs are assigned and maintained by registration agencies. Registration Agencies (RAs) provide services to people or organisations who need to identify and track the things that matter to them. Their work involves allocating DOI prefixes, registering DOI names, and providing a metadata schema associated with each DOI record.

As each RA represents a distinct industry or a community, most have developed unique services that build on top of the basic DOI registration that are useful for the communities they serve. Every RA is different but they all abide by certain commitments.

International DOI Foundation (2016) stated that Registration Agencies provide services such as allocating prefixes, registering DOI names and providing the necessary infrastructure to allow Registrants to declare and maintain metadata and state data to Registrants. This service is likely to cover quality assurance measures, in order to maintain the integrity of the DOI system as a whole at the highest possible level. IDF highlighted the roles of Registration Agency and Registrant as follows;

Registration Agency

1. Offers services for registration of prefixes and individual DOI names using the DOI system.
2. Provides added-value services for registrants and other customers.
3. Must be a member of the IDF.
4. Engages in marketing, training, development, etc. for their chosen community.
5. May maintain a Handle mirror site (optional).
6. May subcontract their service provision (optional).

Registrant

1. Can be any individual or organization that wishes to uniquely identify entities using the DOI system.
2. Registers DOI names with a Registration Agency. If a registrant has multiple types of content or application requirements, it may choose to use several RAs to provide services.
3. Ensures appropriate content management of their own material (maintenance of URLs and data), either directly or by contract (e.g. with RA).
4. Does not need to be a member of the IDF.
5. Has an agreed relationship as a customer or client of a Registration Agency.

DOIs assigned agencies and Service

Each registration agency provides specific services for the community it serves, depending on specific metadata that it requires of registrants. Some of the DOI assigned agencies are**:**

Crossref: it is a global community infrastructure making all kinds of research objects easy to find, assess, and reuse through a number of services critical to research communications. It was started in January 2000.

DataCite: DataCite is a global non-profit organization that provides DOIs for research data and all other research outputs. By assigning Data Cite DOIs, research outputs become discoverable and associated metadata is made available to the community. DataCite develops additional services to make it easy to connect and share research outputs with the broader research ecosystem and to assess the use of outputs within that ecosystem. All organizations within the research community can join DataCite to start registering DOIs.

EIDR: The Entertainment Identifier Registry (EIDR) provides identification services for Content Identifers and Video Service Identifers. Content IDs are a registry of movies, television shows, radio programs, podcasts, and other audio/video assets of commercial, cultural, historic, or scientific interest. Video Service IDs are a registry of content delivery services including terrestrial broadcast channels, satellite delivery channels, cable television networks, Internet streaming services, etc. EIDR IDs are commonly used for process automation, linked data, engineering standards, academic citation, universal search, and so forth.

mEDRA: The multilingual European DOI Registration Agency (mEDRA) is a persistent citation system for Internet documents. Relation tracking between intellectual property entities. Certification of voluntary deposits includes time stamping and digital signatures.

OP: The Publications Office of the European Union (OP) is the official publisher of the institutions, bodies, offices and agencies of the European Union. As such, it is responsible for assigning DOI names to content produced by these clients. Types of content currently covered by this service include official EU publications, online journal articles, datasets and grants.

Conclusion

Digital object identifiers, or DOIs, are becoming a vital tool for research and academic communication because they offer a dependable and permanent means of locating and identifying digital items, including datasets, journal articles, and research outputs. In addition to helping researchers get credit for their work, DOIs are essential for ensuring correct attribution, discoverability, accessibility, and preservation of research outputs. They also make it easier for research outputs to be shared and reused. DOIs have greatly increased the effectiveness and dependability of scholarly communication and research procedures by giving digital items a distinct and permanent identity. The creation of new services and technologies that use DOIs to support innovative and collaborative scholarly practices has also been made easier by their widespread adoption. It is imperative that scientists and writers keep on.

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