ADVISOR REVIEWS—STANDARD REVIEW

IEEE Xplore Digital Library

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Composite Score: ★★★★

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Abstract

The IEEE Xplore Digital Library is a free search interface that provides access to scientific and technical content from the IEEE (Institute of Electrical and Electronics Engineers), IET (Institution of Engineering and Technology), and other publishing partners. The content of IEEE Xplore is technical in nature and will appeal to researchers working in technical fields, particularly electrical engineering, electronics, and computer science. Libraries and organizations may select from a variety of subscription options to provide full text access to the content that is included on the IEEE Xplore platform. This review presents an overview of the content offered in IEEE Xplore, as well as details about the IEEE Xplore interface, subscription packages and options for Open Access publishing in journals sponsored by IEEE.

Pricing Options

Searching IEEE Xplore Digital Library is free and available to the general public without authentication. Content can be purchased via a wide variety of packages.

When asked to describe IEEE's pricing philosophy, Michael Spada, IEEE Director of Product Marketing, explained in a February 16, 2016 e-mail:

> IEEE, as a not-for profit society, maintains a strict policy of providing fair and consistent pricing across the IEEE Xplore subscription products for all of our customers. We want to ensure our subscribers receive continuous value for their investment in IEEE. We consistently add new, cutting-edge content, value-added features, and continue to provide the most trusted content in the field. IEEE offers many flexible subscription options with pricing based on the size of the institution, the number of users and sites. We also offer special tiered pricing options for smaller schools.

IEEE Xplore offers a variety of pricing options to individual IEEE members, companies, governmental organizations, and academic institutions. The Web site advertises "IEEE knows librarians are the gatekeepers to the content users need. IEEE offers an affordable solution for all levels of colleges, universities and academic institutions. Now, smaller colleges can subscribe to the same IEEE content that large universities receive, but at a lower price, based on your full-time enrollment and degree"

Pricing can vary based on the size of the institution, number of users, and number of sites, and interested parties are encouraged to contact their IEEE representative to obtain a pricing quote. IEEE representatives can also provide pricing for the third party content. Custom consortial pricing is available on request and is also based on subscription, number of users, and number of sites. More details about subscription options can be found at <http://innovate.ieee.org/>.

Despite recommending that potential subscribers contact their representative for pricing, IEEE Xplore still publishes pricing for select packages, as follows:

IEEE All-Society Periodicals Package (ASPP)

Online: $58,645; Print: $73,295; Online + Print: $76,140

IEEE Proceedings Order Plans

- IEEE Proceedings Order Plan (POP) - Core online collection of conference proceedings from approximately 125 of the most important IEEE conferences. 2016 single-site price US$38,150
- IEEE Proceedings Order Plan All (POP All) - Access to all conference proceedings from over 1,400 annual IEEE conferences. 2016 single-site price US$77,325.

OPEN ACCESS

In addition to providing several Open Access options for authors publishing in hybrid journals, IEEE Xplore offers institutions several different models to support researchers who want to help their affiliates make research openly available through IEEE Open. The available list of online partners notes a small cohort of institutions, including CERN, Google, and universities from the UK and Germany. Sadly there are no U.S. universities listed as partners. Possible partner opportunities include: the IEEE Open Access Deposit Account, a deposit account paid in advance by institutions to fund APCs for IEEE journals; or the IEEE Open Access Partner Discount Fee, in which institutions pay a flat yearly rate based on the number of possible authors at the institution, and institutional authors receive a discount on Open Access APCs for IEEE publications. The discount is based on the size of the institution varies from 10% to 20% and would apply to articles published in IEEE fully Open Access journals or hybrid journals.

The IEEE Open Web page <http://open.ieee.org/> notes that there are "flexible options for any size budget," so interested parties should contact their IEEE salesperson for a quote.

Product Description

IEEE has long been a leading publisher of journals and conference proceedings that cover the fields of electrical engineering, electronics, and computer science. The IEEE Xplore Web page boasts that

IEEE Xplore now includes, "170+ journals, 1,400+ conference proceedings, 5,100+ technical standards, approximately 2,000 e-books, and 400+ educational courses." And "approximately 20,000 new documents are added to IEEE Xplore each month." Instead of purchasing access to all of the content hosted on the platform, IEEE Xplore content can be mixed and matched to best meet the needs of the subscribing organization.

Launched in 2000, IEEE Xplore was a relatively new product when it was first reviewed for *The Charleston Advisor* in 2001 (Wilde, 2001). At that time IEEE Xplore only contained journals, standards, and conference proceedings from IEEE and IEE (Institution of Electrical Engineers). In 2006 IEE merged with IIE (Institution of Incorporated Engineers) to form the Institution of Engineering and Technology (IET), and IEEE Xplore continues to host materials from the newly formed organizations. In recent years the IEEE Xplore platform has expanded to offer content from a variety of third party science and technology publishers.

In 2015 IEEE Xplore celebrated its 15 year anniversary, and the celebration Web site included statistics about how the platform has expanded during that time. Since its inception, over 1 billion IEEE Xplore documents have been downloaded. Each month over 3 million unique users visit IEEE Xplore and more than 8 million documents are viewed and downloaded. Table 1 illustrates how IEEE Xplore has grown over the years.

IEEE/IET bundles content into a variety of packages that can be mixed and matched to meet an organization's needs:

IEEE/IET Electronic Library (IEL)

Billed as the most comprehensive option in IEEE Xplore, IEL claims to include "almost one-third of the world's current literature in electrical engineering, communications, and computer science." This collection provides access to 179 IEEE journals, 26 IET journals and magazines, proceedings from over 1,400 IEEE and IET annual conferences, 2,800+ approved and published IEEE standards and more.

IEEE All-Society Periodicals Package (ASPP)

Includes access to 174 IEEE online society-sponsored journals with back files to 2005.

IEEE Conference Proceedings Order Plans (POP and POP All)

POP is comprised of a 2005-present core collection of proceedings from approximately 125 IEEE conferences.

POP All includes 2005-present coverage of all IEEE conference proceedings (more than 1,400 titles).

TABLE 1 Growth of IEEE Xplore 2000–2015

IEEE Xplore Content	2000	2015
Periodical titles	100	200+
Annual conference titles	350	1,400+
Papers published per year	77,000	225,000+
Author records	350,000	3,500,000+
Total Documents	553,000	3,650,000+
Annual number downloaded	11,000,000	100,000,000+

IEEE Computer Society Digital Library (CSDL)

Provides online access to 32 IEEE Computer Society periodicals, magazines, and transactions plus more than 5,000 conference publications.

IEEE Standards Online

There are 16 different collections of standards offered through IEEE Xplore, which gives libraries a tremendous amount of flexibility in subscription options.

IEEE-Wiley E-books Library

Includes access to over 800 Wiley e-books in subject areas relevant to IEEE Xplore users. Available for purchase as a subscription. A perpetual access option is also offered.

Online Courses

IEEE English for Engineering: The product of a partnership with Cambridge University Press, these online courses are designed to provide English language instruction to engineers and other technical professionals.

IEEE eLearning Library: Includes 400+ courses in core and emerging technology courses selected from IEEE conferences and workshops.

In addition to the IEEE/IET Content, IEEE Xplore also hosts content from third party publishers that can be purchased separately or as an add-on to existing subscriptions. Products include:

- MIT Press Journals Library—Computing & Engineering Collection
- Morgan & Claypool Synthesis e-books Library
- SMPTE Digital Library
- IBM Journal of Research and Development
- Journal of Systems Engineering and Electronics
- CABA Impact of Smart Grid on Connected Homes—Landmark Research Study
- Bell Labs Technical Journal (included with IEEE Xplore)
- VDE VERLAG English Language Conferences (included with IEEE Xplore)
- Tsinghua Journal of Science and Technology

OPEN ACCESS AND IEEE XPLORE <http://open.ieee.org/>

The IEEE Open program offers three different models for making articles openly accessible:

Hybrid journals

Most of the IEEE commercial journals, transactions, and proceedings offer authors an option to make articles Open Access for an APC fee of $1,750 plus other applicable fees (e.g., over-length paper charges and color page charges).

IEEE Access

This fully Open Access "mega-journal" boasts a rapid binary peer-review process that promises articles will be published in 4 to 6 weeks. Articles in the journal focus on IEEE's traditional areas of expertise and focus on "applications-oriented and interdisciplinary" topics. The APC is $1,750. Winner of the 2015 PROSE Award for Best New Journal in STM.

IEEE Fully Open Topical Journals

These peer-reviewed, fully Open Access journals have APCs that start at $1,350 and may vary due to page count and color page charges, if applicable.

- IEEE Journal of the Electron Devices Society
- IEEE Photonics Journal
- IEEE Journal of Translational Engineering in Health and Medicine
- IEEE Journal on Exploratory Solid-State Computational Devices and Circuits
- IEEE Life Science Letters
- IEEE Nanotechnology Express
- IEEE Power and Energy Technology Systems Journal

Critical Evaluation

Due to the number of subscription packages on IEEE Xplore, it is necessary to separate the evaluation of the content and the evaluation of the IEEE Xplore platform and interface.

CONTENT

The content on IEEE Xplore is high quality and academic, but with the addition of new material types and third party publishers, the importance and usefulness of the product will vary depending on subscription packages and organizational need. Articles are offered as both HTML and PDF files.

The crown jewel of IEEE Xplore remains the IEEE/IET journals, proceedings, and standards. These materials are both high quality and high impact, and they will be an important part of any collection that supports electrical engineering, electronics, or computer science programs. ISI's Journal Citation Reports indicates that IEEE publishes 17 of the top 20 highest impact journals in the subject area of Engineering, Electrical & Electronic. The journals have been digitized back to the first volumes, and some date back to the late 1800s. The image quality of the articles, even the very old ones I looked at, is good. The standards are an important technical component of the IEL package, but it is important to note that they may not be lent through Interlibrary Loan. The conference proceedings are also impactful, but there are still some challenges in providing complete proceedings coverage.

In a print world, the IEEE conference proceedings were challenging to work with for a variety of reasons. In one of the early evaluations of IEEE Xplore in *Issues in Science and Technology Librarianship*, the authors explain why the confusion exists, noting: "Librarians have viewed IEEE conference titles as 'aggravators' for many years. The Library of Congress treats some IEEE conference titles as serials and some as monographs, with no rationale that is transparent to the user (or even to the average engineering librarian)" (Matylonek, 2001). In an electronic environment, the issues with some IEEE publications having both an ISBN and an ISSN are diminished, but sadly the IEEE conference proceedings still create some headaches for librarians and users.

In the first review I wrote on IEEE Xplore, I noted that some conference proceedings were missing from the electronic holdings. IEEE explained that this was a result of the decentralized nature of the organization and other organizations holding the copyright for select proceedings. After 15 years I hoped that this issue would have been resolved, but it only took a few searches to realize that although the holdings are generally more complete than they were in 2001, there is still some recent content missing from the collection. These omissions seem to be a result of IEEE sharing copyright with other entities. The missing volumes appeared to be offered online through different publishers, so the gaps are more annoying than catastrophic. However, it is important for subscribers to realize that they may occasionally run into missing proceedings content.

The e-book selection on IEEE Xplore includes titles from MIT Press, Morgan & Claypool, and Wiley-IEEE Press. These are all high quality publishers, but individual libraries will need to decide whether these titles fit collection development goals and needs. The execution of the e-books is very basic, and the titles are offered as individual chapters that can be downloaded as PDF files. Although the user can download chapters individually, there does not seem to be an option to download an entire title at once.

The IEEE e-learning courses offer a variety of modules on different topics. The content is professionally produced, and some of the courses that are offered as continuing education have quizzes attached. Publication dates for the modules vary, but some date back to 2005. Before subscribing, interested parties should carefully review the content to see if it meets their needs.

The addition of fully Open Access journals to IEEE's offerings is an important and welcome development for the Open Access movement. In an environment where new and sometimes suspect Open Access publishers are entering the market, it is critical that established and high-impact publishers provide researchers with an Open Access venue in which they can confidently publish their research.

As of the publication of this article, IEEE Photonics Journal is the only IEEE Open Access journal to have an impact factor, but the IEEE Journal of Translational Engineering in Health and Medicine is being indexed in Web of Science. As these IEEE Open Access titles become more established, hopefully they will be indexed in Web of Science as well.

IEEE Xplore content is indexed by a number of databases, as well as Google and Google Scholar. As a participant in NISO's Open Discovery Initiative (ODI), IEEE Xplore has a Web page outlining its ODI compliance. Content from IEEE Xplore is available in a variety of Web scale discovery services, including EBSCO Discovery Services, Primo, Summon, and WorldCat Discovery Services.

INTERFACE

Many scientific information providers offer freely available search interfaces that seem like afterthoughts, designed to provide the lowest common denominator search experience that affords the user the maximum number of opportunities to buy expensive content. IEEE Xplore is different; a stunning interface is complemented by search functionality that rivals some of the best commercial library databases.

The entry page to IEEE Xplore serves the control panel for the search experience, and it is designed for both functionality and engagement. A large basic search box is prominent at the top of the page, and the links to browsing options, account settings, and advanced search templates are obviously displayed. If a subscriber IP address is detected, a note acknowledging who is providing access appears, and a clearly labeled What Can I Access? link informs the user what parts of IEEE Xplore are included in the subscription. There is an obligatory rotating advertisement, but it does not distract from the search interface. The bottom of the page displays the Just Published and Most Popular

FIGURE 1 IEEE Xplore article display

articles for the journals and magazines, conference proceedings, e-books, and courses. Because all of the search functionality is very obviously located at the top of the page, the additional information provides a welcoming atmosphere for the user without interfering with the search functionality.

The IEEE Xplore Web site includes detailed information about usability and accessibility <https://www.ieee.org/about/webteam/styleguide/usability_accessibility.html>. According to the IEEE Xplore Accessibility Statement:

> IEEE strives to provide an accessible web presence to all people, regardless of disabilities. To support this commitment, IEEE has adopted the W3C's Web Content Accessibility Guidelines (WCAG) 2.0 Level A as the enterprise Web Accessibility objective. However, IEEE Web publishers are encouraged to deliver content at higher accessibility levels (Level AA or Level AAA) whenever possible.

BROWSE

Browsing options are offered for books and e-books, conference publications, journals and magazines, and courses. Each browsing screen allows the user to search the collection by key words, topic, or publisher. There are also limiters so that the results can be refined by date, publisher, or other facets depending on the collection. Browsing by subject is also available. The browsing functionality is particularly useful in determining coverage for conference proceedings.

SEARCH

The search box on the main page is billed as a Global Search. This option just searches for one or more key words in any fields. It does not accept Boolean logic, and searches retrieve lots of results. Directly under the global search box there are links to search by author or publication.

If the Global Search does not retrieve adequate results, IEEE Xplore offers a variety of other search options. The Advanced Search option accepts Boolean logic, and allows users to search either the Metadata or the Full Text and Metadata of the articles. The search boxes default to searching Metadata, but users can also select one of 19 other fields to search, including MeSH Terms, INSPEC controlled or non-controlled terms, Standards ICS Terms, and more. Users can limit searches by publisher, content type, or year. It is also possible to limit the search to subscribed content or Open Access publications. Command Searching allows users to command line search, and a citation search is also included that allows users to search by DOI or citation information.

Any lack of granularity in search results is somewhat counteracted by the option to limit the search by keyword or a variety of facets, including content type, year, author, affiliation, publication type, publisher, or conference location. Each results screen also allows the user to change the sort from relevance to a more appropriate option or to increase the number of results displayed on each screen.

IEEE Xplore does not have a mobile app, but it does have a site optimized for mobile users at <http://ieeexplore.ieee.org/mobile/>. The site only offers a search box, and the results are displayed in a mobile friendly format. According to Spada, an IEEE Xplore app is in the works.

ITEM LEVEL DISPLAY

The display for item records in IEEE Xplore is extremely clear and intuitive. In addition to showing standard information such as citation information, links to the item, and the article abstract, these records have been enhanced to offer some useful and interesting options. Listed as the most popular journal and magazine article on February 21, 2016, the article "Internet of Things for Smart Cities" provides a good example of a complete article display (Figure 1).

Each item record offers a variety of tabs to the user. The tabs seem to vary by item type and subscription level, but they can include the following:

- **Author** Links to other articles by the authors in IEEE Xplore.
- **References** Links directly to IEEE Xplore-indexed articles in the bibliography and provides a CrossRef link for non-IEEE Xplore titles. Institutional subscribers may also display the icon for their link resolver.
- **Cited By** Provides citations from IEEE publications, other publications, and patents.
- **Keywords** Lists the indexing for each item, including INSPEC controlled and non-controlled index terms, IEEE terms, and au-

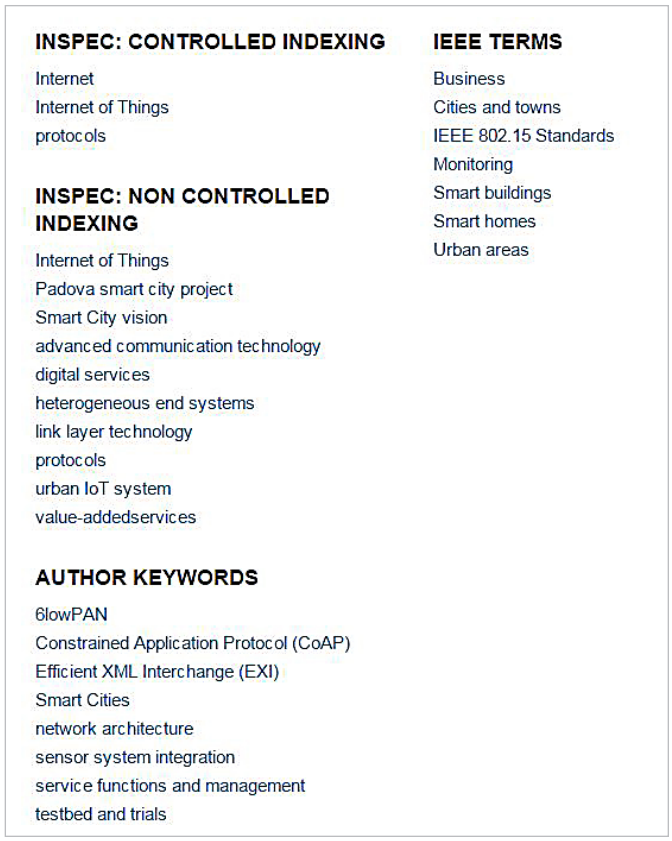

FIGURE 2 **IEEE Xplore indexing sample**

thor supplied terms. Links are provided to the index terms so users can automatically search for other articles in IEEE Xplore that share those index terms (Figure 2).

- **Metrics** Displays a variety of altmetrics, including how many times the article has been downloaded, and citations from CrossRef, Scopus, and Web of Science when available (Figure 3).
- **Similar Articles** Links to similar articles in IEEE Xplore.

On each tab a toolbar allows users to download, e-mail, print, or export the citations. The item can also be shared on Facebook, Twitter, or LinkedIn. It is nice to see these selections so clearly offered, but the option that really stands out is the link to Request Permissions for the article. The link takes the user to the Copyright Clearance Center, and the user can choose from a variety of reuse options. I suspect that very few people will actually follow through with purchasing or requesting rights, but I think that including this link sends an important message to the user. In an environment where there is so much free content available online, it is difficult for users, even faculty, to forget that there are copyright laws and that not everything can be freely reproduced. By including this link, IEEE is giving the user a cue that the item is copyrighted in a very professional, non-confrontational way. For those interested, it even gives an option to easily obtain the appropriate rights, which hopefully will increase compliance.

OPENURL INTEGRATION

Subscribers to IEEE Xplore can activate their link resolver in the IEEE Xplore interface. This integration is extremely important as it provides institutional users with an easy way to utilize services such as InterLibrary Loan to access non-subscribed content.

The resolver link appears prominently in the search results display, but in the individual records it is somewhat hidden. However, if a user clicks on the full-text link from an item record, they will be taken to a page that offers them the option to buy the item or click on the icon for the link resolver. The option is labeled OpenURL, and it is easy to imagine that it would be easy to miss the link. It would be nice if the link resolver item appeared at the item record level as it does in other databases.

In addition to providing users an access point to non-subscribed content, IEEE Xplore also displays link resolver icons in the list of references for subscribed content. This is wonderful, as institutional users will be able to easily access subscribed content from bibliographies without having to look up the articles by hand.

Users may set up a free account that will allow them to customize preferences such as the content to be searched, display options, and bibliographic citation format. Users can also set up search alerts or contents alerts for journals, conferences, standards, or e-books.

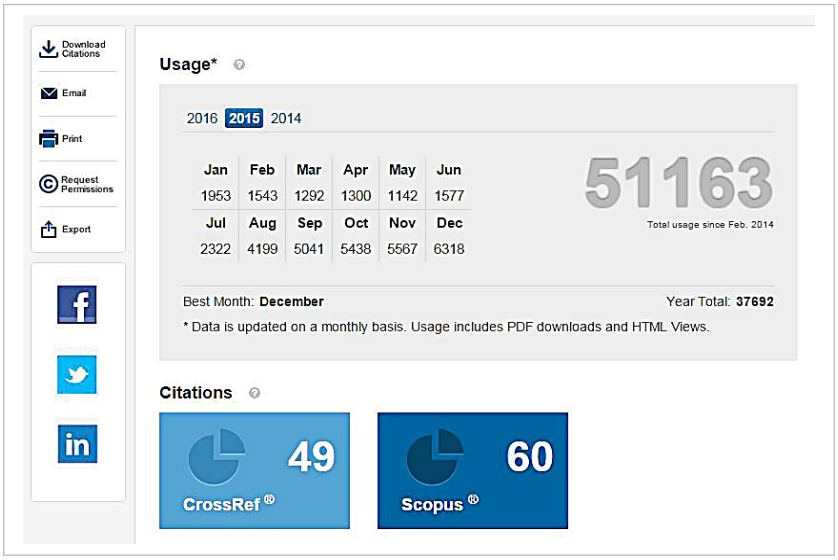

FIGURE 3 **IEEE Xplore article usage metrics**

IEEE Xplore Review Scores Composite: ★★★★

The maximum number of stars in each category is 5.

Content: ★★★★

The content from IEEE/IET and third party publishers is high quality and academic in nature. The IEEE/IET content is essential for organizations that support computing and electrical engineering programs. The value of books, online courses, and third party content will vary depending on what packages are selected and institutional needs.

User Interface/Searchability: ★★★★ 3/4

With indexing from INSPEC, a diverse selection of browse and search options, article level metrics, and a variety of other search options, the freely available IEEE Xplore offers functionality similar to or better than many commercial databases.

Pricing: ★★★

Searching the IEEE Xplore interface is free, but the pricing will vary based on the size of institution, packages purchased, and consortial discounts. From the posted online pricing, it is clear that the IEEE/IET content is very expensive.

Contract Options: ★★★★

A variety of contract options and packages are offered to subscribers based on institution size, number of users, and number of sites.

REACHING THE GOOGLER

After the 2008 recession, libraries experienced reductions in materials budgets, and many institutions are being forced to make difficult collections decisions. Metrics are becoming an important variable in collections projects; it is no longer enough for a vendor to produce a quality product, and journals and databases have to earn their keep by being used.

Thanks to IP address recognition, most library products are automatically available to on-campus users whether they are accessing the journal or database through the library home page or a Google search. Off-campus users are usually more difficult to reach, but IEEE Xplore has really worked to connect Googlers with their institutional subscriptions.

IEEE Xplore offers subscribing institutions the opportunity to set up an institutional authentications service such as Shibboleth to work with IEEE Xplore. Once this service is activated, those who enter the IEEE Xplore interface and try to set up an account will be offered an option to sign in with an institutional login so they can gain access to their organization's collections.

Even when an institutional login is available, the option is often not usually offered at the article level, and users who reach an article via an internet search just see the option to purchase it. On every record, IEEE Xplore offers a Full Text Sign In or Purchase option to users who want the full text of an article. In addition to seeing a purchase option, the menu also gives the user an opportunity to sign in with an institutional subscription. This gives off-campus users a reminder that they may have access through their organization's library. IEEE Xplore is expensive, and directing users to subscribed content benefits both libraries and IEEE Xplore by insuring that high-cost institutional subscriptions get the highest use possible.

Until I began working on this review, I was unaware that IEEE Xplore offered this functionality, and I was dismayed that we have not set it up for our users. Upon looking at the list of organizations that offer institutional logins, I was surprised to find that there are many international universities and corporations on the list of available institutional logins, but very few universities in the United States. In an environment of shrinking budgets, IEEE Xplore should consider working to increase the number of participating U.S. universities to insure that IEEE Xplore maintains high usage statistics.

The one noticeable flaw in the execution of IEEE Xplore is that there is sometimes a lag time in the searches. This appears to happen erratically, in both wireless and online environments. Although the lag is only a few seconds, in relation to other databases, it sometimes takes a noticeably longer time to retrieve results.

Overall IEEE Xplore is an attractive and impressive interface, and it is evident that a lot of thought and care was put into designing the user experience. Because the interface is free, many libraries would benefit from making the interface available to their users. Most academic libraries that support computer science or engineering programs will want to consider subscriptions to the IEEE/IET content. With a tiered pricing program, IEEE Xplore may be more affordable to smaller schools.

Contract Provisions

IEEE Xplore is COUNTER compliant and provides usage statistics to organizational subscribers by request. Calendar years statistics appear on the COUNTER compliant statistics site.

MARC records are available for e-book collections, and IEEE Xplore offers downloadable OPAC listings for other packages. IEEE Xplore articles may be used to fulfill Interlibrary Loan requests from non-commercial, academic libraries in compliance with copyright law; however, the contract explicitly states that IEEE Standards may not be provided through Interlibrary Loan.

IEEE Xplore works with Portico to preserve a "dark archive" of IEEE scholarly material. Access to this archive is available to subscribers in the case of certain trigger events such as a cessation of publisher operation or catastrophic failure. For libraries that have to cancel IEEE

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URL: <https://supportcenter.ieee.org>
<www.ieee.org/innovate>

Xplore subscription packages such as IEL and ASPP, IEEE provides post-cancellation access through IEEE Xplore to IEEE and IET journals and conference content purchased during the years of the active subscription. Online maintenance fees may be required to maintain access, and post cancellation access to Standards is not provided.

Authentication

According to Spada, "IEEE offers several different authentication options including IP authentication, user name and password, blind login (which is a username and password login script embedded within a subscriber's intranet link to IEEE Xplore), remote access for mobile users, and Shibboleth/Athens as well as corporate single sign-on. IEEE is a member of most major Shibboleth federations in North America, Europe and Asia."

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Michael Spada, IEEE Director of Product Marketing, e-mail to author February 16, 2016.

Wilde, Michelle. "IEEE Explore." *The Charleston Advisor* 3, no. 1: 26-29.

About the Author

Michelle Wilde is Coordinator of the College Liaisons unit at the Colorado State University Libraries where she has worked since 2000. In her capacity as a science librarian she currently has liaison responsibilities in the biomedical and physical sciences. She holds a B.A. from Oregon State University and an M.L.S from Indiana University. ■