

Open Source Networking Education: A Systems Approach

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ABSTRACT

Open source software has been central to the development of networks for decades, but until recently, networking education has largely relied on proprietary textbooks produced by traditional publishers. In 2012, we set out to produce an open source version of our networking textbook *Computer Networks: A Systems Approach*. This paper describes our experiences to date and offers some suggestions for future directions.

1 INTRODUCTION

In 2012 we published the fifth edition of *Computer Networks: A Systems Approach*. As with all the prior editions, we worked with a traditional publisher who retained full copyright to the material. At the time, open source software was becoming ever more important to the networking industry. Larry had decades of involvement in open source projects such as the PlanetLab and was embarking on a new initiative with the Open Networking Foundation to build an open source SDN stack, while Bruce was at Nicira contributing to the Open vSwitch project. It seemed to us that the time was right to consider how to leverage open source for networking education materials, not just for the network software.

Like many textbook authors, we embarked on writing a book mostly as a labor of love. We wanted to contribute to the development of the next generation of networking students, researchers, and professionals. We recognized that this desire to educate, and to reach the widest possible audience, aligned well with an open source approach. We also recognized that the book could be better if we drew on the input of the community more effectively than we were able to do in a traditional proprietary textbook. Last but not least, we recognized that traditional textbook publishing was at a crossroads, and we wanted to assert some level of control over our own destiny.

Over the next several years we negotiated with our publisher an arrangement in which we would continue to furnish them with new editions—ideally leveraging community contributions as well as our own work—while also gaining the rights to make the entire contents of the book freely available under an open source licence.

This paper reports on our experiences and progress to date in developing the open source version of *Computer Networks*. We also offer some thoughts on future directions for networking texts, which are likely applicable to many other technical fields [1].

2 GETTING STARTED

Once we had the idea to explore an open source approach to our own networking book, we also engaged in a discussion with members of the SIGCOMM community about producing open source textbooks for the networking community. (Bruce was SIGCOMM chair at this time.) This discussion was picked up by members of the Executive Committee and resulted in the book *Recent Advances in Networking*.

A significant simplification in this case was that, being new content, SIGCOMM could publish it freely under an appropriate licence [2].

For *Computer Networks*, we had to address three issues:

- (1) Persuade the publisher to part with the exclusive rights to the content we'd produced for them over the years.
- (2) Construct a licencing model that would work for the publisher, for us, and for other contributors.
- (3) Design a model for producing both traditional editions and freely available online versions of the book.

Once these issues were addressed, we had to get to work on developing new content and building a community of contributors. Plenty of open source software efforts fail to thrive because there's not a community of contributors, and our goal here was similar to a software project: make something that is constantly improving as the community makes updates. We discuss our experience in tackling these issues below.

3 EXPERIENCE

The following highlights some of the lessons we have learned over the last two years of working with our open source textbook.

3.1 Licensing Terms

While we had experience with licenses for source code, with the Apache 2.0 license emerging as a consensus choice, everyone we asked pointed to Creative Commons as the right model for other academic content, including data sets and textbooks. Their range of terms gave us the options we needed [3].

Elsevier ultimately agreed to make the source to our book available under terms of Creative Commons CC BY 4.0 license. One of the CC's more liberal licenses, CC BY allows others to copy, remix, and redistribute the material (including commercially). We are still under contract to not publish a competing introductory networking textbook, but we are allowed to enhance and promote the online version, in part to encourage community contributions. This was the best outcome we could have hoped for.

We have subsequently written two "spin-off" books on emerging/advanced topics: *5G Mobile Networks* and *Software Defined Networks*. The source content is also available on GitHub, and an HTML version is available online, but we subsequently learned that CC BY precludes potential publishers being able to exclusively license translations. Those books are (for now) available under the more restrictive CC BY-NC-ND license terms (no commercial use and no right to distribute). The source remains on GitHub and web versions are available for anyone to access.

3.2 Community Contributions

Our hope was that by putting source to the book on GitHub we would encourage others to contribute, both improving/Updating the existing content, and adding new chapters on emerging topics.

With respect to the existing textbook, many people have submitted “bug fixes” but contributions of updated content were modest.

We can speculate about why this is, but we have had better success finding contributors willing to co-author stand-alone micro-books on advanced topics. These are roughly the length of a chapter in the full textbook, with the aforementioned 5G and SDN books being two examples [4]. This seems to provide the right incentives, giving co-authors the requisite ownership and credit. Being able to work on a modest-sized and narrowly-focused project also has the advantage of lowering the barrier-to-entry. Co-authoring a micro-book isn’t so daunting.

On the one hand, it is easy to imagine a community-wide collection of such micro-books, and we have started a *Networking Systems* series with Morgan & Claypool doing exactly that [5]. (This approach has been successful in the Computer Architecture community, and the hope is to replicate that success in the Networking community.) On the other hand, a series of unrelated monographs does not result in a coherent set of teaching collateral, especially at the undergraduate level.

To address this issue, we plan to curate a set of micro-books that are mutually coherent and written in a consistent style. Today, that involves co-authoring those topic-based books with domain experts, but it is possible that a proactive editing hand can accomplish the same result. The set will also include “framing” material that will help both instructors and students navigate the material. Our experience is that instructors who are also active networking researchers have strong opinions about how their course is framed and organized (and would prefer integrating their own combination of content modules), but the vast majority of instructors prefer a more seamless, end-to-end solution.

It’s worth noting that we always had the goal of maintaining the consistency of perspective that exists in a traditional textbook. Unlike Wikipedia, for example, where edits can be made by anyone, we viewed the open source software model (in which changes are reviewed before committed) as more conducive to a consistent style and judgement about what is important. We see the set of core committers expanding over time but remaining small relative to the total number of contributors, just like an open source software project. As in the open source software world, there is room for more than one approach, such as the work of Bonaventure *et al.* [7].

3.3 Other Teaching Collateral

Textbooks are only part of the equation. There is a substantial amount of other teaching collateral that further differentiates what we do from Wikipedia. For example, we have found a similar balancing of disaggregated-vs-integrated concerns applies to video content. Our approach is to record and distribute bite-sized video modules through CUvids rather than pursue a MOOC-style complete course [6]. This gives instructors the freedom to organize material as they see fit, using a combination of text and video.

Exercises also naturally fit this model. Our current collection of exercises is not extensive, but a set of hands-on programming problems associated with the SDN micro-book points to an obvious match between open source textbooks and open source problem sets, of which there may be more than one to choose from [7]. Given our systems-oriented approach, pairing the textbook with a corresponding open source software stack is an ideal scenario [8].

3.4 Publication Tool-Chain

Much of the value traditional publishers bring to the table is their formatting and design chops. Self-publishing tools are becoming widely available, but most require substantial buy-in to some underlying platform, making them less than ideal for a community-based, open source effort.

After experimenting with several options, we settled on a minimalist approach: reStructured Text (reST) as the canonical representation for content, and Sphinx as the document generation tool-chain [9]. (We also use Pandoc to convert the original LaTeX source into reST format, but non-trivial by-hand edits were still required due to the publisher’s heavy use of formatting tweaks.) Sphinx does a good job generating HTML for web-based output, is adequate for eBook output, but just barely sufficient for producing PDFs. The latter case would benefit from a well-designed set of LaTeX macros, preferably open sourced.

Related to the tool-chain, we have adopted an agile development process, with minor revisions released continuously, and major revisions released (approximately) quarterly. And taking advantage of standard GitHub tools, we have adopted a variant of semantic versioning to help instructors know all their students are working with the same instance of the material [10].

4 RECOMMENDATIONS

We can’t help but notice how the trend to build disaggregated, open source software systems—which in many cases are designed to disrupt an industry stifled by a set of incumbent vendors—applies equally well to textbook publishing. (Truthfully, given our experience with networking software, this similarity is intentional.)

It is clear the textbook publishing industry is in the midst of major changes, making it an ideal time to put forward an alternative model. Our approach, which we would advocate to the broader community, is to pursue the following four-part model: (1) disaggregate our teaching collateral into self-contained modules, (2) make those modules available as open source, (3) curate a consistent collection of modules and reward community contributions to that collection, and (4) offer end-to-end packages that integrate a subset of the available modules into a coherent and consumable whole. We are making tangible progress on the first three, and have ambitions to address the fourth. Time will tell.

To our minds, curation is key. There is already an abundance of “facts” about computer networks available on the web. Our job as educators is to apply perspective to these raw details. We advocate doing that as an open source, community-based effort.

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