Resources for Teaching Computer Networking in the Time of COVID and beyond

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Abstract. We describe open resources we have developed that are available to instructors of an introductory-level course on computer networks. We also identify additional resources that we believe will be of particularly high value to the community, particularly for teaching in the time of COVID and beyond.

1. Resources

Our textbook, Computer Networking, a Top-Down Approach is now in its 20th year of publication, with the 8th edition having been published in spring of 2020. Since our very first edition, we've made many resources associated with our book open to all (i.e., not restricted to faculty or students using our textbook). We do so because we're members of the networking research and education community, and believe that they’re useful to many faculty and students in that community. We make these resources available in original source formats so that faculty and students can add, delete and adapt them to their needs.

These open resources, which are online at http://gaia.cs.umass.edu/kurose_ross, have grown and expanded over the years, and now include:

- **Powerpoint slides.** We’ve been sharing our powerpoint slides since before our book was first published. There are now more than 800 Powerpoint slides, many with animations, covering almost any topic one might include in a modern introductory computer networking course. We extensively updated these slides in the Spring of 2020 with content updates, many more animations throughout, a common "look and feel", and a 16:9 aspect ratio for modern projectors.

- **Wireshark labs.** We believe that a student’s understanding of network protocols can be greatly deepened by “seeing” them in action. Our inspiration for developing these labs was the old proverb, "Tell me and I forget. Show me and I remember. Involve me and I understand." The Wireshark labs embody this proverb - students take actions using their local computer, and then capture, observe and analyze packets that flow “on the wire” as a result of these actions, using the open Wireshark (www.wireshark.org) packet capture and protocol analysis tool. We distribute wireshark labs (and traces for students who can’t perform their own packet capture) for HTTP, DNS, TCP, UDP, IP, ICMP, Ethernet, ARP, WiFi, and TLS.

- **Online interactive problems.** We often hear from students that the end-of-chapter problems are very useful for them to test their knowledge and understanding. In our printed book, there are only one or two instances of a given problem, and solutions are not provided to students since faculty often assign these problems as homework. Our “online interactive problems” generate instances of a problem (e.g., a shortest path routing algorithm calculation, the analysis of a TCP segment trace or of some other protocol “in action”) and also displays (when asked) that problem’s solution, so students can check their understanding. Importantly, students can
keep generating new instances of each problem (and hopefully solving each one!) until they’ve mastered the material.

- **Online lectures, knowledge checks.** In the spring and summer of 2020, we’ve been making pre-recorded lectures of our textbook material available. It’s still too early to understand how students and faculty might use this open resource. One of us (Jim) is planning to use these lectures in the Fall of 2020, in an online class, to replace class-time lectures with more time for discussion, group activities, and active learning. Knowledge checks, which are simple, ungraded review questions (and answers) accompany the online lectures, and interactive problems (see above) are also linked together with the lectures.

- **LMS solutions to wireshark labs** (currently available only to instructors). As teachers, there are few activities we find less enjoyable than grading. Nor do we always have access to sufficient Teaching Assistant time and expertise for grading. Like many faculty members, we’ve begun experimenting with auto-grading in learning management systems and have created an LMS version of the questions and graded answers for our Wireshark labs. These were developed in Adobe Captivate, so they can be imported into a wide range of LMSs. Of course, there’s value to in-person grading, particularly when done carefully. There’s also an art to creating auto-gradable questions that accurately reflect and encourage mastery and understanding of the material. But as online evaluation increases as a result of the COVID pandemic, enrollment in networking courses continues to increase, and TA resources become increasingly scarce (at least in some schools), we think that auto-graded LMS questions will be in place for the long term.

In addition to these open resources, there are also interactive animations, Python socket programming labs, VideoNotes, and additional review questions available on the publisher’s (Pearson’s) website for students who purchase our textbook.

We’ve been gratified over the years by the number of faculty and students who have used our book, and the open resources listed above. Table 1 below shows annual (2019) access statistics to some of the resources listed above that are served from our personal authors’ website. (We note that both Powerpoint and Wireshark resources are also available via the publisher). We believe these numbers show the value, popularity and use of open, shared resources. We found it interesting that “old” resources (e.g., 6th edition Powerpoint slides) remained popular in spite of the availability of updated (e.g., 7th edition) resources.

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<td>Interactive problem: packet-switching versus circuit-switching</td>
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Table 1: 2019 Web page accesses (awstats) for selected open resources (via authors’ book homepages)

2. A look at, and over, the horizon

With an increasing amount of shared, open resources – including high-quality pre-recorded topics lectures – we’ve sometimes been asked what a teacher should do with class time that would have otherwise been filled with lecturing. Our answer to that is simple: personalize. Textbooks, and their associated materials, have always been generic. The true “value-added” by a professor is the ability to contextual, adapt and personalize subject matter to the particular needs and interests of the particular students in a particular class. Another critically important value added by an instructor is to create and nurture a community of active learners within a classroom, regardless of whether that classroom is physical or virtual. Without such personalization, a student’s experience in one introductory computer networking course might be pretty much the same as in any other similar course.

We believe it takes a tremendous of thought, creativity and effort to effectively personalize course content and activities, and to create a community of learners. Indeed, traditional “sage-on-the-stage” lecturing is easier, and requires significantly less effort. But if professors who teach networking are to undertake more creative, more time-consuming activities, we believe that sharing pedagogical techniques – what is it that we can do to personalize material? What activities can be undertaken to create community within a classroom? What are successful practices and approaches for teaching specific material – will be a tremendously valuable undertaking. This will require an actively curated repository (a repository quite distinct from one that contains artifacts like powerpoint slides, code, and labs) as a service to the networking teaching community.