

Cybersecurity Competitions: The Human Angle

Masooda Bashir, April Lambert, and Boyi Guo |

University of Illinois at Urbana-Champaign

Nasir Memon and Tzipora Halevi | New York University Polytechnic School of Engineering

In mid-December 2014, on the heels of allegations that North Korea hacked into Sony Pictures' systems, causing millions of dollars in damage and revenue losses, the US Congress passed the Cybersecurity Workforce Assessment Act (Public Law No. 113-246). This act required the US Department of Homeland Security to assess the government's current cybersecurity workforce and develop a plan for increasing and training cybersecurity professionals. Programs such as CyberCorps: Scholarship for Service (www.sfs.opm.gov), which awards scholarships to qualified students planning government cybersecurity careers, are already in place to attract and educate talent. Unfortunately, in the US and globally, attracting sufficient cybersecurity professionals has proven difficult.¹

To address this shortage, government and industry often sponsor cybersecurity competitions. These events—typically coordinated by US educational

institutions for high school and college students—use hands-on competition to generate interest and train the next generation's cybersecurity specialists. Competitions give students the opportunity to not only develop and apply new skills but also work with fellow students and potential employers.² The competitions' primary goal is to encourage interested students to pursue cybersecurity careers. The cybersecurity education community has worked to develop superior competitions^{3,4} and explore how they can further cybersecurity education.⁵⁻⁷ However, little empirical research has assessed these competitions' actual effectiveness in attracting talent or explored the characteristics of students who compete and then go on to cybersecurity careers.

Focusing on competitors from one US competition—Cybersecurity Awareness Week (CSAW)—our research explored who attended and why, whether the competition met

the participants' expectations, and how the competition experience affected their career plans.

By understanding competitors' characteristics, expectations, and experiences, we can begin to develop effective competition programs that inspire students to pursue cybersecurity professions. In future research, we hope to look more closely at those students who are well suited for cybersecurity careers but don't compete or are put off by the competition experience.

Research Description

The CSAW competition—held annually for the past 11 years at the New York University (NYU) Polytechnic School of Engineering^{5,6}—is an entry-level capture-the-flag competition geared toward high school and undergraduate students. CSAW organizers sent an email with a link to our online survey to approximately 8,000 participants from the competition's first decade. We include here the responses of the first 588 respondents in spring 2014. Although some self-selection bias exists with online surveys, we encouraged the broadest response by compensating respondents who completed at least 70 percent of the survey with a US\$10 Amazon gift card. Moreover, although CSAW is the longest-running and largest student-run cybersecurity competition in the US,⁵ future research will assess our sample's representativeness of competitors as a whole.

Our survey collected a range of information about the participants, including

- demographics;
- competition experience;
- hacking practice;
- intentions or actuality of pursuing a cybersecurity career (depending on age); and
- responses to several standard psychological, career inventory, and cultural measures.

Some survey sections were dynamic: depending on their responses regarding age and employment and education status, participants were asked different questions relevant to their current situation. For example, respondents who currently worked in cybersecurity were asked about their work experiences, whereas students were asked about their academic and career plans.

Survey Results

In this article, we focus on the respondents' demographics, competition experience, and career intentions. We'll explore the other survey topics in future work.

Who Attends Cybersecurity Competitions?

The lack of diversity among cybersecurity professionals—and computer science professionals more generally—is an oft-cited concern and challenge for efforts to increase the workforce.^{1,9} Do competitions direct diverse participants to cybersecurity careers? Or does the challenge lie in getting diverse participants to attend competitions in the first place?

We attempted to answer these questions by comparing the diversity of the students who participated in the CSAW competition to that of the participants already in the workforce. Of our respondents, 37 percent ($n = 161/431$) were currently employed full time, more than half (58 percent, $n = 93$) in a cybersecurity-related field. (The remaining respondents were either

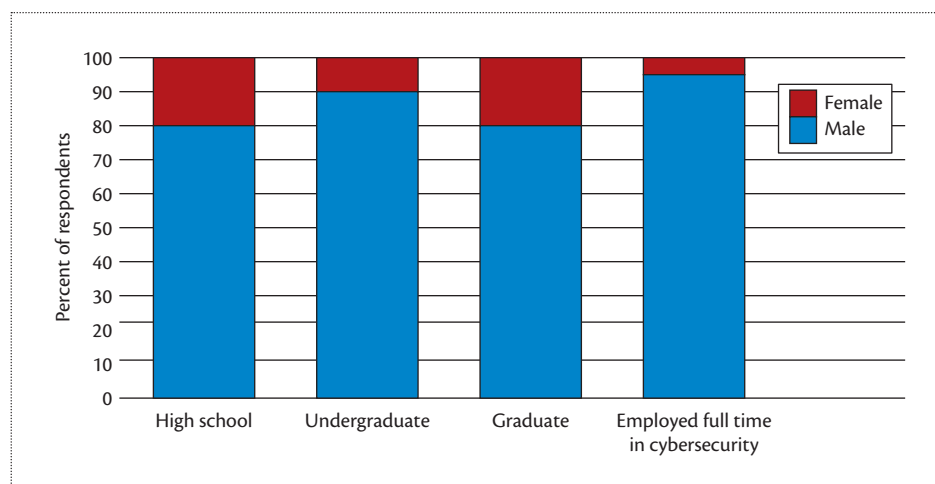


Figure 1. Gender profile of Cybersecurity Awareness Week (CSAW) competitors ($n = 477$ respondents). Approximately 15 percent of the students were women, while women accounted for only 6 percent of those employed in the cybersecurity field.

unemployed, were employed part time, or didn't report their status.) Students constituted 72 percent ($n = 404/559$) of the respondents: 50 percent ($n = 199$) were currently undergraduate students, 29 percent ($n = 116$) high school students, and 17 percent ($n = 67$) graduate students. (The remaining students were in other categories.)

As Figure 1 shows, gender varied depending on education level. Approximately 15 percent ($n = 57/381$) of the students were women, while women accounted for only 6 percent ($n = 6/93$) of those employed in the cybersecurity field.

The participants' racial/ethnic diversity reflected a similar trend, with undergraduate students—the largest student group—being the least diverse (see Figure 2). Also noteworthy is that the percentage of African American students participants fell by half between high school and college; Hispanic and Latin American students' participation also decreased by the graduate level. Non-Asian minorities constituted approximately 12 percent of the overall student group. However, despite some differences within the student population,

those who attended the competition were still far more diverse than those who continued on to cybersecurity careers.

These results seem to indicate that although some racially/ethnically diverse students are attending competitions, they don't tend to go into cybersecurity professions. However, these conclusions are limited by the lack of research on cybersecurity competitors and employees: we don't know how our results compare with those from other competitions or related professions or how diversity has changed over time.

Field of study is another diversity area to consider. Our data show that most students came from the expected fields: computer and information science (87 percent, $n = 109/126$) and engineering (6 percent, $n = 8$). The rest were studying social sciences, business, mathematics or statistics, and biological or life sciences. Cybersecurity isn't an established field of study in many institutions, so interested students might be located in myriad departments. In addition, students who are interested in cybersecurity and have the relevant skills might

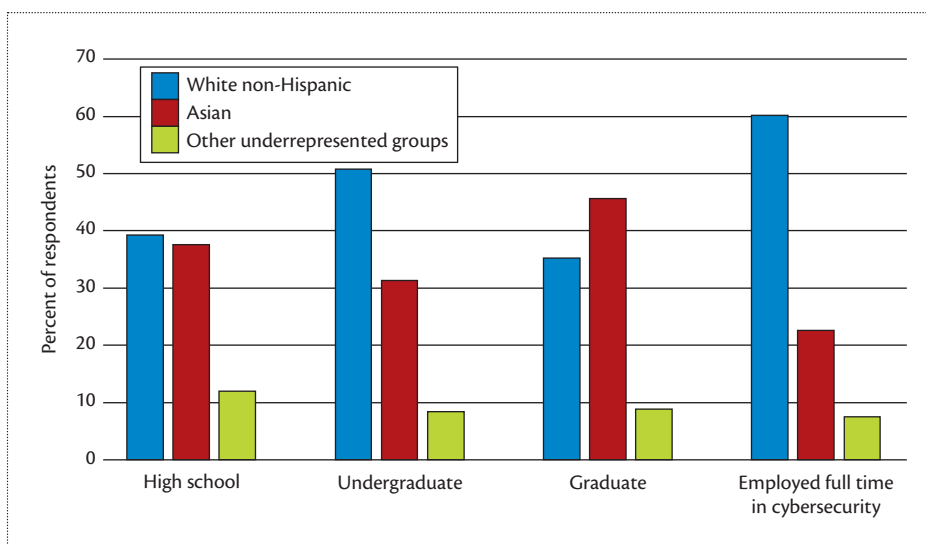


Figure 2. Racial/ethnic profile of CSAW competitors ($n = 477$ respondents). The other underrepresented groups included African Americans, Hispanics or Latin Americans, Native Americans, or other race/ethnicity.

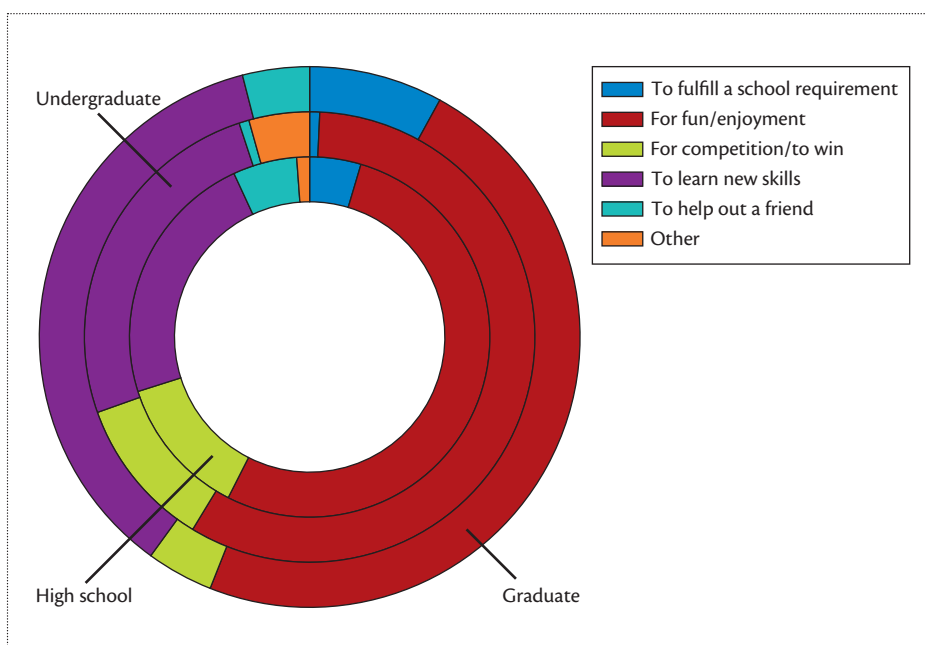


Figure 3. Students' reasons for attending the CSAW competition ($n = 274$ respondents). The primary reason was for fun and enjoyment.

be undecided on their field of study. Thus, because cybersecurity might attract students from unexpected fields, competitions should consider targeting outreach to non-computer science students as well.

Why Do Competitors Attend Competitions?

As Figure 3 shows, the primary reason the students attended competitions was fun and enjoyment. Learning new skills was the second most popular reason.

These two reasons for attending competitions were consistent across demographic groups and weren't affected by the number of competitions attended or interest in a cybersecurity career. Very few students attended because they wanted to compete or win. We can conclude that if a competition focuses on providing an enjoyable experience and teaching new skills, most students will be satisfied. And satisfied competitors might be more attracted to related experiences, such as a cybersecurity career.

Do Competitions Meet Competitors' Expectations?

To gauge whether cybersecurity competitions meet students' expectations, we can look at how often they participate in such events. Many students attend more than one competition per year. In the high school group, 28 percent ($n = 24/87$) attend two or more competitions per year. For the undergraduate group, this rate rises to 59 percent ($n = 81/138$), with 17 percent ($n = 23$) attending six or more per year. Frequency of attendance continues to increase for graduate students, with 66 percent ($n = 33/50$) attending two or more per year. Thus, a significant number of respondents have attended not only the CSAW competitions but also several other competitions.

We also asked respondents whether they learned new skills in the competition, which was cited as a significant reason for attending. Most students reported that they did in fact learn new skills (64 percent, $n = 174/274$). In addition, the overwhelming majority of students would recommend the competition to a friend (85 percent, $n = 242/285$). The results for all these factors—frequency of competition attendance, learning of new skills, and likelihood of recommending—suggest that competitions effectively meet the students' expectations.

Do Competitors Intend to Pursue Cybersecurity Careers?

We explicitly asked the participants whether they intended to pursue a cybersecurity career. Figure 4 breaks down their responses by student group.

As these results show, older students were the surest of their career plans, while high school students were the least. Thus, to attract those not yet committed to pursuing cybersecurity careers, competitions should target high schoolers and also communicate to undecided undergraduate and graduate students that cybersecurity isn't just about competitions but also a viable career option.

Do Competitions Influence Students' Career Plans?

Many competitors who intend to pursue a cybersecurity career might have decided to do so prior to competing. Our primary concern was assessing whether competitions actually change student career plans. As Figure 5 shows, the overwhelming majority of students indicated that competition participation made them more likely to pursue a cybersecurity career.

However, actual employment doesn't reflect this enthusiasm for a cybersecurity career. Future work should determine why some students turn these intentions into a cybersecurity career and others move on to different fields.

What Do Cybersecurity Professionals Think about Their Competition Experience?

Many respondents were several years removed from their competition experience; they could therefore provide retrospective information about whether competitions were significant to their career choices. As Figure 6 shows, these respondents' reasons for

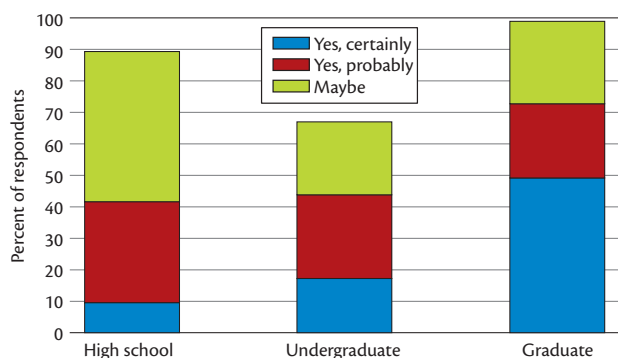


Figure 4. CSAW student competitors' intent to pursue a cybersecurity/information assurance career ($n = 380$ respondents). Older students were the surest of their career plans, while high school students were the least.

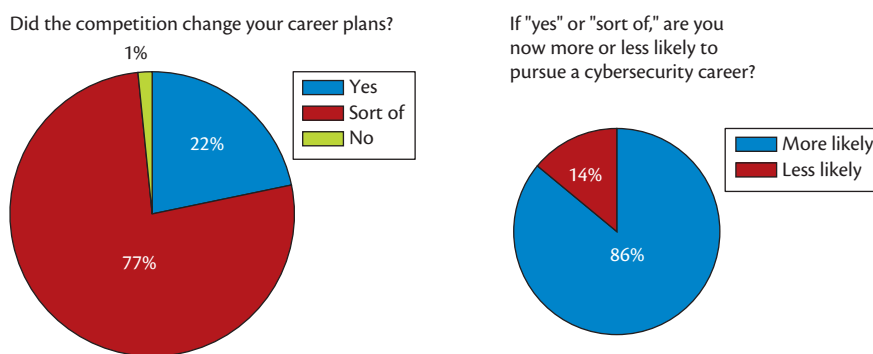


Figure 5. The effect of cybersecurity competitions on students' career plans ($n = 52$). The overwhelming majority of students indicated that competition participation made them more likely to pursue a cybersecurity career.

attending competitions in the past were consistent with the students'.

Those who went on to cybersecurity careers were very likely to report having learned new skills at competitions (80 percent, $n = 50/63$). This implies that competitions should emphasize skill education to motivate students to pursue cybersecurity careers.

Those respondents working in the cybersecurity field also attended far more competitions than the student groups: 83 percent ($n = 52/63$) of professionals had attended two or more per

year. This indicates that competitions are a significant part of the education experience for cybersecurity professionals.

Finally, more than half (51 percent, $n = 47/93$) of the respondents currently employed in cybersecurity believed that the competitions they participated in as students influenced their career paths.

Although just the first step in a longer research program, our survey results support the notion

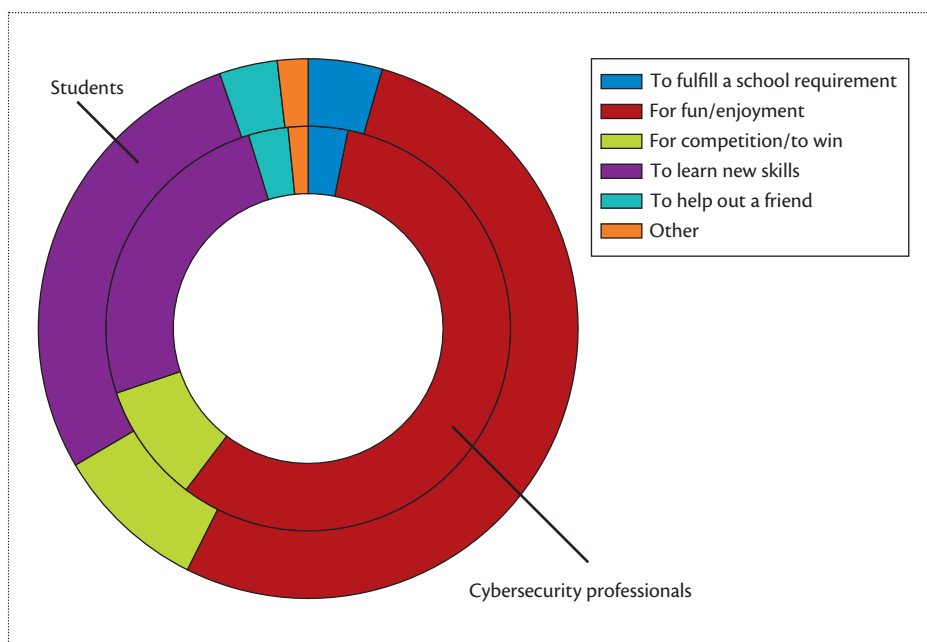


Figure 6. Competitors' reasons for attending the CSAW competition ($n = 108$). Those who went on to cybersecurity careers were very likely to report having learned new skills at competitions.

that competitions effectively attract people to cybersecurity careers. However, at first glance, competitions appear to be more effective for some students than for others: women and students from under-represented minority groups are less likely to make the jump from competition to employment. However, to really understand the effectiveness of competitions and the determining factors for increasing the cybersecurity workforce, we must undertake longitudinal studies that follow a subset of students from enrollment in a competition through employment.

Our exploratory research wasn't guided by a particular theoretical model. However, it reflects an understanding that attracting people to cybersecurity careers depends on not only the competitions' pedagogical aspects but also the participants' psychological and sociological characteristics. In future research, we'll more rigorously apply theoretical models such as Robert Lent and his colleagues' social cognitive theory of career

choice⁸ and John Holland's career interest profile model.² The ability to draw correlations between particular personality types and employment in cybersecurity careers, for example, might provide insight into the types of students we should encourage to attend competitions. As possibly the first in-depth study of its kind, our research seeks to understand competitors differently. We hope our survey begins the conversation and inspires similar studies with other competitions and larger samples. ■

Disclaimer

This material is based on work supported by the National Science Foundation under grant 1342090. Any opinions, findings and conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. "2015 Global Cybersecurity Status Report," ISACA, 2015; www.isaca.org/pages/cybersecurity-global-status-report.aspx.

2. M. Bashir et al., "Exploring the Vocational Interests of Cybersecurity Competition Participants," to be published in *Proc. 19th Colloquium for Information Systems Security Education (CISSE 15)*, 2015.
3. A. Conklin, "The Use of a Collegiate Cyber Defense Competition in Information Security Education," *Proc. 2nd Ann. Conf. Information Security Curriculum Development (InfoSecCD 05)*, 2005, pp. 16–18.
4. J. Werther et al., "Experiences in Cybersecurity Education: The MIT Lincoln Laboratory Capture-the-Flag Exercise," *Proc. 4th Conf. Cybersecurity Experimentation and Test (CSET 11)*, 2011, p. 12.
5. "World's Biggest Student Cybersecurity Contests Reveal Best Young Hackers and Researchers," New York University Polytechnic School of Engineering, 17 Nov. 2014; <http://engineering.nyu.edu/press-release/2014/11/17/worlds-biggest-student-cyber-security-contests-reveal-best-young-hackers-re>.
6. E. Gavas and N. Memon, "Winning Cybersecurity One Challenge at a Time," *IEEE Security & Privacy*, vol. 10, no. 4, 2012, pp. 75–79.
7. D.H. Tobey, P. Pusey, and D.L. Burley, "Engaging Learning on Cybersecurity Careers: Lessons from the Launch of the National Cyber League," *ACM Inroads*, vol. 5, no. 1, 2014, pp. 53–56.
8. R.W. Lent, S.D. Brown, and G. Hackett, "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance," *J. Vocational Behavior*, vol. 45, no. 1, 1994, pp. 79–122.

Masooda Bashir is an assistant professor in the Graduate School of Library and Information Science at the University of Illinois at Urbana-Champaign. Contact her at mnb@illinois.edu.

April Lambert is a doctoral student in the Graduate School of Library and Information Science at the University of Illinois at Urbana-Champaign. Contact her at adlambe2@illinois.edu.

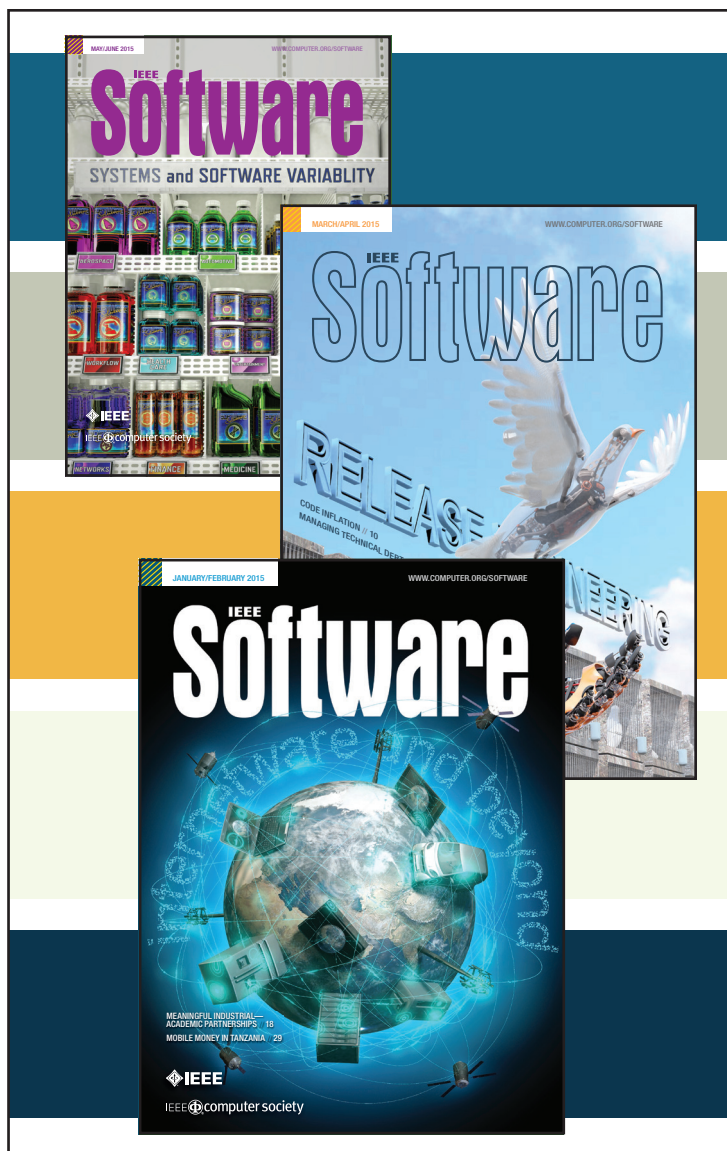
Boyi Guo is a masters student in the Department of Statistics at the University of Illinois at Urbana-Champaign. Contact him at boyiguo1992@gmail.com.

Nasir Memon is a professor in the Department of Computer Science at the New York University

(NYU) Polytechnic School of Engineering. Contact him at memon@nyu.edu.

Tzipora Halevi is a postdoctoral fellow in the Department of Computer Science at the NYU Polytechnic School of Engineering. Contact her at thalevi@nyu.edu.

cn Selected CS articles and columns are also available for free at <http://ComputingNow.computer.org>.



IEEE Software offers pioneering ideas, expert analyses, and thoughtful insights for software professionals who need to keep up with rapid technology change. It's the authority on translating software theory into practice.

www.computer.org/software/subscribe

SUBSCRIBE TODAY