Creation of an Online Video Tutorial Library at a State University

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Dr. Mariappan "Jawa" Jawaharlal, Professor of Mechanical Engineering at California State Polytechnic University in Pomona, has more than 20 years of academic, industrial and entrepreneurial experience in engineering and is renowned for his innovative, engaging teaching pedagogy. He received the California State University System’s highest honor, the Wang Family Excellence Outstanding Faculty Award, as well as the Provost’s Award, the Northrop Grumman Award for Excellence in Teaching, and a Fellowship in the Biomimicry Institute. At Rowan University in Glassboro, NJ, he was one of the first faculty members recruited to develop a new engineering program with a $100 million donation.

Dr. Jawa is founder and director of Robotics Education through Active Learning (REAL), a K-12 outreach robotics program that educates thousands each year and culminates in the Annual Robot Rally, the nation’s largest robotics event. He also co-founded the Femineers (Female Engineers), which the White House recognized for its empowerment of young women to become engineers.

Since founding an online education company in 1998, Dr. Jawa has developed hundreds of interactive, engaging learning modules, online tutorials, and CSU course redesigns focusing on bottleneck courses. He has brought many new engineering and robotic products to market from mere concept stages. He also writes columns for The Huffington Post and Medium on various K-12 and higher education topics. A marathon runner and scuba diver, he has completed 25 marathons and has run across the Grand Canyon from rim to rim to rim.

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Creation of an online video tutorial library at a state university

Abstract

This paper describes the creation and utilization of a video tutorial library by the Mechanical Engineering Department at California State Polytechnic University, Pomona (Cal Poly Pomona), which is a primarily undergraduate institution. The library was started in March 2013 and currently contains over 600 original videos covering topics in statics, dynamics, fluid mechanics, thermodynamics, strength of materials, stress analysis, control systems, computer programming, numerical methods, and heat transfer. Twelve faculty members and full-time lecturers have contributed to this library by either creating videos or allowing their in-class lectures to be recorded. In addition to full-length lectures, the library contains numerous shorter videos covering single topics and example problems. The videos are hosted on the department’s YouTube channel and organized on a website called ME Online (www.cpp.edu/meonline). All videos are captioned and available to the public as an open educational resource. As of April 2019, the YouTube channel has accumulated over 4.2 million views and 37,500 subscribers.

The funding to develop content for the video library was obtained during 2011-2017 through a series of small internal and external grants for the purpose of course redesign. Costs were kept low by utilizing on-campus entities and student assistants to help with recording and editing, and faculty members volunteered their time to maintain the YouTube channel and ME Online website. In addition to being a supplemental resource for students at Cal Poly Pomona and around the world, videos have been repurposed for flipping a computer programming course and fluid mechanics course, as well as teaching a massive open online course. In Winter 2018, a survey was administered to 340 mechanical engineering undergraduate students at Cal Poly Pomona to gauge the impact of the video library on their academic career. Information was gathered on awareness of the video resources, frequency of viewing, perceived usefulness, and other topics. The majority of students were aware of the video resources, felt the videos had a positive impact on their education, and felt the videos helped improve their grades in at least one class.

1. Introduction

The open courseware movement has grown significantly since the early 2000s. Today many prestigious institutions with large endowments such as MIT [1] and Harvard [2] have developed extensive databases of videos and other free education resources, including complete self-paced online courses. These courses are sometimes created in partnerships with platforms that host massive open online courses (MOOCs), such as Coursera [3] and edX [4]. However, the high cost to develop and maintain such content has made it challenging for primarily undergraduate institutions, such as state universities and community colleges, to participate in the open courseware movement. Their relative lack of prestige also forms a barrier for collaboration with MOOC platforms – Coursera’s and edX’s university partners are mostly well-known Ph.D.-granting institutions [5], [6].

Fortunately, in the past decade advances in recording technology and hosting solutions have dramatically reduced the cost of developing and distributing educational content. With modern
recording and editing software (such as Camtasia Studio, iMovie, or Adobe Premiere Pro), a
decent microphone, and a free YouTube account, an individual can produce and share high-
quality content inexpensively and easily. Indeed, many individual instructors routinely create
videos for their students and host them on their personal YouTube channel or website. However,
there are not many examples of entire departments creating and organizing content for their
entire curriculum collaboratively.

This paper describes the development and utilization of a library of video tutorials by the
Mechanical Engineering Department at California State Polytechnic University, Pomona (Cal
Poly Pomona), which is a primarily undergraduate institution. The library was started in March
2013 and currently contains over 600 original videos covering topics in 10 core subject areas, as
well as other engineering-related topics. Twelve faculty members and full-time lecturers (about
half of the department) have contributed to this library by either developing original content or
allowing their full-length lectures to be recorded. In addition to the full-length lectures, the
library contains many shorter videos explaining single topics and worked example problems. It is
the authors’ hope that this paper can be a blueprint for departments at other institutions to
develop their own video library for relatively low cost.

2.1 Early efforts at developing video content

Throughout the mid to late 2000s, a few faculty members in the Mechanical Engineering
Department at Cal Poly Pomona created a small number of videos for grants that focused on
bottleneck courses (high enrollment, high failure rate). The videos were long (>30 min), similar
to a traditional lecture format, hosted on a local university server, and not shared with other
faculty members [7]. As a consequence, the videos had limited impact and were eventually
forgotten. A couple faculty members also created a game for vector statics, but it was not shared
widely and soon forgotten as well [8]. These resources had negligible impact outside the
university.

A sustained effort began in 2011 with two small internal grants from Cal Poly Pomona to
develop video resources. The first grant ($1000) was obtained in 2011 to create 10 videos
showing example problems for a vector dynamics course, and the second grant ($2000) was
obtained in 2012 to create 42 videos for a hybrid introductory computer programming course. A
few faculty members involved in these projects attended a week-long summer institute from the
university’s teaching and learning center (called “eLearning”) which discussed best practices in
video design. As a result, the videos created for the two grants were short and modular, with
most videos being less than 10 minutes in length and covering a single topic or example; short
videos are generally preferred by students [9], [10], [11]. The videos were initially uploaded to a
local university server and links were made available to other mechanical engineering instructors
who had the option of sharing the links with students. It is unknown how many people accessed
the videos, but the number likely was very low since the local server required people to login
using their university ID and password, preventing the general public from watching the videos.
Another significant disadvantage to using the local server was its limited storage space and
streaming capability, hindering potential future growth of the library.
2.2 Creation of a department YouTube channel and ME Online

In order to share the videos more easily with students and instructors, both locally and with the general public, the authors created a department YouTube account in March 2013 called CPPMechEngTutorials [12]. YouTube has numerous advantages over using a local server to host video content including zero cost to the university, unlimited storage space, and the videos are accessed easily by students and instructors in most of the world. Additionally, YouTube has the ability to automatically sync uploaded text with narration, creating captions instantly. For videos without an accompanying script, the YouTube video manager also can generate captions automatically, though the accuracy varies – moderate manual intervention is needed to guarantee accurate captions, which is required for accessibility purposes. The initial video library consisted of the 52 videos mentioned above and the viewership was on the order of a meager 10 views per day. Viewership would temporarily increase by an order of magnitude when an instructor would use the videos for a course, but then would drop back down after the term was over.

Additional funding to develop content for the video library arrived piecemeal during 2014-2017 as various faculty members received over 10 moderate external grants for the purpose of redesigning their courses through the Cal State University Course Redesign with Technology (CSU CRT) program [13]. Each grant varied between $15000 and $35000, and the authors estimate that approximately $100,000 – $150,000 of these grants was utilized for developing video content, mostly in the form of release time for instructors to create videos, paying student assistants to record and edit videos, purchasing recording technology, and paying for captioning services. Recognizing that the department would develop the library slowly over the course of many years, the authors created a framework that would allow new video resources to be incorporated into the library as they are developed. While the department did not place restrictions on the type of video tutorials that would accepted into the library, guidelines were established to ensure a base level of quality – e.g., all videos must be captioned, the video quality should be 720p or higher, audio quality should be clear, demonstration videos should have ample narration, etc. These guidelines were developed with the university’s eLearning staff to increase the accessibility of the videos.

In addition to the CSU CRT grants, the Mechanical Engineering Department also provided a small amount of funding for student assistants to record and edit a few full-length lecture series taught by well-respected senior instructors who would retire in the near future (e.g., [14]), as well as produce demonstration videos of student laboratory experiments (e.g., [15]). These videos would serve as both a resource for current students and a reference for new instructors.

By 2015, over 100 videos had been produced and it was becoming evident that the department needed a better method of organizing content by subject area. While it is possible to make playlists in YouTube, account administrators have limited control over the layout of the interface and it can be difficult for students to find content easily. In order to create a more user-friendly experience for students, the authors worked with the university’s eLearning team and IT Web Development team to create a website named ME Online [16] within the university’s content management system, Cascade. ME Online organizes the YouTube links by subject area and provides additional content such as syllabi and handouts. Although the university’s IT Web
Development team created the initial version of ME Online, its day-to-day management is handled by two of the authors.

One key partnership that saved the department a significant amount of time and money was the use of the university’s MediaVision team, which is an entity dedicated to providing Cal Poly Pomona with educational, informational, and public relations video content. Initially, MediaVision’s role was limited to adding title and credits sequences to existing video lecture series that were already recorded and edited by mechanical engineering student assistants. However, relying on mechanical engineering student assistants to edit lectures often led to long production delays due to schoolwork obligations. Additionally, the quality of videos varied greatly depending on the skills of the videographer and editor. MediaVision had much quicker turnaround times and superior recording capabilities, and their role soon elevated to recording, editing, and captioning entire lecture series. The department was only charged for captioning, which is approximately $100 per hour of recorded lecture. In order to ensure the department’s vision for each lecture series was realized, one of the authors acted as a liaison between the instructor being recorded and MediaVision’s staff.

2.3 Current status of the video library

At the time of writing, the department has released over 600 videos to the general public as an open educational resource. YouTube allows for wide distribution of videos to anyone in the world while ME Online allows students and instructors to quickly find content that is of interest to them. The YouTube channel has over 4.2 million views and 37,500 subscribers, and experiences approximately 6000 views per day when school is in session.

Figure 1 shows the daily viewership during the entire lifetime of the channel. The number of views was relatively low until Spring 2014 and Spring 2015, when the computer programming videos were repurposed for a MOOC. Viewership steadily grew in the subsequent years as new videos were added to the channel, ME Online was created, and the department started actively promoting the video library.

The analytics data available within YouTube offers some insight into how the video library is being utilized around the world. As of April 2019, the total amount of viewing time for the entire library is over 19 million minutes. Table 1 shows that the United States accounts for 35% of the total viewing time, with India (9.8%), Canada (5.5%), U.K. (3.7%), Turkey (3.5%), and Malaysia (2.2%) all having at least 400,000 minutes of total viewing time. The most highly watched videos are full-length lectures, although many of the shorter videos are popular as well.
Figure 1: Screenshot from YouTube showing the viewership history from March 22, 2013 through April 1, 2019. The spikes in April 2014 and April 2015 are due to the videos being used in a massive open online course. The seasonal dips in viewership correspond to summer and winter breaks.

Table 1: YouTube viewership by region as of April 1, 2019 (minimum 175,000 minutes)

<table>
<thead>
<tr>
<th>Region</th>
<th>Watch time (minutes)</th>
<th>Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>6,875,000&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>1,181,000</td>
</tr>
<tr>
<td>India</td>
<td>1,905,000</td>
<td>711,000</td>
</tr>
<tr>
<td>Canada</td>
<td>1,073,000</td>
<td>196,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>727,000</td>
<td>162,000</td>
</tr>
<tr>
<td>Turkey</td>
<td>679,000</td>
<td>129,000</td>
</tr>
<tr>
<td>Malaysia</td>
<td>425,000</td>
<td>87,000</td>
</tr>
<tr>
<td>South Africa</td>
<td>347,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Pakistan</td>
<td>307,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Australia</td>
<td>300,000</td>
<td>64,000</td>
</tr>
<tr>
<td>Egypt</td>
<td>281,000</td>
<td>67,000</td>
</tr>
<tr>
<td>Philippines</td>
<td>270,000</td>
<td>77,000</td>
</tr>
<tr>
<td>Germany</td>
<td>214,000</td>
<td>50,000</td>
</tr>
<tr>
<td>France</td>
<td>186,000</td>
<td>47,000</td>
</tr>
<tr>
<td>Brazil</td>
<td>185,000</td>
<td>34,000</td>
</tr>
</tbody>
</table>

<sup>(a)</sup> Number of minutes and number of views rounded to nearest thousand.
3.1 Using the videos for pedagogical experiments

The videos from the library have been utilized by the department to experiment with new pedagogical strategies. Faculty have conducted studies on the impact of introducing video tutorials in a vector dynamics course [17], flipping a fluid mechanics course [18], [19], and flipping a computer programming course [20], [21]. In the fluid mechanics course, the flipped classroom strategy resulted in failure rates decreasing by over 50%, a large increase in the number of A’s compared to a traditional lecture pedagogy, and enhanced student satisfaction with the course. The flipped classroom approach also resulted in improved grades in the computer programming course. In the vector dynamics course, most students watched all the videos but the videos alone did not have a significant impact on grades. Currently a study is being conducted on the impact of videos in a vector statics course – thus far students have reacted positively to the videos (especially those discussing basic concepts such as forces and centroids), all students have watched the videos, and students have requested more videos showing example problems. Other benefits of the video library to the department include the use of videos to ensure a consistent curriculum among part-time lecturers and the repurposing of videos to develop Cal Poly Pomona’s first massive open online course (MOOC) in 2014 [22] and 2015 [23].

The videos are being used by instructors at other institutions to experiment with new teaching styles as well. For example, the authors received an email from a mechanical engineering professor at Eindhoven University of Technology in the Netherlands describing their use of the fluid mechanics videos in an online version of their Heat and Flow course. Another mechanical engineering professor at Cal Poly Pomona’s sister-campus, Cal Poly San Luis Obispo, is using videos to supplement his thermodynamics course. Numerous other instructors at other institutions have contacted the authors asking for permission to use parts of the video library for their courses, which we enthusiastically granted.

3.2 Student feedback about the video library

In order to gauge the impact of the video library on current Cal Poly Pomona mechanical engineering students, in March 2018 (end of Winter 2018 quarter) the authors created an anonymous survey that was administered to 340 mechanical engineering students in sophomore, junior, and senior-level courses, which was over one-quarter of the entire department. Instructors distributed paper surveys to students during class time, collected the completed surveys, then gave the surveys to the authors after class for analysis. Students were not asked to provide names, university ID numbers, or any other data that could easily identify them. This meant the authors were not able to confirm that a representative sample of the entire department was obtained in terms of gender, GPA, etc. However, it was hoped that administering the surveys to a large number of students over many courses would yield a fairly representative sample.

The surveys asked students about many topics such as awareness of the video resources and frequency of use, as well as soliciting open-ended feedback about the video library. Results from the surveys indicated that 77% of mechanical engineering students were aware of the department’s YouTube account and 67% were aware of ME Online. Below are responses from
students who were aware of YouTube account (Note: Some totals do not equal 100% due to rounding).

Frequency of viewing videos produced by the department for help with a class in W2018

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>Daily</td>
<td>1%</td>
</tr>
<tr>
<td>Few times per week</td>
<td>20%</td>
</tr>
<tr>
<td>Few times per month</td>
<td>28%</td>
</tr>
<tr>
<td>Few times per quarter</td>
<td>25%</td>
</tr>
<tr>
<td>Did not watch any videos</td>
<td>26%</td>
</tr>
</tbody>
</table>

Frequency of viewing videos not produced by the department for help with a class in W2018

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<table>
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<tr>
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<tbody>
<tr>
<td>Daily</td>
<td>5%</td>
</tr>
<tr>
<td>Few times per week</td>
<td>19%</td>
</tr>
<tr>
<td>Few times per month</td>
<td>22%</td>
</tr>
<tr>
<td>Few times per quarter</td>
<td>32%</td>
</tr>
<tr>
<td>Did not watch any videos</td>
<td>24%</td>
</tr>
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</table>

Use of videos by your instructors in W2018

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>Required for at least one course</td>
<td>5%</td>
</tr>
<tr>
<td>Recommended for at least one course</td>
<td>38%</td>
</tr>
<tr>
<td>Not required nor recommended</td>
<td>57%</td>
</tr>
</tbody>
</table>

What type of videos do you find the most beneficial?

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<table>
<thead>
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<tbody>
<tr>
<td>Full-length lectures</td>
<td>47%</td>
</tr>
<tr>
<td>Short conceptual videos</td>
<td>29%</td>
</tr>
<tr>
<td>Short example problems</td>
<td>23%</td>
</tr>
</tbody>
</table>

How valuable has the department’s video content been to your education?

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<table>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Large positive impact</td>
<td>31%</td>
</tr>
<tr>
<td>Small positive impact</td>
<td>56%</td>
</tr>
<tr>
<td>No impact</td>
<td>12%</td>
</tr>
<tr>
<td>Small negative impact</td>
<td>0%</td>
</tr>
<tr>
<td>Large negative impact</td>
<td>0%</td>
</tr>
</tbody>
</table>

How have the videos impacted your grades?

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<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved grades in 3+ classes</td>
<td>10%</td>
</tr>
<tr>
<td>Improved grades in 2 classes</td>
<td>29%</td>
</tr>
<tr>
<td>Improved grades in 1 class</td>
<td>40%</td>
</tr>
<tr>
<td>Not improved my grades</td>
<td>21%</td>
</tr>
<tr>
<td>Hurt my grades in 1+ class</td>
<td>0%</td>
</tr>
</tbody>
</table>

The surveys reveal that among students who are aware of the video library, 74% students accessed the videos multiple times per quarter, 88% felt the content made at least a small positive impact on their education, and 79% felt the videos have positively impacted their grades in at least one course. Unfortunately, at this time it is not possible to gauge whether the videos have actually made a significant impact in the overall academic performance of the students in
the department since there are too many variables to consider. However, the authors are encouraged by the fact that students perceive the videos as helping their academic performance.

There appears to be a strong need to continue producing video content as 76% of the students report using videos that were not produced by the department to help them in their coursework multiple times per quarter. Indeed, when asked how ME Online could improve, many students requested more videos. One benefit of creating a video tutorial library is that the department can vet the content for accuracy; there are numerous videos on YouTube that present topics in an incomplete or incorrect manner, which could harm students academically as they may not have the ability to discern accurate videos from inaccurate videos.

Interestingly many students felt that full-length lectures were the most beneficial type of video in the library. It is unclear whether this was due to students being accustomed to learning in a classroom setting, a lack of shorter videos discussing concepts and example problems, a sense that the lecture quality is higher than the shorter videos, or some other reason. It should be noted that the instructors in the full-length lectures were selected in part because they are personable and engaging, making the lectures more enjoyable to watch.

There is ample anecdotal evidence for the videos being valued by students both at Cal Poly Pomona and beyond. The YouTube comments are almost all positive and the average like:dislike ratio is 36:1 across all videos. This video library project has impacted the participating instructors positively as well. On many occasions, Cal Poly Pomona students have stopped instructors in the hallway and thanked them for the videos, even when they never took a course with the instructor. Additionally, many people from all over the world have emailed instructors directly to thank them for making the videos available. Below are quotes from instructors whose full-length lectures were recorded:

- “This has been the most rewarding experience of my teaching career and it is humbling to know I have helped for many students across the world and how much they appreciate my videos.”
- “My experience with being recorded and the subsequent feedback that I have received have been entirely positive…. It is, of course, very satisfying to get emails from strangers and to know that people on the other side of the world are benefiting from what I have done.”

A general concern of instructors who are considering creating their own videos is the potential of attendance being negatively impacted. One instructor whose lecture series was recorded stated, “I hope that the students will not assume that they can watch the video and skip the class. I still believe that the classroom experience and the ability to be able to ask questions is irreplaceable.” Studies have shown that students value video and audio recordings as a tool for reviewing material much more than as an alternative for attendance, and that negative impacts on attendance are usually minor or non-existent [24], [25], [26], [27], [28]. Another instructor mentioned, “I was somewhat surprised that [the videos] did not negatively impact my student class attendance. I had close to 100% student attendance in every class lecture.”

Another concern is the potential of the instructor and students being uncomfortable with a camera in the classroom. All instructors who recorded full-length lectures were volunteers and students signed release forms prior to filming. Students who did not want to be recorded were
asked to sit outside the viewing angle of the camera. While most instructors who were recorded reported not being significantly affected by the camera’s presence, the recording of one lecture series was terminated early at the request of the instructor because he felt the recording was possibly preventing students from asking questions.

4. Discussion and the future of video library

The ME Online video library is an example of how collaborations among individual instructors and university entities can produce a resource that is utilized and appreciated by students locally and around the world. Our department has created a system that allows instructors to share videos easily for relatively low cost and can continue to grow in a sustainable way as new content is produced. It should be noted that the video library is not complete by any means. It is an ongoing project, and instructors continue to add more videos or update previous videos to remain consistent with their curriculum.

Currently the video library is being used to experiment with a supplemental instruction pedagogical model and a podcast series on topics relevant to current and potential engineering students [29]. Additionally, the authors are modifying the full-length lectures on the YouTube channel to enhance the user experience by (1) adding timestamps in the video notes which allows students to jump directly to portions of the lecture that interest them the most (e.g., an example problem that starts at 12:53 in a particular lecture) and (2) adding “cards” to the end of each lecture which allow students to view the next lecture in the series and provides another avenue for viewers to subscribe to the channel.

At the time of writing, YouTube offers content producers the option of “monetizing” their channel if they have at least 4000 hours of viewing annually and over 1000 subscribers – CPPMechEngTutorials easily qualifies for monetization. In exchange for commercials playing at the beginning and/or middle of videos, a channel owner receives small amounts of money per view. Thus far the department has decided to forego the monetization feature in YouTube for the following reasons:

- Commercials can be annoying and we do not want to negatively impact the student experience.
- There are many unanswered questions regarding how the money would be distributed. How would the money flow from the YouTube account to the department? Should the creator of the video receive a portion of the money? If MediaVision helps record a video, should they receive a portion of the money? Who would pay taxes on the money? Assuming all of the above issues are resolved, who decides how the money will be spent by the department?

The authors hope this paper will inspire others to create their own video library regardless of their resource limitations, and we encourage others to use our videos to experiment with different pedagogies. If the reader uses the videos in his or her own courses, the authors would appreciate feedback about the library.
5. Acknowledgments

The authors would like to thank the Cal State University Course Redesign with Technology Program, Cal Poly Pomona Engaging the Digital Student Initiative, Cal Poly Pomona Graduation Initiative, and the Cal Poly Pomona SPICE program for providing the initial funding for the video library. The authors also would like to thank the university entities eLearning, MediaVision, and IT Web Development team for providing technical support and guidance during part of the project. Finally, the authors would like to thank the following mechanical engineering instructors for contributing original content to the video library (along with the authors): Professors David Miller, Mohammad Izadi, John Biddle, Hassan Rejali, Peter Dashner, Jaehoon Seong, Amir Rezaei, Mehrdad Haghi, Henry Xue, Chris Chen, and Priscilla Zhao.

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