Research team receives $7.9M from NSF to develop Internet for 21st century

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The National Science Foundation's Directorate for Computer and Information Science and Engineering has awarded a team of researchers led by UCLA $7.9 million to develop a more efficient and robust Internet that can meet the challenges and opportunities of the 21st century.

Lixia Zhang, a professor of computer science at the UCLA Henry Samueli School of Engineering and Applied Science; Jeff Burke, a professor at the UCLA School of Theater, Film and Television and executive director of the UCLA Center for Research in Engineering, Media and Performance (REMAP); and Deborah Estrin, director of the UCLA Center for Embedded Networked Sensing (CENS) and a professor of computer science at UCLA Engineering who holds the Jon Postel Chair in Computer Networks, will be the three principal investigators on the project.

Van Jacobson of PARC, a Xerox company, will serve as the network architect for the new approach, called Named Data Networking (NDN), working closely with Zhang. Partner institutions include Colorado State University, the University of Arizona, the University of Illinois at Urbana-Champaign, UC Irvine, the University of Memphis, UC San Diego, Washington University and Yale University.

"I am proud to see that, as the birthplace of the Internet, UCLA Engineering has been chosen once again to lead a project that could have significant implications for the future of global communications," said

Vijay K. Dhir, dean of UCLA Engineering. "Nobody could have imagined the evolution of the Internet in those early years and the major role UCLA would play, and I am confident our role in the growth and success of the Internet will continue."

"The future of the Internet is integral to the future of creative expression and civic engagement. I am excited that REMAP's participation will bring storytellers into a significant and productive collaboration with engineers and computer scientists," said Teri Schwartz, dean of the UCLA School of Theater, Film and Television. "The NDN project exemplifies the extraordinary potential for interdisciplinary research at UCLA and demonstrates the proactive role that great film and theater institutions should play in developing fundamental next-generation technology."

The transmission of the first message over the Internet took place at UCLA in the fall of 1969. At that time, telephony was the one example of successful global-scale communications. That, along with the goal of connecting the few supercomputers that existed with one another, resulted in the development of Internet protocol (IP). Based on point-to-point communication architecture, like the telephone system, IP was designed to allow computers to find and communicate with one another. The use of IP addresses and hosts — the "where" model of the Internet — has been a huge success.

However, after 40 years, the network has experienced exponential growth, evolving into a system of hundreds of millions of computers and hundreds of thousands of networks used by almost a quarter of the world's population. And importantly, large numbers of Internet-connected devices have become mobile, losing their fixed "where" addresses. Many applications increasingly focus on content accessed independent of a single host location. The host-based communication model of IP is beginning to show some inherent limitations and

constraints.

"Our vision is conceptually simple," said Zhang, the project's lead investigator. "We plan to explore a new Internet architecture, Named Data Networking, in which we'll replace the 'where' — addresses and hosts — with 'what,' the content that users and applications care about. By naming data instead of locations, the new architecture transforms data into a first-class entity."

NDN will offer several new opportunities for Zhang's team to explore. With regard to security, for example, instead of the current one-size-fits-all model of armoring the channel between two IP addresses, NDN will allow all data to be secured end-to-end, and the data's name will provide the essential context for security. Communications security will no longer be divorced from the data it secures. Named Data Networking will be able to tell if the data on a Web page was actually produced and signed by the owner of the site, similar to one's bank. IP does not have that capability.

"Technical challenges will be addressed to validate NDN as a future Internet architecture," Zhang said. "Routing scalability, fast forwarding, trust models, network security, content protection and privacy, and fundamental communication theory will all need to be considered."

To test and drive the architecture, applications will be built to investigate how NDN best enables efficient authoring of distributed and "cyber-physical" applications. Today's applications are conceived in terms of what information one wants but still must be written to consider on which specific devices that information is located. This means that application-specific middleware has to be used to map between the application model and the Internet. With NDN, the application's 'what' model can be implemented directly, removing all the middleware and its associated configuration and communication inefficiencies.

Co-principal investigator Jeff Burke, of UCLA's REMAP, will be leading the effort to develop and deploy prototype applications.

"REMAP has been exploring the use of named data at the application networking level since 2002, when we realized it would help us organize and develop distributed applications that incorporated sensors, media and automation of the physical environment," he said. "The NDN project is very exciting, as it makes a more sophisticated and comprehensive version of this idea fundamental to the network itself."

Burke, along with collaborators at UCLA and the University of Illinois at Urbana-Champaign, will consider a broad range of future applications to inform the network architecture. Prototypes built at REMAP and UCLA's CENS will focus on three high-impact areas: streaming content distribution; media-rich, instrumented environments (often called "smart buildings"); and participatory sensing on mobile phones.

"REMAP's research integrates cultural, social and engineering objectives; we are interested in applications that are both expressive and functional," Burke said. "This is crucial to understanding future network applications, as the Internet has become integral to not just commerce but our social and creative lives."

According to Zhang and Burke, there will also be an education and outreach component to the project. Materials to teach "architectural thinking," integrated with NDN-enabled research, will be developed, encouraging students to view networking in new ways. Graduate students will be involved in core research and thesis work, and a summer internship program for traditionally underrepresented undergraduate students will be created.

"Network architecture is an important concept that has been somewhat neglected for a number of years. Current research tends to be more

about clever ideas for individual pieces, but people haven't really been looking at the overall architecture," Zhang said. "The NSF's Future Internet Design program put the topic of architecture back on the table. I think the NDN project will be a great opportunity for students to learn how to think architecturally about the Internet and do side-by-side comparisons of the old and the new."

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