Telecommunications expert and former technology researcher Dr Louis Fox explains how his organisation is connecting Californian research and education institutions.

Can you introduce the main aims of the Corporation for Education Network Initiatives in California (CENIC), and the context in which it was established?

CENIC connects California to the world – advancing education and research state-wide by providing the world-class network essential for innovation, collaboration and economic growth. Our non-profit organisation operates the California Research and Education Network (CalREN), a high-capacity network designed to meet the unique requirements of over 20 million users, including the vast majority of K-20 students together with educators, researchers and other vital public-serving institutions. CENIC’s Charter Associates are part of the world’s largest education system; they include the California K-12 system, California Community Colleges, the California State University (CSU) system, California’s Public Libraries, the University of California system, Stanford, Caltech and the University of Southern California. CENIC also provides connectivity to leading-edge institutions and industry research organisations around the world, serving the public as a catalyst for a vibrant California.

How have CalREN and the California OpenFlow Testbed Network (COTN) changed the CENIC members’ network capabilities?

Our members are the most highly connected community in the world – all research universities are connected directly at 100 gigabits per second (Gbs⁻¹), with a goal of 10 Gbs⁻¹ for all; and library jurisdictions at 1-10 Gbs⁻¹, with several 10 Gbs⁻¹ library jurisdictions (many of which are national or global firsts), and the world’s first 100 Gbs⁻¹ library system in the offing.

Is collaboration particularly important to achieving CENIC’s aims? Could you highlight some of the outcomes of these partnerships, such as those with the California Telehealth Network and the Energy Science Network?

We are a platform for collaboration between and among the educational segments, and we therefore undertake and facilitate a number of collaborative endeavours. That might mean, for example, enabling libraries to be a part of CENIC, since they have some partnerships with local K-12 schools or community colleges. This kind of thing extends across the education spectrum. We also connect a lot of cultural institutions, such as the Exploratorium in San Francisco – a fabulous science museum – and SFJAZZ, the first freestanding facility built for jazz in the US. Jazz is an indigenous American art form, and therefore has a great cultural importance. SFJAZZ can derive many benefits from their connectivity: they might audition a student using the network, or they might do a concert at a school with high definition video and sound.

What have been the greatest challenges in connecting universities with high-speed networks at low cost?

For networks, the biggest challenge in California is the geography. Most people, even in the US, think of California as being this handful of big cities, but it’s also a mountainous and rural state, which is a complicating factor. So, there’s a diversity of geography and serving these communities often requires complex and costly construction projects.

Do you aim to replicate the CENIC model elsewhere to give research and education institutions a competitive advantage by providing high performance networks at low cost?

Yes – in fact, we are already doing this! There are research and education networks like CENIC throughout the US; some of them are state-based and some are regional. We are very involved with our region, so we work with partners and, for example, the Western Regional Network – a Western regional collaboration; the Pacific Northwest Gigapop – they serve Washington, Idaho, Montana and parts of Oregon; the Front Range Gigapop, which serves Colorado and Wyoming; and the New Mexico Gigapop. Collectively, we have put together fibre assets throughout the west that enable really important scientific collaborations to go on between and among the research institutions in our state. We also partner with national networks like Internet2 and the Energy Sciences Network. One that I haven’t mentioned yet is Pacific Wave, an international peering fabric that allows research and education networks from around the world to interconnect with our network and operate as if it were a single network fabric. CENIC’s model exists in other places, it’s just that the scale that we do things in California has more in common with other national networks than state networks, given the size, complexity and number of institutions in California.
A golden opportunity

The Corporation for Education Network Initiatives in California, USA, is seizing opportunities to improve network infrastructure between education organisations in the Golden State.

**IN MANY WAYS**, communication is the hallmark that distinguishes humans from other animals. Although some species have been observed to develop relatively complex verbal communication, none can approach the loquacity of humankind – and supported by increasingly powerful technology through history, this compulsion to talk with one another has led to an incessant stream of information passing between people all over the world. In fact, human discourse has become so ubiquitous that much of it seems redundant. The internet, for example, facilitates the passage of important messages between communicators worldwide – but much of its traffic is concerned with subjects as banal as sharing amusing videos and idle chatter.

The growing private demand for data – including, increasingly, mobile data – puts heavy pressure on existing commercial infrastructure. This presents a problem – while consumers are amicable to the prospect of spending an increasing amount of money on securing internet access, public institutions such as libraries, universities and medical centres do not necessarily have that capacity. Research and education are the foundation of a strong economy, as well as being powerful forces for quality of life and societal development. It is therefore essential that institutions dedicated to these pursuits be allocated the resources they need to succeed. This includes networking resources, particularly since collaborative ties are a real asset in both research and education.

**ALL-TERRAIN FIBRE FOR HIGH-SPEED RESEARCH COLLABORATION**

Establishing network infrastructure at the capacity required by these critically important public entities is not easy – and in certain areas, it is especially difficult. California, for example, is the largest of all the US states in terms of population; 1 in 8 US citizens call the state home. It is also geographically diverse, with terrain ranging from fir forests and mountains to deserts and valleys. It is in California that both the highest and lowest points in the contiguous US can be found. The Golden State is also the second-most likely to experience earthquakes, preceded only by Alaska, and is also at high risk of wildfires. These factors make it very challenging to establish reliable networks of the type required for collaboration between partner institutions. Yet California is also home to a number of world-leading education and research organisations, such as the University of California campuses, Stanford and Caltech, as well as Department of Energy laboratories and NASA research centres, all of which rely on cooperative links for their success.

The Corporation for Education Network Initiatives in California (CENIC) is a non-profit organisation dedicated to enabling this kind of high-capacity networking and safeguarding the critical research infrastructure that California’s world-leading education and research organisations rely on.
Almost 4,000 miles of optical fibre were required to link the participating institutions, and today around 10,000 sites connect to CalREN

California’s future. Headed by CEO Louis Fox, CENIC’s mission is to contribute to research and education by enhancing network capacity, one of the main ways in which this is accomplished is through the California Research and Education Network (CalREN), a high-capacity network purpose-built to serve an audience of students, educators and researchers. “From biomedical data to particle physics, today nearly all research and data analysis involves remote collaboration. In order to work effectively and efficiently on multi-institutional projects, researchers depend heavily on high-speed access to large datasets, scientific instruments and computing resources,” Fox explains.

CALIFORNIA’S BACKBONE

The scale of CalREN is impressive. The physical fundament of this network – which connects members in every single one of California’s 58 counties – is expansive in scale, almost 4,000 miles of optical fibre were required to link the participating institutions, and today over 10,000 sites connect to CalREN. What is more, whether they know it or not, 20 million Californians use CalREN, emphasising the great importance of this resource to society. The network is the backbone of CENIC’s wide-ranging activities within the state, and acts as a vital support to the organisation’s work. For this reason, the company recently completed an upgrade of the network, pushing its speed up to a huge 100 gigabits per second (Gbs⁻¹).

Opening the network up to libraries is currently an important goal for CENIC. In 2016, the organisation assessed the capacity of these public institutions, finding that 75 per cent had low-speed connections, two-thirds were operating at or above their capacity and that the total bill being paid for this poor service was US $14 million. CENIC therefore decided to open CalREN to libraries, bringing them high-speed broadband that is 30 to 1,000 times faster than their current services at around one-third of the cost. Libraries will be able to join the project from September 2015 and over 1,000 libraries will be joining the library over the next two to three years.

THE RESPECT OF PEERS

“We peer with networks like Microsoft, Google and Amazon,” reveals Fox. “The traffic goes from our network, which is a fibre network, throughout California and the west to their network, without ever going over the commercial internet.” It is peering with these large private networks that allows CalREN to achieve such remarkable performance, and it also presents the option of offering novel cloud services that avoid the commercial internet. Another important resource in terms of peering is the Pacific Wave peering service, which is provided by the Pacific Northwest Gigapop, and allows for international connectivity. Pacific Wave is the main route by which advanced networks cross the Pacific Ocean and by which California research universities connect to the rest of the world.

A PACIFIC PLATFORM

Currently, however, some of the most exciting work being undertaken by CENIC concerns the Pacific Research Platform (PRP) – an ambitious project to integrate various networks including the US Department of Energy’s Energy Science Network (ESnet) and its DMZ model into a high-capacity ‘data freeway’ for scientists and researchers. The National Science Foundation (NSF) has awarded a grant of $5 million to support the project over five years, and more than 20 research-performing institutions have joined the partnership in order to be part of the developing network – including all 10 University of California (UC) campuses. Researchers at UC San Diego and UC Berkeley in particular have played a leading role in the project.

The PRP’s data-sharing architecture allows for end-to-end connections throughout the network with a speed of not less than 10 Gbs⁻¹, although speeds of up to 100 Gbs⁻¹ are possible. Because it is a dedicated environment for science data and avoids the commercial internet, it is also highly secure and large amounts of data can be transferred without risk. These impressive capabilities make it the ideal tool for pursuing data-intensive collaborative research projects concerning topics from cancer genomics to climate modelling, and CENIC is working towards making it a reality for researchers across California, the Western US, and among international research and education network communities.