This paper was presented at the conference:

Oxford eResearch 2008

11-13 September 2008

University of Oxford

Conference website:
http://www.oii.ox.ac.uk/microsites/eresearch08/index.cfm

Conference papers collection:
http://ora.ouls.ox.ac.uk/objects/uuid%3A64aa6f39-7e81-4d42-a008-ee2d7524bd67

Conference organisers:

Oxford Internet Institute
University of Oxford
1 St Giles, Oxford OX1 3JS
http://www.oii.ox.ac.uk/
email: enquiries@oii.ox.ac.uk

Oxford e-Research Centre
University of Oxford
7 Keble Road, Oxford OX1 3QG
http://www.oerc.ox.ac.uk/

ENHANCING E-RESEARCH THROUGH THE KIWI ADVANCED RESEARCH AND EDUCATION NETWORK – THE AOTEAROA/NEW ZEALAND EXPERIENCE

Tracy Williams[a], Julian Carver[b] and Dean Patfield[c]

[a] New Zealand Institute for Crop & Food Research Limited, Private Bag 4704, Christchurch 8140, New Zealand
[b] Seradigm, 190 Hereford St, PO Box 30042, Christchurch, New Zealand
[c] Christchurch Polytechnic Institute of Technology, PO Box 540, Christchurch 8140, New Zealand

Abstract

The Kiwi Advanced Research and Education Network (KAREN) was set up by the New Zealand government in 2006 to facilitate collaboration and leading edge e-Research amongst the research, education and innovation sectors, both nationally and internationally. A specific goal is to connect the research and education sector to the broader innovation community for pre-commercial, R&D-based collaboration. Activities that use the speed and capacity of KAREN to deliver innovative education and research outcomes include: improved access to local or overseas partners; access to digital resources from universities or New Zealand Crown Research Institutes; access to local, national and international advanced networks and their digital content; real-time collaboration for teaching and research; video streaming; multi-media services; and remote collaborative teaching and learning.

To encourage broad participation amongst the organisations currently connected to KAREN an Institutional Capability Build Fund has been established by the New Zealand Government to accelerate the capability of these members to exploit KAREN's full value. This paper describes the experience of the New Zealand Institute for Crop & Food Research Limited, a Crown Research Institute with the

vision of leading New Zealand innovation in food and food production, in applying those funds to enhance KAREN uptake amongst its science and business professionals. Prospects for new applications as well as the institutional learning that is taking place are also described.

Keywords KAREN (Kiwi Advanced Research and Education Network); collaboration; institutional learning; REANNZ (Research and Education Advanced Network of New Zealand)

Introduction

New Zealand's national icon, the kiwi, might be a nocturnal flightless bird but we are a nation of travellers, explorers and innovators. Our physical presence on the planet, tiny and tucked away `down under', creates some unique challenges in combination with our population of 4 million and the way it is clustered. Whilst 1 million New Zealanders live in Auckland, a city that the Government is committed to ensuring becomes a city of international importance, the rest of the population is found in four key cities scattered across our two islands. Those living in our rural communities (around 20%) make a significant contribution to our economy, through agricultural and horticultural production, our wine and cheese exports as well as adventure and mainstream tourism – and not to forget film making!

When it comes to undertaking research in New Zealand, we have internationally recognised individuals working at very high levels in their fields but often struggling to secure stable funding and high quality facilities. Maintaining critical mass and retaining the talent that is emerging from our world-class universities can be difficult. Collaborating directly with colleagues around the world requires considerable time, finances and jet fuel while direct contact via phone or teleconference means one party is likely to be sleep deprived in the short term! Such are the obstacles that must be overcome to establish and maintain dialogue with research teams and visit their laboratories many thousands of kilometres away.

One of the New Zealand Government's recent responses to these challenges has been to build the first piece of new national infrastructure seen in New Zealand for several decades. In 2006 they funded the establishment of the Kiwi Advanced

Research and Education Network (KAREN) − a next generation telecommunications link for New Zealand educators, researchers and innovators. It operates at 10,000 times the speed of a standard New Zealand broadband connection. KAREN went live on 15 December 2006 to facilitate collaboration and leading edge e-Research amongst the research, education and innovation sectors, both nationally and internationally. It currently provides high-capacity, high-speed connectivity between tertiary institutions, research organisations, the national library and the rest of the world (Figure 1). Work is also underway to connect wananga (educational organisations that promote Te Reo or Maori language and learning practices), polytechnics, schools, museums and industry to KAREN.

REANNZ (the Research and Education Advanced Network of New Zealand), a Crown-owned company, was established in 2005 to own and operate KAREN. This agency is 100% owned by the New Zealand government. It has a Board of 7 Directors and 12 full-time equivalent employees. Its mission is “to accelerate, through operating the country’s advanced research and education network, New Zealanders having the connectivity and capability to excel in a weightless, low-carbon, global economy”.

The objectives of REANNZ include enabling leading edge e-Research, encouraging universal connectivity throughout the New Zealand and international research and education community, promoting broad participation by the research and education sector in New Zealand through accessible technology and reasonable pricing, and connecting the research and education sector to the broader innovation community (Anon. 2008).

Twenty-five members and associate members are now connected to KAREN, including New Zealand's nine Crown Research Institutes (CRIs), eight universities, the National Library, polytechnics, schools and partners at 62 sites around the country. By March 2006 a physically resilient, national, very high speed network with 16 local interconnect points, a 10 Gb/s national backbone and two international circuits to Sydney and Seattle connecting to similar overseas networks was in place. KAREN is now connected to over 16 other advanced research and education networks internationally, giving New Zealand members global reach. The next stage of development is to connect the polytechnics, wananga and schools in New Zealand by way of a National Education Network (NEN) running over KAREN. A project is underway to design the architecture for a NEN and test a range of services and contents to be offered over it. The project will investigate appropriate architecture for the NEN, deliver educational services, identify issues, demonstrate and prove benefits of the NEN, and validate the integrity of the architecture and services through test cases and rigid testing.

In 2007 a comparative analysis of 26 EU/EFTA research and education networks revealed that KAREN has the eighth largest network size (in Gigabytes/second/km), the sixth smallest budget and the best network size:budget ratio (TERENA Compendium 2007).

Currently KAREN members pay approximately 28% of the total costs (including capital expenditure) involved in supporting KAREN and the New Zealand Government funds the balance. The cost per individual member is based on the type

of organisation (CRI, university or polytechnic, etc.) and a scale factor that reflects the size of the organisations and the level of use they are likely to make of KAREN. Financial forecasts of REANNZ show a continuing gap between network revenues from users and the level of income required to meet financial sustainability. The agency is seeking recommitment to KAREN from Government beyond the initial four-year commitment from 2006 to 2010 with a raise in contribution sufficient to cover REANNZ's cash operating costs and essential reinvestment. Increases in costs to members are a further option.

Support for REANNZ and the continued development of KAREN has come from a number of sources as the benefits of the advanced network become well established. Science New Zealand, a science advocacy agency for New Zealand's CRIs with the role of fostering an appreciation of the value of science and technology in creating economic, environmental and social wealth for New Zealand, supports the Government's continued investment in KAREN and has advised Government that "the State should recognise KAREN as an essential utility, part of national infrastructure, and thus fund the balance of the necessary investment as a public good" (Anthony Scott, Chief Executive, Science New Zealand, pers. comm.).

Public policy justifications for investing public money in REANNZ are that it overcomes temporary barriers (such as co-ordination issues, time to realise benefits and scale effects) and ensures benefits to the wider community on an ongoing basis. REANNZ is seeking long-term partial support for KAREN from the Government to ensure maximum benefit to the country is realised. As the largest purchasers of broadband and networking in New Zealand the Government is being encouraged to

gain maximum advantage from its ownership of REANNZ to achieve better outcomes for all New Zealanders, not just the research and education sectors, by requiring that REANNZ purchases, owns and operates a national backbone network of Access Aggregation Points and interconnects on behalf of the state sector. A wider scope of objectives is consequently envisaged for REANNZ in the future, including economic development, science, education, digital and ICT, and environmental sustainability.

In addition, Government initiatives articulated by the National Science Panel in 2008 (A Science Manifesto, National Science Panel, 2008) include increased collaboration between the science system and business, reducing transaction costs, and working more closely with the education sector. These initiatives directly require KAREN.

However, it is widely felt that the major limitations on KAREN's current use is the lack of time needed for researchers to familiarise themselves with the technology, and the lack of funding to support the development of middleware and the purchase of software and infrastructure required for complex research projects.

This paper describes the role of KAREN in supporting New Zealand's science and innovation infrastructure and a capability development fund designed by REANNZ to enhance connectivity and ensure continued scientific progress through the sharing of data, assets and people across the country and across the world. Since 2006 NZ$4 million (approximately £1.5 million) of e-Research capability funding out of a total fund pool of NZ$4.8 million (approximately £1.7 million)

available until June 2009 has been distributed. The paper also outlines the experience of the New Zealand Institute for Crop & Food Research Limited (CFR) when applying funding granted by REANNZ to explore KAREN's potential and relevance to our business along with the organisational learning that has taken place.

The Capability Build scheme – encouraging exploration by KAREN members

REANNZ has established a Capability Build fund and, with input from the Capability Build Advisory Panel, has established a vision and goals for the Capability Build Fund to help raise awareness and use of KAREN.

The vision is that as a result of projects supported by this fund, in the near future:

1. New Zealand researchers will be able to participate in international research as equal partners;
2. new or enhanced research collaborations, facilitated by KAREN, will be established within New Zealand;
3. funding agencies will be fully aware of the value of KAREN to education and research;
4. KAREN will facilitate the development of new types of research that will be undertaken in New Zealand;
5. KAREN will facilitate the development of new forms of education, including the use of national and international services such as data repositories and simulation.

The goals of the Capability Build Fund are to:

1. Establish an awareness of KAREN:

- Produce success stories to demonstrate value
- Facilitate New Zealand access to international funding

2. Enable the effective use of KAREN

- Establish sufficient expertise within each current member to enable KAREN to be used effectively
- Establish centres of expertise and co-ordination, e.g. for Access GRID scheduling
- Enable new forms of collaboration, leading eventually to new funding opportunities
- Develop a culture amongst educators and researchers that includes elements of awareness of and ability in advanced networking techniques

3. Promote the use of KAREN

- Develop a culture amongst educators and researchers that includes elements of awareness of and ability in advanced network techniques
- Produce success stories to demonstrate value
- Ensure that the use of KAREN is not inhibited by lack of skills or access to expertise.

4. Create a community ethos of sharing knowledge.

It is also envisaged that all activities will share acquired knowledge and technology development.

A further pool of funds, the Institutional Capability Build Fund, has been designated to accelerate the capability of KAREN members to exploit KAREN's full value. Grants of up to NZ$50,000 (£19,230) per member institution are available to support staff time investment in capability development and awareness-raising activities relevant to KAREN. This fund supports the appointment of a `KAREN champion' within each core member institution. To qualify as a KAREN champion the individual must have the following key features:

- the sponsorship of the executive team within the member institution

- reporting arrangements to the highest level research and/or education manager within the member institution
- good standing with the research/education community
- an understanding of and experience with (or willingness to develop) e-Research concepts and tools.

KAREN champions are required to share their ideas and experiences through the KAREN wiki hosted by REANNZ (www.karen.net.nz/home).

All applications to the Capability Build Fund are evaluated against a set of criteria that includes the extent to which the proposal:

1. Encourages collaboration
2. Builds professional skills
3. Increases the use of KAREN
4. Benefits the wider research and education community
5. Matches one or more of the following priorities:
    a. Supporting adoption and implementation of real-time collaboration technologies for teaching and research
    b. Supporting the adoption and implementation of middleware – specifically enabling sharing of data and/or information or computational resources, scientific equipment or facilities, national or international collaboration

c. Co-ordination of standards-based novel methods of data collection and analysis, e.g. tele-instrumentation, visualisation and simulation, data and text mining.

Capability Fund projects in New Zealand organisations

Early discussion on the opportunities that KAREN presented CRIs with was initiated in 2006 by HortResearch, a Crown Research Institute that successfully applied for Capability Build fund support to run a series of workshops with CRI staff. The workshops aimed to raise the level of awareness amongst staff, particularly those involved in existing large-scale collaborative programmes, about the existence of KAREN and the opportunities offered by advanced networks. Presenters at the workshop were asked to elicit information from staff about the issues and barriers that would need to be addressed as part of the process of KAREN uptake.

As a result of the workshop it was recommended that Science New Zealand takes a leadership role in relation to KAREN and facilitates CRI participation in national initiatives to develop e-Research infrastructure, particularly in areas such as real-time collaboration, grid services, and identity and access management, and that an e-Research capability development strategy be developed. Individual CRIs were also encouraged to review their policies and practices with a view to establishing an e-Research framework that would foster external collaboration. In the short term, CRI science and information technology leaders were encouraged to work together on a plan to embed readily available KAREN-enabled tools within current projects. Generally a need was identified for leadership, co-ordination and commitment from

the CRIs. That leadership would help identify generic collaboration software, end user training and support, necessary functionality to support scientific collaboration, and data sharing technology policies and processes. Since that time, Science New Zealand has facilitated discussion amongst strategy manager, finance managers and communications staff from CRIs about their experiences with KAREN. `War stories' have been exchanged and areas for innovation and technical input identified.

During 2007-08 a number of Capability Fund projects have stimulated projects on a huge range of subjects across the KAREN community. Many of these were reported at the 26th Asia-Pacific Advanced Network conference held in Queenstown, New Zealand, in August 2008, including:

- earthquake engineering research at the University of Auckland, which involves sharing data with members of the Network for Earthquake Engineering Solutions on building responses to earthquake stresses, mitigation practices, testing of materials and methods
- PulseNET – a network that shares data to enable the identification of strains of pathogens and typing to food source to allow early confirmation of contaminated food sources, isolation and removal of contaminated products from the food chain, preventative measures for avoiding repeat events and the ability to protect export reputations
- social science networks – using Access GRIDs in video conferencing to allow many sites to connect and share activities at the same time. The Access GRID node has a large display, often an entire wall to show three projector images side by side. Up to 10 sites can be video streamed to display data-sharing tools and to show life-size images of participants. The Building

Research Capability in Social Sciences Network is using this technology for a range of activities, from routine management meetings to a series of `virtual' seminars involving postgraduate students and researchers from around the country

- Environmental education – outreach to schools, providing software that students can use to manipulate data gathered from data loggers embedded in the environment, generating graphs and reports on environmental conditions
- Maori network – since July 2007 more than 300 people across the country have attended weekly Access GRID seminars that provide opportunities for university researchers of Maori descent and those with an interest in undertaking research on topics relevant to Maori to hold discussions
- Advanced materials research at the Melbourne synchrotron – New Zealand imaging scientists and practitioners will be able to use KAREN to access synchrotron-based capabilities to pursue a wide range of research, particularly in the areas of biotechnology and materials science. Several beamlines have robotic and remote operation programmed into their development, creating opportunities for real-time manipulation of experiments from the desk top
- Training courses for the seafood industry – workers from industry are registered at either Auckland or Otago Universities to undertake a full-year course on aspects of marketing, production, law, economics, food science and biology related to fisheries and aquaculture. Students are also learning about the New Zealand Quote Management System, indigenous fisheries, global fisheries, and environmental issues, including biosecurity and fisheries ecosystems.

Crop & Food Research explores the opportunity

The New Zealand Institute for Crop & Food Research Limited (CFR) is one of New Zealand's nine CRIs. These 9 institutes have more than 50 locations around New Zealand. At 20 sites more than one CRI has a presence or is/are co-located with tertiary institutions. Crown Research Institutes also have a large number of subsidiaries, associate companies and joint ventures. In addition, they collaborate extensively between themselves, with tertiary institutes in New Zealand and with research organisations around the globe. They are therefore a vital conduit to science and related intelligence from offshore, which is of importance to New Zealand's future economic development.

Each CRI has signed up to KAREN and is committed to its use in order to enable a transformational step in accessing, supplying and manipulating information across internal and external networks.

Crown Research Institutes are investing two-fold in the development of KAREN, indicating their commitment to its ongoing importance: the financial resourcing via levies and usage; and the considerable internal investment in capability development (technical and human) within their organisations.

CFR's role is to support the transformation of the New Zealand economy by providing fundamental and applied science for some of the country's key sectors: arable and vegetable crops, seafood, ornamental plants, and food (Figure 2). A key part of CFR's strategy is to deliver innovations in food production and design as well as new technologies in sustainable crop production to growers, industry and

consumers in New Zealand as well as around the world. New areas of investment for CFR are nutrigenomics, intragenics and nanotechnology where we are combining New Zealand's reputation for producing high quality raw and processed foods using world-leading science to deliver value and benefit to our clients.

In August 2006 CFR signed a 3-year agreement to become a member of the KAREN network. Since then six of our eight sites have been connected to the network via PoPs (points of presence). Membership for CFR is NZ$110,000 (£42,300) per annum, which is funded through our Information Services team budget.

A number of technical enhancements at CFR are required before we can start to capitalise on the full computing potential that KAREN offers. These include calibration checks, setting parameters on our servers and ensuring features are supported.

To date, improvements to our video conferencing and commodity internet capabilities have been enabled through membership of KAREN.

As well as the new research activity and collaborations that KAREN will facilitate for CFR science and business staff, other benefits include using the network for file management purposes and to transfer large amounts of data between sites to safe and secure servers for back-up and archiving. These processes allow us to develop disaster recovery scenarios that avoid the need to restore lost data from tape or disc, ensuring a faster response time to staff and a quicker return to operational mode.

In 2008 CFR was awarded two grants from REANNZ to explore the opportunities that KAREN created for our business. Both projects – one entitled `Enabling real-time remote diagnostics for biosecurity applications' and the other, the Institutional Capability Build Project − are currently underway to delivery on the proposed investment plans.

A) The Capability Build project – `Enabling real-time remote diagnostics for biosecurity applications'

Dr David Teulon, entomologist at CFR, and his colleagues in New Zealand, Australia and Canada, received a grant for approximately NZ$100,000 (£38,500) to demonstrate the value of KAREN for real-time remote identification of invasive pests and diseases by sharing knowledge amongst New Zealand workers and international experts. New Zealand is under constant threat from invasive pests and diseases. This project addresses the need to rapidly and accurately identify organisms intercepted at the border in association with imports to determine whether they pose security risks to New Zealand's natural and productive ecosystems and whether remedial action (e.g. eradication) is required. New Zealand has limited taxonomic expertise (there are few specialists and their expertise is usually restricted to particular insect groups) so verification by overseas experts is often needed to ensure accurate identification. This process can be time-consuming (specimens are sent by post) and delays can be disastrous. The Ministry for Agriculture and Fisheries' Biosecurity New Zealand relies on collaboration with taxonomic experts in New Zealand's Crown Research Institutes and universities, and in international organisations, to identify pests and diseases intercepted at the border. The need for real-time collaborative

diagnostic tools is a priority identified in the recent Biosecurity Science Strategy, along with further strengthening science and end-user collaborations within New Zealand and internationally.

This project is scoping the available middleware for use in real-time remote diagnostics through KAREN. This will include general-purpose collaboration software (EVO, BeSTGRID), diagnostic-specific systems, and relevant technologies used in other fields (e.g. medical science). One or more real-time remote diagnostic systems will be tested under a range of constraints (e.g. time zones, cable speeds) both within New Zealand (between Crown Research Institutes and universities) and between New Zealand and Australia, and New Zealand and Canada. Finally, a protocol is being developed to best utilise KAREN for real-time, remote pest and disease diagnostics by New Zealand biosecurity scientists. Recommendations will then be provided for the use of KAREN for real-time remote diagnosis for biosecurity to the wider science community through a multi-provider government and industry-funded research collaboration called Better Border Biosecurity.

The process of insect identification using real-time remote diagnostics brings the scientist, the specimen, and other collaborators or students together within the virtual environment enabled by KAREN. Specimens can be compared interactively with voucher specimens, digital diagnostic keys and database images, allowing collaborative identifications to be made rapidly and accurately. By testing the remote diagnostics system with taxonomists in Australia and North America, this project is providing a basis for developing and strengthening

international collaborations for border biosecurity, through KAREN's associated research and education networks.

B) The Institutional Capability Build Project

CFR is currently identifying how KAREN can be applied to achieve its corporate vision of `fresh thinking in food' by developing an action plan to implement opportunities, embed e-Research initiatives into organisational and research planning processes, and implement key projects. The plan is to identify opportunities that will enable us to better connect with key markets, science partners and consumers around the world. New Zealanders are well recognised for their ingenuity and ability to improvise – necessities imposed by our distance from key markets and our small population base. These features put us in an excellent position to gain real advantage from KAREN and global telecommunications networks to enhance our nation's competitive advantage. By building on our legacy of top quality agricultural products combined with our aspiration to be a knowledge-based economy we are committed to seeking new opportunities to apply smart thinking.

The institutional capability fund project involves identifying possibilities, defining how CFR could apply KAREN to achieve its business goals, and developing an action plan to implement opportunities and embed e-Research thinking into organisational and research planning processes.

An investigation of likely opportunities for CFR has identified virtual research environments as a key area where KAREN can provide our scientists with a single interface to distributed and disparate sources of data about the same phenomenon.

A virtual research environment can provide access to much more data, creating opportunities for simulations to be run, interpretations to be formulated and new discoveries to be made. Sensor-based tracking of environmental changes and the remote delivery of this data into crop simulation models can be enhanced through KAREN. Data transfer and database access are obvious applications of KAREN for CFR, providing faster access to information made available from collaborators around the world. Our Nutrigenomics New Zealand collaboration is generating considerable data about the effects of food and food ingredients on the health of individuals with diseases associated with particular genetic combinations, such as Crohn's disease. KAREN can make sharing this data and collaboration over its analysis more rapid.

Working remotely with scientists around the world on visualising images using video feed is another exciting application that may make the identification of pests and disease more immediate, allowing control measures at our borders to be triggered. Other possibilities include better collaboration as a result of being able to see other people and their data in real time, distributed research team meetings using high-performance Access GRID video conferencing equipment, and training of future researchers by capturing and storing digital representations of experiments.

Interviews with a range of CFR staff have revealed a further suite of opportunities that build on projects that are already underway. They include video conferencing to collaborators involved in FoodFrenz − a European Union-NZ research linkage that has been established to strengthen relationships between consumers, knowledge providers and industry in New Zealand and the European Union, and develop cross-sectoral collaboration. CFR is establishing an international

reputation for its crop modelling and computer-based decision support systems. These are very data intensive and supply growers with crop management advice on a range of aspects of crop production, including timing of inputs and harvesting. While these models are currently focused on a crop scale, there is potential to construct them at an enterprise or district scale with data being provided to the models via remote sensors rather than farmer input. These models often run data over 30-year timeframes to produce average responses and make predictions. Fast access will be needed to new crop modelling platforms in the future and KAREN will play a role in this. The key will be to ensure that the private sector and the public eventually have access to the ultra high speed processing made possible via advanced networks. Generic applications raised during interviews include: support for dataset access, access to data manipulation tools and simulation processing capacity, discovery of collaboration opportunities, collaborative workspaces for project coordination, desktop screen sharing in order to view data, centralisation of data to avoid data silos, access to databases of genetic sequences, capturing data from live satellite feeds, high definition video to access difficult locations such as the bottom of the ocean floor, and remote access to lab equipment and resources.

The key organisational challenge is that many CFR researchers do not currently know what is possible. To spark researchers' thinking and help them identify potential opportunities findings from the review and initial interviews with staff are being explored in workshops in both the North and South Islands of New Zealand with collaborators in another CRI, LandCare Research. The first of these workshops was held on 27 August 2008 at Lincoln, near Christchurch. Nineteen CFR and LandCare Research staff met to hear about the opportunities KAREN

offers and explore how they might capture them in their own research programmes. They also documented technical and logistical barriers to undertaking KAREN-enabled research. Finally, organisational responses to those barriers were identified. Workshop discussion confirmed that the key areas of interest are: collaboration with scientists in distant locations (using tools packaged into virtual research environments), interfaces for data transfer and sharing, remote control of equipment and sensing of data, and more integrated and rigorous science through enhanced computing power.

In addition, the investment plan allows for upskilling CFR's KAREN champion, Tracy Williams, providing support and advice to researchers preparing research funding proposals or engaging in projects, and sharing knowledge between CFR and other institutions. The professional development of CFR's KAREN champion has been extended through participation in the APAN (Asia-Pacific Advanced Network) 26 Conference, held in Queenstown, New Zealand, 4-8 August 2008, and the Oxford e-Research Conference, held in Oxford, UK, 11-13 September 2008.

Conclusion

KAREN has a role to play in delivering CFR's food strategy by bringing the organisation into closer contact with scientists, industry and consumers from both within New Zealand and around the globe to create more sustainable production systems and foods and beverages of the future. By exploring the infrastructure required to support the applications identified through discussion at CFR, access to research collaborators, within CFR, between New Zealand-based research organisations and with R&D organisations around the world will be enhanced.

The key to more widespread economic development lies in the potential to connect large research investors with research providers and allow early-stage innovative companies to experience the benefits of collaboration across an unlimited broadband network.

While REANNZ's current constitutional objectives require it to focus on research and education connectivity, extending this mandate to include economic and sustainability outcomes will help to realise the value of New Zealand's investment in terms of improved national wealth and quality of life. With this wider membership, valuable research will continue to be undertaken in New Zealand ensuring that research capability and talent are retained and New Zealand's contribution to global knowledge is secured.

References

Anon. (2008) `REANNZ Today – an analysis of advanced networking in New Zealand.' REANNZ, Wellington.

www.crop.cri.nz

www.reannz.net.nz

www.apan.net/meetings/newzealand2008/index.html

Acknowledgements

The authors would like to thank CFR and REANNZ for providing financial support for this paper. Michael Sampson; Daniel Park and John Shaw of CFR; and Vicki Lindsay of REANNZ also provided valuable comments.

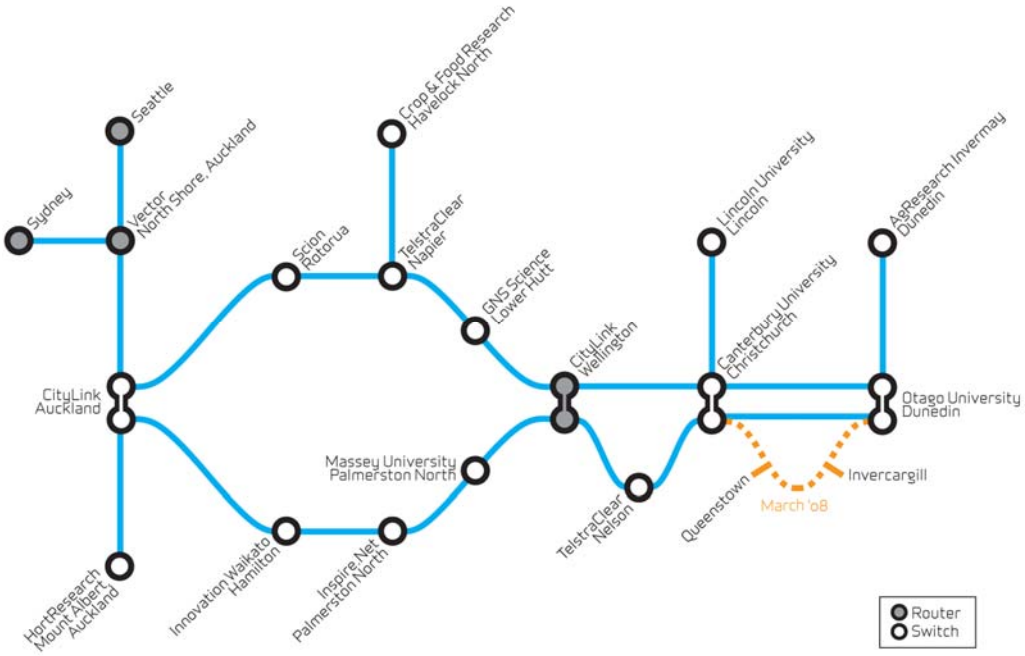

Figure 1: The KAREN network, August 2008.

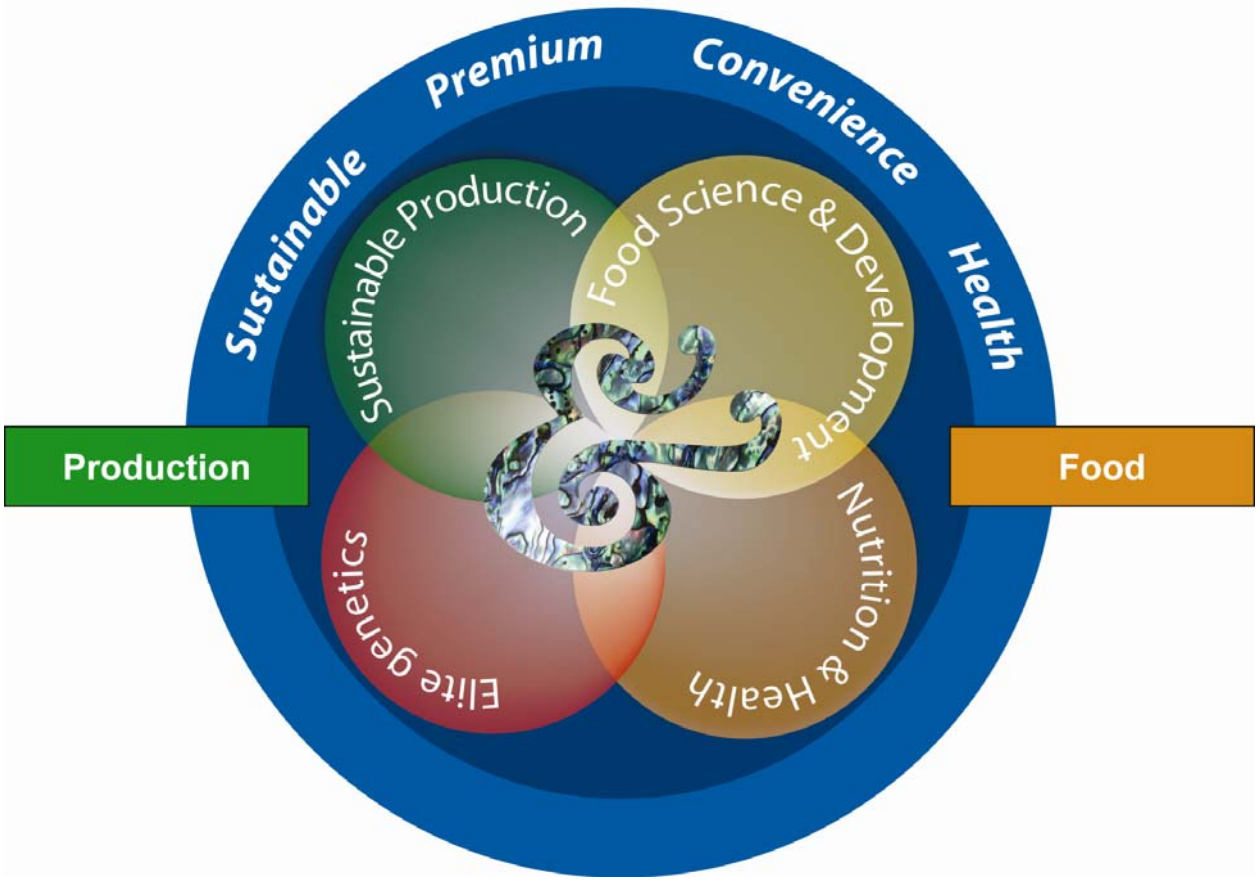

Figure 2: Crop & Food Research's business – strategic drivers, areas of capability and platforms.