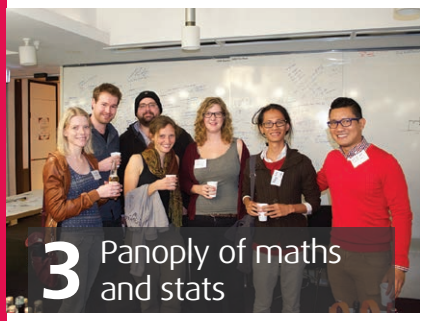
News Update
Australian Mathematical Sciences Institute

2014 Issue 3

Research & Higher Education



3 Panoply of maths and stats

"The best thing about the graduate theme program was getting a feel for what my peers are doing and learning about cutting edge research in the area."

Schools Education

5 Up, up and away

"Every day, every school we visit, teachers are so excited to tell us what their students are gaining from participation in AMSI Schools outreach work."

AMSI Intern

6 Set to soar with co-investments

"Eight universities have invested in strengthening the links between academia and industry."

AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Photo credit: Chrystal Cherniwchan

Nina Snaith's mathematics links physics, women, industry and school students; that's our kind of maths!

Nina Snaith is a Reader at the University of Bristol. The title Reader isn't used often in Australia, it denotes a senior academic with a distinguished international reputation in research or scholarship. After meeting Nina I knew exactly why she has this title; she is humble and gracious, intelligent and passionate. It was a delight to get to know this deep, thoughtful thinker.

Dr Nina Snaith is the Hanna Neumann lecturer at the 8th Australia – New Zealand Mathematics Convention, Stéphanie Pradier talks with Nina about her work.

Nina's world has been full of numbers since she was born; her father, an academic mathematician, her mother and grandfather, mathematics teachers and her brother has a PhD in mathematics. Nina doesn't believe this is simply a coincidence nor does she think it is purely genetic; she pointed out her sister, Anna, is a Professor in Twentieth-Century Literature at King's College.

So not all the Snaiths are mathematicians, but Nina did marry one!

Despite being surrounded by mathematicians, Nina never dreamt of becoming one. At school she found mathematics class a little dull and repetitive, however she still enjoyed the subject. She joined mathematics clubs, took part in mathematics competitions and has fond memories of her father and grandfather giving her fun puzzles. So, while Nina has always been aware of the fun to be had with mathematics it wasn't until university that the inkling to become a mathematician hit her.

Born in London and bred in Canada, Nina took an undergraduate degree in theoretical physics at McMaster University; her interest in Random Matrix Theory (RMT) saw her migrate back to the United Kingdom in the late 90s to begin her PhD research with Jon Keating. Nina completed her thesis, *Random matrix theory and zeta functions*, in 2000 at the University of Bristol.

Nina's work is a good example of the two-way relationship between mathematics and physics. Nina explores the rich mathematical structure of RMT and continues to be fascinated by the connections it has with pure mathematics, even though the more intuitive links are with fundamental physics and engineering.

As my day was beginning Nina's was ending, but before hers was completely over she spoke to me about her past, her present and her future.

AMSI runs a *Vacation Research Scholarship* program over summer; I believe you participated in something similar?

I did. During these summer internships I realised how much I love learning and investigating new things. This experience…

Continued on page 2

Dr Nina Snaith interview—*continued*

is so different from learning material for assessment, such as an exam. I did three such projects throughout my time at McMaster. The first was in a molecular biology lab, the second was concerned with solid-state physics, but it was the final project that I did in theoretical physics that introduced me to random matrix theory. These projects showed me what it was like to study independently. If you want to see if research suits you, there is no better way than by doing a project like this, either over summer or as part of an undergraduate program.

Would you tell me about your course "Mathematics in Schools"?

Our undergraduates have a placement in a local school in a maths class. They act as a role model for the students, provide support for the teachers and gain valuable experience for themselves about teaching maths and working in a school environment, it benefits everyone involved.

Because our students have chosen to study mathematics at university they are enthusiastic about it; this can help spark the interests of the school students.

How did you end up at Bristol?

I did my final undergraduate project at McMaster on quantum chaos, which links with random matrix theory, the field I now work in. I knew I wanted to continue in the same sort of area, so I asked my project supervisor to suggest some names of people I could do a PhD with. I wrote to several mathematicians and physicists and the advisor I chose, Jon Keating, wrote me the nicest email. He used the phrase "don't fret" when I was worried about having a background in physics instead of maths. I figured anyone who used that phrase had to be lovely!

A solid mathematics background is needed in many jobs. Have your peers chosen other professions?

Software development and finance seem to have been popular career choices for my postgraduate peers. Also, many have continued in research or teaching mathematics in various environments and at various levels. But basically it prepares you for anything that doesn't need honing of a specific skill, but rather the ability to think, learn, plan, be creative and investigate.

Theoretical physicist or applied mathematician?

What you are called depends on what country you are in. When I came to the UK

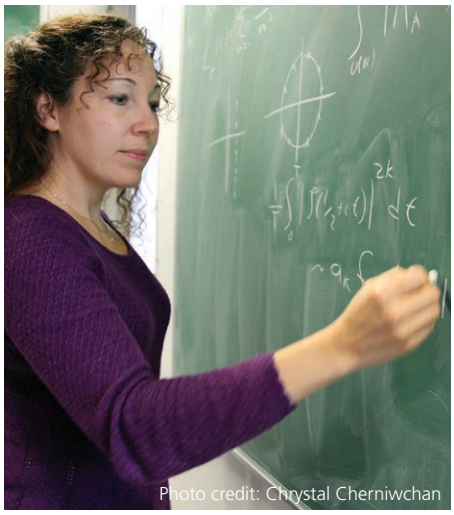


Photo credit: Chrystal Cherniwchan

the structure was very different to that in Canada. You would be called a physicist in Canada, but over here [UK] you're called an applied mathematician.

I believe there is a continuous scale from maths to physics, and you can sit anywhere on that scale—from pure maths, to experimental physics. So, there doesn't need to be any difference between applied mathematics and theoretical physics.

Would you explain your research in the connections between statistical properties of L-functions and RMT?

The Riemann hypothesis—for the Riemann zeta function and other L-functions—says that these functions take value zero at points that lie on a straight line in the complex plane; we call it the *critical line*. These zeros are located at positions along this line—like beads on a wire. The statistical description of how these positions are located is the same for the zeros and for the eigenvalues of suitably defined random matrices (matrices with entries that are random, apart from appropriate symmetry constraints). It turns out that the similarity between the zeros and the eigenvalues is far reaching and means that properties of random matrices can be used to predict properties of the L-functions—even properties that don't seem immediately connected to the positions of the zeros.

So, for example, properties of the values of the Riemann zeta function on the critical line, where it hops along between the zero values, can also be predicted by random matrix theory. Some problems of this sort are extremely hard to solve in number theory, so doing an easier random matrix calculation and having it provide a conjecture for what is happening in number theory is invaluable.

What surprises you about your research?

Given that we are using this rather tenuous, unproven connection between random matrix theory and number theory, what surprises me the most is how our predictions can be so incredibly detailed and accurate!

Why do you believe women are underrepresented in maths?

I'm sure there are many reasons. I think academia demands quite a lot of one. Of course it has its rewards too, but I think it is still the case that to do that top-notch research you have to put a lot of extra time into your job. I've heard female colleagues say that an academic career isn't so important to them that they would sacrifice other parts of their life. There is also the issue of few role models and still some unconscious bias amongst current academics.

I started a "Women in Maths Group" at Bristol about 12 years ago to support women studying maths. We get together once a week and have lunch, talk about things that are going on in our research and non-research lives. We also hold events for undergraduate students, so that they can see women in senior academic positions that also have lives outside of academia.

How important are female role models?

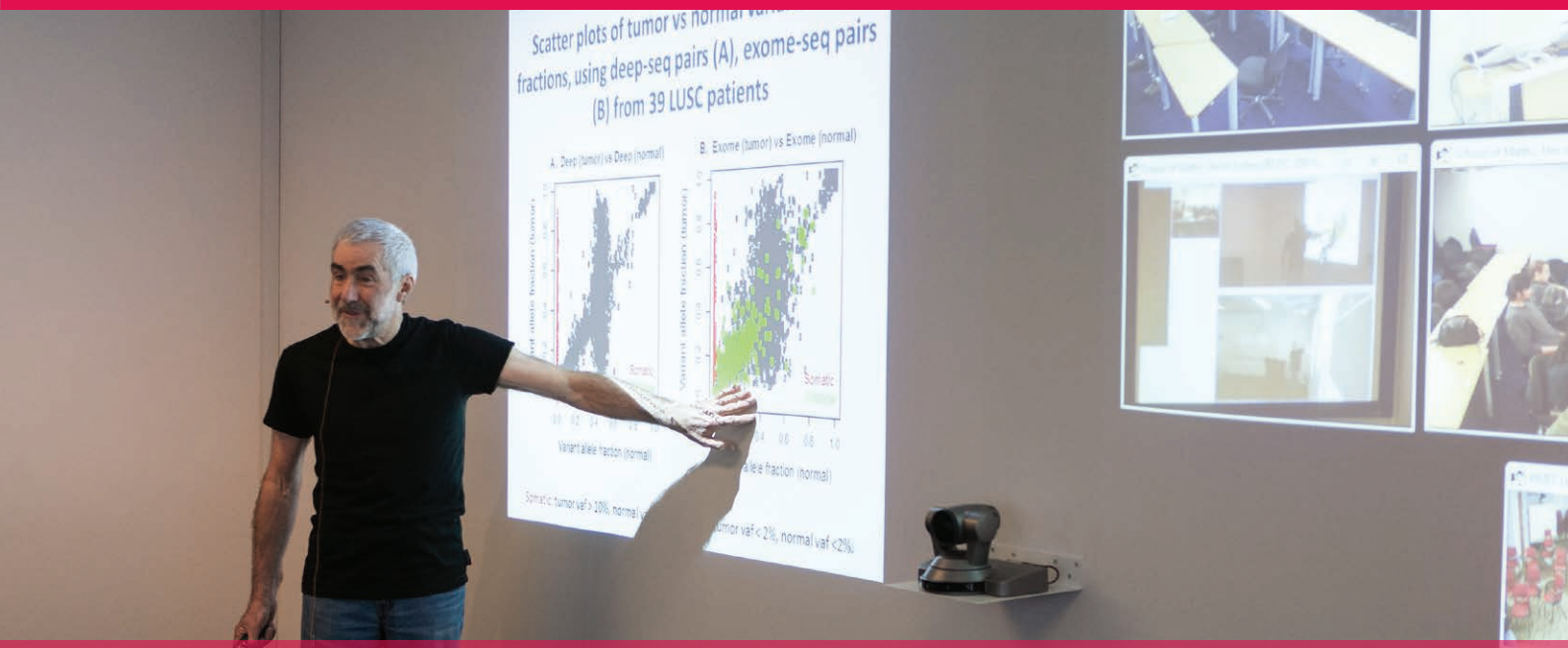
Very important. I remember vividly when one of my physics lecturers happened to mention that she had to run because she was picking up her son from football. My friend and I looked at each other with excitement because it was evidence that you could live a regular life, with kids, etc. and be a physicist. So many of our other lecturers were older men, and it was harder to imagine ourselves like them. I'm sure the same is true in maths.

Your brother is also a famous musician, do you see a similarity between studying mathematics and music?

The honest answer is that I do not know if there is a link between maths and music. Especially by the time you are performing music professionally. But, I think there is a similarity in the way we learn both of these things.

I observe my son doing his maths homework and I watch him at his piano lessons and I see exactly the same interest in the two activities…

Extended interview: www.amsi.org.au/snaith-interview



A big thank-you to Terry Speed

Professor Terry Speed FAA, FRS, the 2013 recipient of the Prime Minister's Prize for Science and one of the world's leading statisticians, embarked on a four-month tour in August to bring the new and critical science of bioinformatics to an Australian audience.

The AMSI-SSAI tours bring to Australia public lectures and technical talks from some of the world's top statisticians. Terry, who currently heads the bioinformatics division at the Walter and Eliza Hall Institute, enthralled audiences with the next frontier of genetics, understanding human *epigenomes*.

Epigenomes are the "instructions" that tell DNA whether to make skin cells, blood cells or other body parts. Epigenetics, Terry explains, also aims to illuminate how cells are re-programmed through interactions with the environment, and how this may lead to some forms of cancer.

Terry's tour: **research.amsi.org.au/amsi-lecturer**

Terry's roadside report

"I've enjoyed getting out and about, meeting mathematical scientists in all their different contexts. From the old Hawthorn Town Hall (Swinburne) to a fine new lecture theatre at the Australian Bureau of Statistics with lots of people in suits; to (almost) a theatre-in-the-round at Australian National University's Haydon-Allen tank, and an Access Grid Room in the delightful colonial setting of University of Western Sydney."

Professor Terry Speed, AMSI-SSAI Lecturer

Research workshops

AMSI's workshop funding scheme sponsors eminent academics to visit Australia annually.

So far this year over 20 workshops have been supported; one of these was the Fourth IMS-FPS (Institute for Mathematical Statistics - Finance, Probability and Statistics) workshop. The goal of these workshops is to bring together leading academic experts, practitioners and junior researchers, to highlight important contributions to mathematical and computational finance made through the use of statistics and probability.

At the pre-workshop, research on new models for analysing trade strategies were presented. Indisputably, this is one of the hottest areas of research in mathematical finance applications.

With 13 plenary speakers and 45 invited talks the workshop provided an opportunity for people from academia and industry to mix.

Workshop report: **research.amsi.org.au/ims-fps-2014-report**

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Mahler Lecturer announced

The Mahler Lectures are a biennial activity organised by the Australian Mathematical Society, and supported by AMSI. Prominent mathematicians tour Australian universities giving lectures at a variety of levels, including for the general public.

We are proud to be part of bringing Professor Manjul Bhargava, Princeton University, to our shores in September 2015.

Hacking the seasons

A not so wintery Winter School at The University of Queensland

Once again, AMSI's *Winter School* provided an excellent learning opportunity for Australian mathematical science students to cement and expand their content knowledge.

This year's theme *Contemporary Aspects of Cryptography* enticed students from cognate disciplines including engineering, information technology, computer science and physics; it also attracted several professionals from related industries.

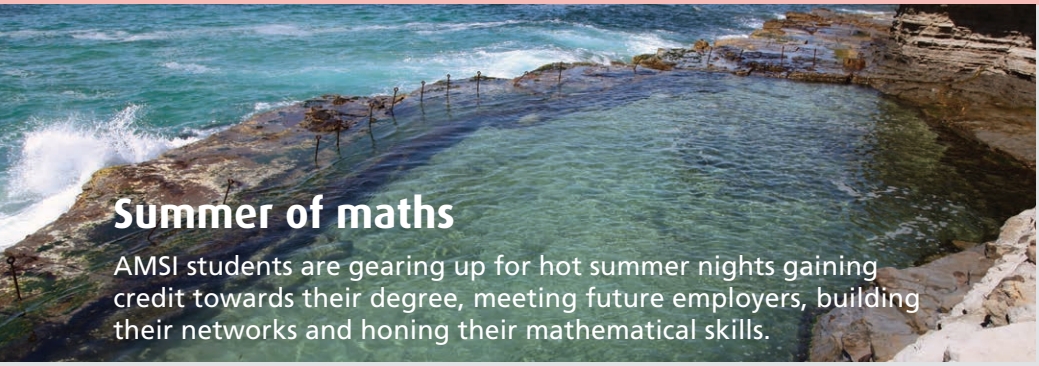
Lectures discussed cutting edge material on quantum cryptography, introduced curve based cryptosystems and algebraic complexity—even bitcoin applications were investigated.

A successful edition to this year's *Winter School* was the AustMS Women in Maths networking evening. The contribution of women in mathematics was highlighted and the evening provided a forum for discussion of career paths. **Over 80 people attended** including a group of Year 11 Science Ambassadors from several Queensland high schools.

Many thanks to the Winter School Director, Dr Victor Scharaschkin and event co-ordinator, Andree Phillips. Their hard work ensured the success of this event.

Winter School 2015: **ws15.amsi.org.au**

A bumper year! 4 major events 13 partnerships 48 experts 425 students



Summer of maths

AMSI students are gearing up for hot summer nights gaining credit towards their degree, meeting future employers, building their networks and honing their mathematical skills.

That's right... *BioInfoSummer*, *Summer School* and *Vacation Research Scholarships* are upon us.

Our Higher Education program plays a vital role in enhancing the experience of mathematical science students from Australian universities. The three summer programs—held annually over one to six weeks—train more than 2,200 students.

This year, Senator Ryan is kicking it all off. Opening *BioInfoSummer* on the first day of the season: December 1.

"I congratulate AMSI on hosting BioInfoSummer to assist researchers across a range of disciplines to develop key statistical and mathematic skills that will enable them to pursue innovation."

Senator the Hon Scott Ryan
Parliamentary Secretary for Education

BioInfoSummer has become one of AMSI's most popular events for undergraduate and postgraduate students, researchers and professionals in cognate disciplines—attracting people from biology, statistics, mathematics, computational biology, computer science, chemistry and physics.

Following *BioInfoSummer* we host one of the biggest national events for science students in Australia. AMSI's *Summer School* gives more than 150 students, from around the country, the opportunity to explore areas of research not usually offered by their home institution. Each year subjects are selected to ensure students gain exposure to recent developments in the mathematical sciences, while also having access to advance courses in core traditional subjects—aka calculus.

BioInfoSummer 2014: **bis14.amsi.org.au**

Summer School 2015: **ss15.amsi.org.au**

Funding from the Commonwealth has allowed us to significantly increase the impact of our programs.

Enquiries Simi Henderson
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Down the rabbit hole and into outer space... AMSI Schools has the maths to get you there

AMSI Schools has been keeping busy and our team welcome the added daylight hours. The Geelong Cluster—funded by The William Buckland Foundation until 2016—is keeping us on our toes, the first two professional development (PD) evenings were extremely popular with attendances exceeding 90.

We are looking forward to filling the halls again in term four with three PD evenings scheduled.

Term four also sees us returning to Sale Primary School—affectionately known as 545. Despite the DEECD Gippsland Cluster winding up in June, 545 have elected to continue working with us for the remainder of the year at their own cost. Michael O'Connor believes the teaching team at 545 is well on the way to developing a strong, comprehensive school plan for the delivery of their mathematics curriculum, he has several visits planned for term four.

> *"Every day, every school we visit, teachers are so excited to tell us what their students are gaining from participation in AMSI schools outreach work. Teachers are working on their content knowledge, planning for delivery of the Australian Curriculum and using and making classroom activities that engage students."*
>
> Janine McIntosh, AMSI Schools Manager

Both Janine and Michael attended the Mathematical Association of New South Wales annual conference *Wonderland in Wollongong: Curiouser and Curiouser* at the start of spring. The theme inspired Michael O'Connor to submit a paper based on one of Lewis Carroll's other works *The Hunting of the Snark*. His paper examines the nature of mathematics teachers and explains how reflective practise may ignite a "spark" of enthusiasm in students. The essay and presentation—among other things we've found—are on *Calculate*:
www.calculate.org.au/category/look-what-we-found

Maths: make your career count is a web and print resource that highlights the varied careers where a background in mathematics is necessary. Many schools order the materials, it's a crowd pleaser.

Speaking of materials, our *Calculate* website continues to grow. New teacher and student resources are added regularly and we have had over five thousand visits since July. Unsurprisingly, the *TIMES Modules* for teachers remains our most popular resource.

Looking ahead, and up, we are pleased Boeing will continue to support our program; on top of funding for the West Melbourne schools cluster (2013–2014) they have recently provided a US $50,000 grant to develop a campaign linking mathematics with careers in the aerospace industry. Launch date: July 2015.

We were recently approached to assist the Australian Academy of Technological Sciences and Engineering (ATSE) in producing updated editions of materials they provide as part of the STELR project. This collaboration is promoting links between the science, geography and mathematics curricula.

STELR resources: **www.stelr.org.au/maths-of-solar-panels**

On top of this the Australian Curriculum continues to be rolled out. The four proficiency strands, *Understanding, Fluency, Problem Solving* and *Reasoning,* reinforce the significance of describing, mathematically, how we explore and develop content. We believe rich opportunities for enhancing the learning and teaching of mathematics will come from teachers having conversations about these strands.

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Co-investments shape intern growth—first collaboration of its kind

The changing of the seasons has brought with it some exciting changes at AMSI Intern.

As of October 2014, we secured a co-investment partnership arrangement with six Victorian member universities—Melbourne, Deakin, La Trobe, Monash, RMIT and Swinburne—and two in NSW with the University of Sydney and the University of Technology, Sydney.

A collaboration uncommon in Australia; eight universities have invested in strengthening the links between academia and industry. The growth MITACS encountered after they secured a similar funding scheme was phenomenal, we expect the same trajectory.

These partnerships will help expand and build the scale of our program. The model allows us to employ additional business development managers, project officers and administrative assistants in both states. This increased capacity will have a transformative effect on the Australian higher degree research community and will simultaneously increase the quality and quantity of industry–academic collaborations.

The delivery of the co-investment partnership will be the overall focus for AMSI Intern over 2015/16.

veski and Defence Science Institute partnerships

Growth of the program has been significant. This quater we also established partnerships with key national industry associations including the Australian Centre of Financial Services, the Defence Science Institute (DSI) and veski. These partnerships offer funding schemes—with a variety of eligibility criteria—to support research in the defence and finance sectors and will help to promote and advance women in science.

In September we launched an innovative program in Victoria designed to inspire women in science with veski and the Office of the Lead Scientist. The program will connect female honours and masters students with Victorian industry and government agencies to work on R&D problems.

The *inspiring women* industry internships are part of a new initiative to support, advance and inform Victorian women currently studying STEM disciplines. The Victorian Government will also provide ten funding grants to eligible Victorian SMEs, government agencies and large businesses.

Julia Page, veski Chief Executive says, "The *inspiring women* internships allow female students to transfer their skills from theory to real-world application, while companies gain a competitive advantage by accessing high-quality research expertise."

Victorian Government Lead Scientist, Leonie Walsh added, "The program will promote links between academia and industry and help meet the current, and future, skills needs of the state."

As the days gained daylight hours, we gained another partnership, this time with the Defence Science Institute.

> *"The opportunity to connect the defence industry with students and academics who will play a lead role in developing innovative solutions for Australia's future is what this program is designed to do."*
>
> Cate Ballard, National Program Manager (AMSI Intern)

Associate Director of DSI, Associate Professor Simon Ng says, "This alliance with AMSI Intern is central to our strategy to enhance defence–industry outcomes and build stronger industry–university connections for the benefit of defence R&D. "

The partnership with DSI will link highly skilled PhD candidates, from all disciplines, with industry to address a research challenge facing their business. The projects will align with DSI's technology themes of: human protection and performance, modelling and simulation, propulsion and energy storage and surveillance and autonomy.

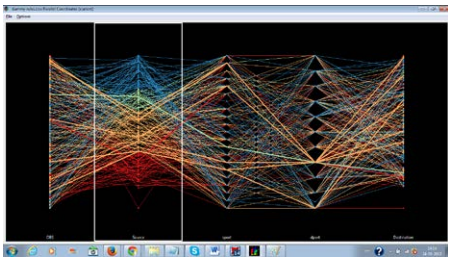
veski partnerships: **www.amsiintern.org.au/veski**

DSI partnerships: **www.amsiintern.org.au/DSI**

Detecting firewall loopholes: COMPUTER vs HUMAN

Understanding firewall rules is time consuming, complicated and hard. The majority of people know how to turn their firewalls off, but do these people know what they are doing or even why?

Probably not, nor could they be expected to.



Viral Maniar, AMSI Intern and RMIT Masters student, spends his days deciphering the complexity of firewall rules. He undertook an internship at Biarri Networks—an innovative commercial mathematics company—to investigate new methods of visually representing firewalls.

Firewalls are built with a set of "do" or "do not" allow rules, usually concerning where a computer is connecting from and what it is trying to do. Two or three rules are easy to follow and understand, however sometimes a firewall might have to follow thousands of rules. This makes finding patterns or irregularities harder.

Visualisation tools help people "see" the data. By clustering common connections and using colouring schemes, patterns that may be indicative of intrusions can be clearly identified.

"Humans are much better at seeing some types of irregularities than computers. Building a visualisation tool aids in detecting security loopholes in some firewall rules."

Viral Maniar, RMIT University

During his internship Viral developed a web application able to load different sets of firewall rules visually. Someone using this application is able to modify and filter how the rules appear (using colour schemes for example) to discover if any loopholes or irregularities exist.

"Viral, Biarri and NBN Co used the tool to review a set of firewalls in use at NBN Co," says Paul Kennedy, CEO Biarri Networks. "NBN Co are now using the results to inform firewall management procedures."

Viral has recently gained employment as a security analyst for a major consultancy and says having the internship experience made all the difference.

Intern: Viral Maniar, RMIT University. **Industry Partner:** Paul Kennedy, CEO Biarri Networks. **Academic Mentor:** Assoc. Prof. Serdar Boztas, RMIT University

RMIT UNIVERSITY

Biarri COMMERCIAL MATHEMATICS

Financial investments... a modeller's minefield

Budgeting, it's a cringe worthy word. Optimisation, that's more like it! Have you the faintest idea of what it is? Some mathematicians use it to help financial planners increase the expected size of their client's nest egg with risks acceptable to them and their stage in life.

AMSI Intern, Wei Wu, is well versed in the mathematical technique of optimisation used in finance. In fact, he recently completed an internship at Optimo Financial—an Australian company that services the financial planning sector.

Hugh Bannister, Principal, Optimo Financial, has been building energy and financial models using optimisation for over 25 years. He believes the work completed during Wu's internship will allow Optimo to improve its offerings to the market.

"Optimo's existing tools greatly improve financial planners ability to offer good, robust financial advice to clients, Wei Wu's input and work strengthens these tools."

Hugh Bannister, Optimo Financial

Wu, a PhD candidate at the University of New South Wales, says the most valuable experience was seeing the differences between theoretical modelling and real world circumstances.

"People have different investment needs, some invest for the short-term, saving for a house deposit, or long term, saving for their retirement. I was able to apply my mathematical skills to help financial planners find the best investment strategies for their clients by looking at, and taking into account, numerous factors," Wu says.

Bannister adds, "Optimo sought academic input through AMSI Intern to ensure the state-of-the-art in the field was recognised, and to make certain the proposed approach was theoretically and practically sound."

Intern: Wei Wu, University of New South Wales. **Industry Partner:** Hugh Bannister, Principal, Optimo Financial. **Academic Mentors:** Prof. Ben Goldys, University of Sydney and Assoc. Prof. Spiridon Penev, University of New South Wales

THE UNIVERSITY OF SYDNEY

UNSW AUSTRALIA

OPTIMO financial

Enquiries Cate Ballard
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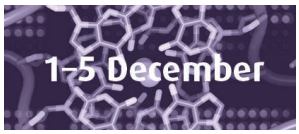
AMSI Sponsored Workshops

Sequences and Their Applications (SETA) 2014
The University of Queensland, QLD



BioInfoSummer
Monash University, Caulfield Campus, VIC

Differential Geometry, Lie theory and Complex Analysis
La Trobe University, City Campus, VIC

Applied Statistics and Public Policy Analysis Conference
Charles Sturt University, NSW

AMSI Summer School 2015
University of Newcastle, NSW

Algebraic, Number Theoretic and Graph Theoretic Aspects of Dynamical Systems
University of New South Wales, NSW

South Pacific Continuous Optimisation Meeting
University of South Australia, SA

Australian and New Zealand Applied Probability Workshop
Vine Inn Barossa, SA

AMSI Workshop Funding

We have streamlined the AMSI and AustMS workshop funding application process: one form, online.

Applications can be made twice a year—June and November.

They are judged on a competitive basis by AMSI's Scientific Advisory Committee and representatives of AustMS and ANZIAM.

Next proposals by

28 November 2014

www.amsi.org.au/funding

For more details on events:
www.amsi.org.au/events

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