

# The Ring

THE JOURNAL OF THE CAMBRIDGE COMPUTER LAB RING

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# Ellexus



## Problems with noisy neighbours?

**Ellexus founder and CEO Rosemary Francis explains how Mistral can solve your shared storage problems.**

*TR: The High Performance Computing (HPC) resource provides researchers with the resources to answer complex questions in engineering, science and mathematics. Understanding IO behaviour is vital as many HPC workloads have an increasingly significant IO component. HPC staff have been tasked with the slow and difficult process of detecting and taking action against risky IO behaviour; to analyse the IO behaviour of a platform's entire workload, a massive amount of data must be collated and analysed.*

*Can you explain what information you can gain from IO profiling and how Ellexus's software suite allows an infrastructure to protect itself against IO behaviour that is considered a particular risk?*

RF: Our software solves the noisy neighbour problem, where one user can submit a job to a compute cluster that does so much IO that no one else can get any work done. When this happens IT managers can see the storage getting overloaded, but without our software they won't know why. Our profiling tools tell the IT managers where the hot spot is and then resolve it by placing a bandwidth limit on the job. As well as solving the immediate problem, our tools also record IO patterns so that users can improve their applications in the future.

*TR: Mistral was developed in collaboration with ARM. How did your collaboration start?*

RF: We have been working with ARM for many years. They became our first customer when they recognised the potential of our first product Breeze, a tool for resolving application file and library dependencies. They approached us to develop Mistral to solve the noisy neighbour problem because there was nothing else on the market that would address the issue.

*TR: Ellexus is based in Cambridge, the heart of the UK's semiconductor and biotech businesses. How do you plan to tap into the broader HPC market?*

RF: We are partnering with a number of storage vendors and other software vendors in HPC. With them we engage with customers

together, we attend trade shows and we do joint marketing. We also find that, within an industry, customers and other vendors are keen to spread the word about our products because we are solving such important problems in HPC and scientific computing.

*TR: In 2011 you were a finalist in the Shell LiveWIRE Young Entrepreneur of the Year award, and in 2014 you won the inaugural Techpreneur of the Year Award in the Veterans category (for women who play a definitive role in an existing company which has been trading for less than five years, and has a turnover of less than £10m). Has being named a finalist and winning an award helped your business?*

RF: We target global markets so local competitions, even national competitions, don't have much impact, but publicity is always good.

*TR: According to UCAS figures, fewer women are reading computer science at UK universities than five years ago. In 2010, 14% of computer science students were female. Despite initiatives to get more women into STEM subjects, by 2014 the proportion of female computer science students had dropped to 13%. Similarly, figures from the Institute of Engineering and Technology show that women make up just 3% of IT and computing engineers in the UK. How can computer science attract more women candidates?*

RF: Although diversity in computer science in general is an area that interests me, I chose to study computer science having grown up with a strong interest in computing and other scientific disciplines so I'm not someone who can relate to why other women don't choose the subject. Research into the problem has shown that negative stereotypes and misinformation about the subject are present in children from a very young age so I think initiatives that involve children at primary school are needed if we are going to make big changes in the future. In the short term, specific scholarships and women's networks in schools and universities have been effective to some extent in attracting women to the field and keeping them there.

# Graphmasters

No more traffic jams!

Iulian Nitescu, co-founder of Graphmasters, reveals what sets Nunav apart from the competition.



*TR: In 2012 you entered Microsoft's Imagine Cup Grants programme and won the first prize of \$100k for your innovative navigation system 'Nunav'. Was this the catalyst for starting Graphmasters? How did it help you expand your project?*

IN: We had been working on Nunav for a while. The initial incarnation was for the 2009 Imagine Cup when we won the UK final. The 2012 grant served as seed funding and allowed us to devote all our time to Graphmasters. This is also when we decided to officially register the company. Being able to work on the project without any strings attached allowed us to create a solid technical base on which to build.

*TR: Can you tell me about Nunav and how it differs from other navigation apps? What sets it apart from the competition?*

IN: The fundamental concept behind nunav is collaborative routing and dynamic tour optimisation. While conventional navigation systems give selfish routes to everyone, we take into account what everyone is doing and distribute traffic optimally (preventing traffic jams instead of reacting to them). On top of this we built a courier tour optimiser that is able to dynamically adjust tours according to traffic conditions, giving minute accurate arrival times for each package.

*TR: Can you explain how Graphmasters leverages IoT capabilities?*

IN: Every day we receive 25 million traffic probes from vehicles. This real-time stream is fed into our traffic model to calculate granular traffic flow and turn costs. We continuously update routes and tours for drivers based on this live traffic. All calculations (including traffic) are done taking into account all participants so we actually connect all devices together in one big family.

*TR: Who are your target customers?*

IN: Our vision is to have Nunav running in as many vehicles as possible. As such, anyone moving about on our road infrastructure is a target

customer. However, we are currently concentrating on courier and delivery services as this is where Nunav can bring an immediate financial benefit.

*TR: In 2014 Graphmasters was one of six winners of the first Cisco Entrepreneurs in Residence Program in Europe, and you began in-residence incubation with Cisco in January 2015. Can you tell me about the experience so far?*

IN: The aim of the program is to leverage the Cisco distribution and partner network to aid startups in finding product-market fit. We found out how the technology behind Nunav can be used to solve a wide range of problems such as packet routing in high availability systems, and traffic light optimisation for public transport networks. Dealing with corporate bureaucracy is sometimes overwhelming for a startup but you have to make it work.

*TR: You currently have offices in Hannover and Lausanne and plan to open an office in the UK. What are the benefits of opening an office here?*

IN: We are a technically oriented company solving diverse problems at scale. Therefore we need a good pool of engineers and the London area can offer this. The other reasons are business related. Our aim is to scale globally and London is a good ground for this.

*TR: What is the greatest challenge you have faced since you started Graphmasters?*

IN: It has to be the roller coaster of positive and negative moments and emotions. In a single day you can go from feeling miserable to being on top of the world or vice versa. The financial uncertainty also contributes to this ride. For me this was much more of a strain than the heavy workload!

# Who's Who

**Jonathan Ayres** (R BA92) recently joined United Trust Bank as CFO.

**Mark Bingham** (CC BA00) is working at TAP Biosystems.

**Jack Butler** (SE BA04) is principal at Full Spectrum Living.

**Thomas Chetwin** (CHR BA13) is working at Bloomberg as a software engineer.

**Oliver Chick** (CAI BA11, MEng12, PhD16) has joined Focal Point Positioning as principal software engineer.

**William Denman** (PhD14) is working as a systems developer for Orbis Investments in Vancouver.

**Amir Hajizamani** (JN BA11) is now working at Yieldify as a product manager.

**Roy Hamans** (PhD, RA08) is working at Cambridge & Co.

**Matej Hamas** (R BA15) is studying for a Masters degree at ETH, Zurich.

**Angela Hey** (MA75) is a technology marketing consultant at Techviser, a company she started.

**Roger Hill** (JN BA85) is working at KPMG as a CRM consultant.

**Val Jerdes** (RA94) is a partner at Innov8 Global Ventures in the San Francisco Bay Area.

**Raghav Kapoor** (PEM MA04) is CEO at Smartkarma in Singapore.

**Matthew Lent** (W MPhil13) is COO at Keep in the San Francisco Bay Area.

**Angus Lepper** (Q BA12) has recently joined Intel Corporation.

**Andy Li** (T MA10) is an analyst at Stream Financial.

**John Mathieson** (T MA81) is director of automotive product architecture at NVIDIA in the San Francisco Bay Area.

**Paul McLellan** (SID MA75) is editor of Breakfast Bytes at Cadence Design Systems in San Jose, California.

**Shreepdipta Mitra** (PET BA13) is working at Shell as a business analyst.

**David Mrva** (PET MPhil02, PhD06) has joined Cantab Research Limited as director of speech recognition.

**Karina Palyutina** (CTH BA13) is a project manager at RealVNC.

**Tomas Pfister** (CAI BA10) is working at Apple in San Francisco.

**James Pitt** (MA98) is CTO at AltAssets.

**Max Spencer** (T BA13, RA15) is an android developer at Guardian News & Media.

**Mark Spiteri** (DAR PhD00) has joined FinancialForce.com as chief R&D officer.

**Bjarne Stroustrup** (CHU PhD79) will be giving a seminar, titled 'No Littering!' at the Computer Laboratory on May 13th at 4.15pm.

Bjarne is a Managing Director in the technology division of Morgan Stanley in New York, and a Visiting Professor in Computer Science at Columbia University.

**Julian Styles** (TH BA87) is director business development USA at GaN Systems LLC.

**Salman Taherian** (JN PhD07) is a director at KASRA

**Oliver Thorp** (CHU MA04) works at Sky as a network architect.

**Rob Thatcher** (CHU MA98) is now working at Deutsche Bank.

**Sarah Thompson** (PhD06) is a software engineer at Google in San Francisco.

**Philip Tuddenham** (CAI BA04, PhD08) is an associate principal at McKinsey.

**Nicko van Someren** (T MA89, PhD94) has been appointed CTO at The Linux Foundation.

**Andrew Warfield** (PhD04) is Associate Professor at the Department of Computer Science at the University of British Columbia.

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# Hall of fame news

## Bromium

Bromium Inc has secured an additional investment of \$40 million to fund its continued growth in the enterprise endpoint security market. This brings the total investment in Bromium to \$115 million. The investment round was led by existing investors and also included Silver Lake Waterman. The company plans to use the new funds to increase its sales and marketing efforts globally, and to open offices in Germany, Benelux and the Nordics.

Bromium's Advanced Endpoint Security was named a winner of the Vendor Excellence Awards for 'Best Emerging Midmarket Solution' at the Spring 2016 Midmarket CIO Forum. Bromium was selected by 200 leading CIO voters, who based their decision on the company's innovative approach to security and powerful partnerships with the midmarket.

## Ellexus

Ellexus's new IO profiling tool *Mistral* scooped Product of the Year Award at the Cambridge Computer Lab Ring annual Hall of Fame Awards.



Rosemary Francis (front left) with team Ellexus

*Mistral* addresses the noisy neighbour problem: when a small number of jobs overload the network or file system in a compute cluster with shared storage (see interview on page 2).

## Jagex

Jagex is reportedly negotiating acquisition with Chinese mining company Shandong Hongda Mining Co Ltd. Jagex confirmed 'Jagex has entered into a non-exclusive, non-binding arrangement for a potential acquisition. The negotiations surrounding the acquisition are ongoing...'

It is reported that the transaction is valued at \$300mio.

## Masabi

Los Angeles' Metrolink has launched the first version of its mobile ticketing app. The app, which allows its passengers the option to purchase their ticket on a smartphone, tablet or other mobile device, uses the Masabi JustRide mobile ticketing system. The app is available in both Google Play and the Apple App stores.

## Raspberry Pi

Last year, leading UK space organisations joined forces with British ESA Astronaut Tim Peake and Raspberry Pi Foundation to offer students a chance to code their own computer science experiments to run in space. Two augmented Raspberry Pi computers, named *Astro Pi*, were flown to the International Space Station (ISS) as part of Tim Peake's mission.

Seven winning programs blasted off from Cape Canaveral Air Force Base in Florida in December 2015 and the first *Astro Pi* deployed in the ISS Columbus laboratory has been running student code.

Since the success of the first student competition, further *Astro Pi* Coding Challenges have been launched. The first asked students to write Python code to turn the *Astro Pi* into an MP3 music player so that Tim could plug in headphones and listen to music. The second challenge required students to compose their own music using *Sonic Pi*. While on board the ISS, Tim can use the MP3 player code from the first challenge to listen to the music created from the second challenge.

Tim Peake said 'This competition offers a unique chance for young people to learn core computing skills that will be extremely useful in the future. It's going to be a lot of fun!'

In other news, Raspberry Pi has updated its camera board with 8MP Sony IMX219 sensor.

The new sensor is used for both the regular camera board and an infrared-sensitive version, and according to Raspberry Pi, it offers better low-light performance, image quality and colour fidelity. The camera accessory is a simple, small board with a ribbon cable that can be connected to one of the Raspberry Pi mini-computers. Creators have used the camera modules to record images through a telescope and equip drones with lightweight camera functionality, among many other applications.

## RealVNC

RealVNC recently showcased the latest VNC® SDK control and support technology for connected devices.

SDK provides the tools needed to integrate remote access with existing software on Windows, Linux, Mac, iOS, Android, Raspberry Pi and HTML5-compatible browser-based platforms. Customers can

integrate VNC SDK within their products to add secure, responsive access, for remote control, support, monitoring, automation or management of Smart IoT.

## Xsilon

Xsilon's "Hanadu" IOT connectivity technology has successfully completed field trials, sponsored by the UK's Department for Energy & Climate Change, and DECC is keen to incorporate Hanadu into the nationwide roll-out of smart metering (due to kick off in the next few months). DECC is also keen to see Hanadu included in the next wave of energy-saving technologies to be deployed into the home, as a platform for demand-response initiatives that will deliver direct benefits for householder bills.

More widely, Xsilon has been engaging with the ZigBee and Thread IOT radio consortiums, receiving encouragement from their leading members to become part of their vision to extend IOT connectivity throughout the whole home. Hanadu allows radio and powerline to combine into a single, whole-home connectivity platform. Major consumer electronics brands see this as vital for the mass take-up of Internet of Things applications in the domestic market, confirming that radio on its own cannot achieve this. This is the "tens of billions" market that is widely talked about, and Hanadu stands to be a global player in this industry.

## Job listing

### May

#### Symfact

- *IT project manager*

### April

#### Yagro

- *Full stack software engineer*

#### Mindmaps

- *Business development manager*
- *Cluster engineer*
- *Core engineer*
- *Lead engineer*
- *NLP engineer*
- *R&D engineer*
- *Visualisation engineer*

### March

#### DE Shaw

- *IT Sys Admin*

#### Codethink

- *Linux coder*

#### IQ Capital

- *Analyst*

#### Qualcomm

- *Engineer (CPU design)*

#### Green Custard

- *Mobile developer*

*If you have a job advert that you would like included in the weekly listing, please send the details (as a word doc) to [cam-ring@cl.cam.ac.uk](mailto:cam-ring@cl.cam.ac.uk)*



# Cambridge 2 Cambridge



Research Associate Graham Rymer reports on an international cybersecurity challenge between the University of Cambridge and MIT's Computer Science and Artificial Intelligence Lab

During early March, in a joint venture between the University of Cambridge Computer Laboratory and MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL), ten of the best student hackers selected from the School of Technology travelled to Boston to compete in a twenty-four hour hacking competition. The competition included a "full spectrum" capture the flag (CTF) event, which required competitors to be skilled in the areas of web security, binary reverse engineering and exploitation, cryptanalysis, and forensics. It culminated with an attack-defence style event, which saw teams of four students going head to head against each other, attacking their enemies' infrastructure whilst trying to protect their own. The whole competition took place within the iconic Ray and Maria Stata Center, a distinctive building designed by Pritzker Prize-winning architect Frank Gehry.



MIT's Ray and Maria Stata Center.

The competition, originally conceived in the context of a bilateral meeting between David Cameron and Barack Obama in Washington back in January 2015, is part of a series of initiatives between the two countries to improve their mutual cyber security stance.

"The aim is to enhance cybersecurity research at the highest academic level within both countries to bolster our cyber defenses." —The White House, Office of the Press Secretary

Dr Frank Stajano, head of the Academic Centre of Excellence in Cyber Security Research here in Cambridge, together with American colleague Dr Howard Shrobe from MIT, both worked quickly to defuse what was initially envisaged as being a head-to-head competition between the two universities into a more collaborative and constructive venture. "Cambridge vs. Cambridge" was quickly rebranded "Cambridge 2 Cambridge". "It is essential for the good guys to work together and compare notes", comments Dr Stajano, "If you're not at least as good as the bad guys, then you have no chance against them". Cambridge students Priyesh Patel and Daniel Wong agreed that the event was successful in uniting the two institutions.

"C2C was a great initiative to increase the awareness of cybersecurity and cultivate a relationship between the two universities." — Priyesh Patel

"The synergy and teamwork during the live CTF was what I enjoyed most. Although our team members were not the best individually, together we were able to gel well together and that feeling of being 'in the zone' and working seamlessly together in attacking other teams, scripting our exploits and rushing to patch our services was fantastic." — Daniel Wong

In addition to more conventional team-based computer security challenges, parallel competitive events included a lock picking competition, and a "rapid fire" event for individuals. There was even a "cold boot attack" demonstration which saw students cooling RAM modules in a running PC using canned air, before ripping them out and hurriedly plugging them into a second PC to attempt to read the contents of the frozen memory. All these challenges were orchestrated by security firm ForAllSecure, whose employees include several members of the extremely successful CTF team "PPP", past champions of the prestigious DEF CON® CTF competition.



*Lock picking competition*

The most hotly contested event was without doubt the “Rapid Fire” competition, which required individual competitors to exploit a series of vulnerable Linux binaries against the clock. They began attacking each challenge by disassembling the binaries with the available tools which included IDA Pro, the original C source code being provided automatically after a few minutes to make the work easier if they had not already solved the problem. This was a very difficult competition: in addition to the significant time pressure there was also a room full of people watching everything they did! Two Cambridge students, Gábor Szarka and Will Shackleton did extremely well in this event, with Will making it through to the final where he eventually secured second place.



*Will Shackleton competing in the “Rapid Fire” event*

Two Cambridge Students, Gábor Szarka and Alex Dagleish of team “Johnny Cached”, were both members of the prize-winning “Top Hacking Team”. They shared the \$15,000 prize with their American colleagues, a prize which was kindly donated by Microsoft®. Team “Total Recursion”, which featured Cambridge students Jan Ondras and Will Shackleton, managed first place in two events, a point of sale hacking competition and a binary breaking competition which ran late into the night. Will Shackleton also managed 3rd place in the “Cracking Crypto” competition, which involved password brute forcing, as well

as 3rd place in the lock picking competition, sharing the podium with Josiah Yan who took 2nd place after only recently learning some basic lock picking skills!



*Team “Johnny Cached” on their way to winning*

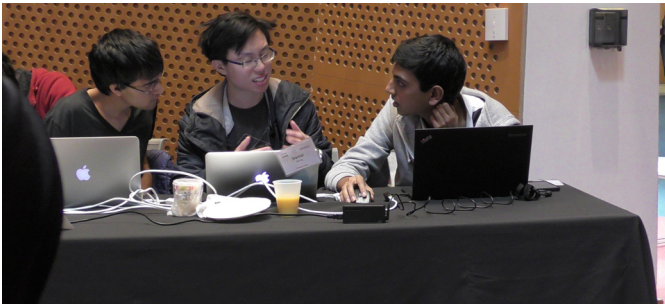
None of the students, on either side of the Atlantic, had very long to prepare for this experience. Dr Stajano has recently recruited hacker Graham Rymer with Cabinet Office funding to help develop training and challenges for this and similar events. The Cambridge team had attended a couple of workshops on Linux binary reverse engineering and exploitation, part of a contemporary course developed in-house by Graham and based around free open source tools and a modern 64-bit Linux distribution. These workshops covered techniques including Return Orientated Programming (ROP) for bypassing protection mechanisms like non-executable memory (NX) and Address Space Layout Randomisation (ASLR), with students able to work on a live server to practice their skills during these sessions. Two “jeopardy style” CTF training competitions were also run in-house, which included a number of specially engineered problems designed to expose students to the tools they would require for tackling a typical CTF event. Cambridge student Gábor Szarka, who participated in these workshops, believes that this type of training is important for developing the next generation of cyber security professionals.

“This form of education is very difficult to implement in a conventional classroom setting, so providing opportunities such as C2C for interested students is crucial to any initiative aiming to train a next generation of cyber security professionals.” — Gábor Szarka

Indeed, Dr Stajano, who lectures on security in the Computer Science Tripos, plans to include challenges developed for Cambridge 2 Cambridge as practical exercises in the official curriculum. Student Brett Gutstein confirmed that this type of training certainly has its place.



“I thought the initiative was really valuable in that it exposed us to concepts and styles of competition that are hard to access in the usual university setting.” – Brett Gutstein



Team “Class Warfare {}” discussing tactics

Between them, the Cambridge students returned with five gold medals, nine silver medals, and five bronze medals to their names, making this a very successful inaugural competition for the Cambridge delegation. It is hoped that this relationship with MIT — and other universities — will continue, and more competitions like this will help to strengthen cooperation on cyber defense and shine a light on academic research in cyber security.

Dr Stajano and Graham Rymer have already organised a similar event in partnership with Facebook for late April, to be hosted at the Computer Laboratory, with all thirteen current Academic Centres of Excellence in Cyber Security Research being invited to send teams to compete. It is hoped that the first “Inter-ACE Cyberchallenge” will get students from the invited universities thinking hard about cyber security challenges, as well as giving them the opportunity to forge new friendships. John McCanny from Queen’s University Belfast comments, “Getting all our PhDs together like this I believe will be a great experience and hopefully will lead to formative and enduring friendships in years to come”.



Frank Stajano (l) and Graham Rymer (r) with the medal winners!

These events, as well as being fun for students, present an opportunity for participants to develop essential soft skills. Gábor Szarka, speaking about his experience in the Cambridge 2 Cambridge competition, observed “Maybe somewhat surprisingly of a computer hacking competition, the live CTF was also an exercise in interpersonal skills, since effectively collaborating with people you have just met under significant time pressure in a generally stressful environment does not come naturally”.

*The first “Inter-ACE Cyberchallenge” was held on April 23rd 2016. Cambridge won both individual and team gold. The winning team comprised Stella Lau, Will Shackleton, Cheng Sun, Gábor Szarka. The winner of individual gold was Dimitrije Erdeljan. All are undergraduates at the Computer Laboratory.*



Inter-Ace Cyberchallenge winners

# Research Skills course

## Christopher Bryant: Automatic Grammatical Error Correction: Where next?

All writing is hard work, but writing consistently grammatical, fluent, natural-sounding sentences is even harder. This is especially true if you are writing in a foreign language. Whether it be through tiredness, carelessness or innocent naivety, all of us invariably make grammatical mistakes at some point in our lives, which, at best, annoy our readers and, at worst, obscure our intended meaning completely. What we would really like then, is a robust tool that not only identifies where we make such mistakes in a text, but also offers suggestions as to how to correct them: think something like a spell-checker, but much more sophisticated.

This is the ultimate goal of Grammatical Error Correction (GEC), a subfield of Natural Language Processing (NLP) which has gained increased attention in recent years, thanks mainly to the successes of four high profile academic shared tasks since 2011. Despite this attention however, the highest scoring system in the most recent of these tasks (CoNLL-2014), a system submitted by the University of Cambridge, still only managed to achieve an F0.5 score of just 37.33%, which just serves to illustrate the complexity of the problem.

One of the main reasons machines have difficulty with identifying and correcting errors is that errors come in many different forms, which often require different correction strategies. For example, subject-verb agreement errors, such as ‘/sleeps’, typically only require the addition or removal of an –s suffix from a verb, constrained only by the grammatical number of the subject, but can be fairly reliably corrected simply by means of handwritten rules. In contrast, preposition errors, such as ‘I am in home’, not only have a much larger confusion set {‘in’, ‘at’, ‘for’ etc.} but are also much more dependent on context, prompting some researchers to instead turn to machine-learned statistical classifiers as a means of correction. When you also consider collocation errors, such as ‘I am 6ft high’, which are much more semantic in nature, correction becomes even more difficult, and so another strategy is to use techniques common to the field of Statistical Machine Translation (SMT) which treat the correction problem as a translation from “bad” to “good” English.

Ultimately, while all of these approaches have their various strengths and weaknesses, I think the biggest breakthrough to be made in GEC is in the area of error detection, rather than correction. A system that is able to accurately detect mistakes, even if it cannot correct them, is still likely to be extremely valuable to an end user who, upon being made aware of any errors, might then be able to correct them by themselves.

Although more robust error detection is something that will no doubt be extremely difficult to achieve, this is just one area of GEC I hope to look into during my PhD at Cambridge.

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*The best essays from the Research Skills module of the MPhil in Advanced Computer Science course 2015/2016 are being published in ‘The Ring’. This is the second of these essays.*

# Computer Laboratory news

## Wheeler Lecture

The 2016 Wheeler Lecture will be given at by Dr Andrew Herbert, OBE FREng, at 4pm on Wednesday May 25th 2016.

The lecture, titled 'A History of Virtualisation in Operating Systems', is an extended version of an invited talk given at the ACM Symposium on Operating Systems Principles 'History Day' last year.

Prior to the lecture (at 2.30pm) there will be a selection of one minute talks showcasing current research at the Computer Laboratory.

If you would like to attend please register at [www.cl.cam.ac.uk](http://www.cl.cam.ac.uk)

## Funding Successes

Leverhulme Trust Research Project Grant

**Dr Mateja Jamnik**

**'ARD: accessible reasoning with diagrams'**  
**£383,728**

The three-year project combines computer and cognitive sciences, and aims to develop a novel and accessible diagram-based logic, based on empirical testing of what humans find accessible. The resulting diagrammatic logic needs to be suitable for information representation and reasoning across a wide range of subject areas. The tools developed will enable better communication and understanding between those who produce the models, and those who use them in real world domains.

Innovate UK

**Dr Hatice Gunes**

**'Sensing Feeling'**

A two-year project to explore enhancing user experience in retail environments by sensing their behaviour and expressions.

EPSRC Digital Economy – Trust Identity Privacy Security (TIPS)

**Professor Jon Crowcroft and Dr Richard Mortier**

**'Control and Trust as Moderating Mechanisms in addressing Vulnerability for the Design of Business and Economic Models'**

Understanding and measuring user subjective vulnerability to TIPS issues and studying implications of this subjective vulnerability for business models in the digital economy.

**Dr Richard Mortier**

**'Databox: Privacy-Aware Infrastructure for Managing Personal Data'**

To build future personal data processing systems requires a cooperative design approach, involving engagement with all stakeholders (data sources, collectors, processors, and subjects and the organisations representing them). By engaging with these groups we will iteratively design means for people to engage with, understand and reflect upon their aggregate personal data — its sources, content, collectors and uses — and to study them doing so.

Google Faculty Research Awards

**Dr Richard Mortier**

To build a personal data aggregation and query point (a 'databox'), control over which rests directly with the user. This will enable real-world study of personal data management, design of physical interactions for digital data management, and development of an open-source platform suitable for extension and deployment for future research.

**Dr Robert Watson (with Professor Simon Moore)**

**'Understanding and Mitigating IOMMU Vulnerabilities for External I/O Interfaces'**

To support hardware purchases and a student bursary to investigate the security implications of contemporary IOMMU use in notebook, desktop, and server computer systems with respect to malicious peripheral devices — as well as potential defences in hardware and software. This project builds on DARPA-funded seedling research joint with Simon Moore, and continues their long-running collaboration in the area of hardware–software security.

Google PhD Fellowship

**Dr Robert Watson**

**'Specializing the OS data plane for performance'**

To fund the remaining year of Ilias Marinou's PhD in the area of high-performance networking. Ilias has been investigating how software specialisation and micro-architectural awareness can improve network–stack performance. This new project extends this work into storage specialisation and performance using PCI-attached flash, which will be integrated with prior network–stack work.

39 Google PhD Fellowships were awarded worldwide; this is the only one awarded to the University of Cambridge.

## OpenStreetCab

Professor Cecilia Mascolo, and colleagues from the University of Namur Belgium and the University of Lancaster, have developed a smartphone app — OpenStreetCab — to compare prices of Uber taxis with those of other minicabs and taxis. The ability to compare prices in this way should give power back to consumers who feel cheated by Uber's 'surge pricing' model.