

The Ring

THE JOURNAL OF THE CAMBRIDGE COMPUTER LAB RING

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Who's Who

Simon Baker (W MPhil13) is now doing a PhD at the University of Cambridge Computer Laboratory.

Jack Bastow (JE BA11) has co-founded Hindsight Software where he is a software engineer.

Nat Billington (Q BA92), co-founder and director of Synergy Energy, a clean tech investment and business incubation company, is a non-executive director at Vantage Power. Vantage Power has designed and is prototyping the B320 System, an innovative hybrid-electric powertrain which will replace the existing engine and gearbox currently found in conventional buses.

Lewis Brown (CHU BA13) is an MSc Research Scholar at École Polytechnique Fédérale de Lausanne (EPFL).

Wing Chan (T BA13) is now working at The Hut Group.

Thomas Chetwin (CHR BA13) is working at Bloomberg where he is a financial software developer.

Omi C Chowdhury (BA12) is in New York working for Identropy Inc.

Cong Cong Bo (BA) has founded Textiler, a Web site that allows anyone to upload their designs and print these into onto a range of fabrics.

Peter Cowley (F MA77) is an investor and board observer at Vantage Power.

Peter has also recently become an advisor to AcceleratorIndia Ltd, a cross-border business accelerator that partners with UK companies to help capture the "India opportunity".

Declan Conlon (F BA03) is the principal engineer at Juniper Networks in Sydney.

Matthew Dingley (Q BA10) is a software engineer at Google.

Peter Dushkin (Q Dip03) is technical team lead at Morgan Stanley Wealth Management in New York.

Calum Eadie (G BA13) is a 2013 cohort member at Entrepreneur First.

Darren Edge (JE BA04 PhD08) is working in Beijing City for Microsoft Research.

Russell Haggar (CHR BA91) has become CEO at Xsilon.

Rob Hague (F BA99 PhD04) is a lead engineer at Azuro (UK) Ltd.

Euan Harris (DAR PhD08) is working at Citrix Systems where he is a senior software engineer.

Demis Hassabis (Q BA97) has sold his artificial intelligence start-up Deep Mind to Google for £400m — Google's largest technology acquisition in Europe — without having released a product. Deep Mind's investors include US Tesla car mogul Elon Musk and early Facebook investor Peter Thiel.

Demis had a notable career in video games after graduating, founding his own games studio Elixir, before returning to academia to study neuroscience in which he gained a PhD in 2009 from University College London.

Grant Hyslop (R BA05) is a director at Oak Connections Ltd.

Jakub Kaplan (CHU BA11) is an interest rate options trader at Citi.

Elliott Katz (BA11) is a technical account manager at OpenMarket.

William Keen (BA12) is graduate engineer at ARM in Cambridge.

Martin Lester (CAI BA06) is doing a PhD at the University of Oxford.

Stephan Liwicki (MPhil10) is doing a PhD at Imperial College, London.

Tzu-Chiang Liou (MPhil10) is a senior research engineer at Yahoo! in Taiwan, and is doing a PhD at National Taiwan University.



Demis Hassabis

Photo by A. Jolly on Flickr at <http://bit.ly/dh-singularity>

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The Ring is the journal of the Computer Lab Ring, which is the graduate association of the University of Cambridge Computer Laboratory.

David Mack (JE BA09) has recently co-founded SketchDeck. SketchDeck has been funded by Y-Combinator, an American seed accelerator named the top start-up incubator and accelerator by Forbes in 2012.

Eur Ing Dr Phebe Mann (HH MA05) has received an Honorary Fellowship from Bradford College in recognition of her eminence in construction law, engineering and education, and her encouragement to women in pursuing engineering.

Jonathan May (K BA05) is CEO of Sponsorcraft, a company he co-founded.

Sponsorcraft provides Web-based fundraising products for the education community — students, educational institutions, organisations, and alumni — enabling them to raise interest, excitement and money for their projects and events. It helps universities to engage better with their alumni especially in a fundraising context.

Jonathan is a winner of The Big Venture Challenge 2013–2014. He is also a board advisor at iHELP World Ltd. iHELP is a mobile phone application that creates a care network.

Shreedipta Mitra (PET BA13) is working at Shell where she is a product management consultant.

James Moore (DOW MA05) is now CTO at Red Gate Software.

Eduardo Muñoz (M BA13) is a software engineer at Microsoft.

Herman Narula (BA12) is CEO at Improbable Worlds.

David Oxley (Dip04) is working at D. E. Shaw & Co. (UK), Ltd as a network engineer.

Sam Pattuzzi (R BA13) is working for RealVNC in Cambridge.

Oleg Podsechin (G BA05) has founded StartHQ, a Web app directory making it easy for organisations to find the right Web app to get their job done.

Harry Ragan (K BA13) is a software engineer at Scuderia Ferrari.

Ben Shaw (JN BA13) is an engineer at Salesforce.com.

Karl Spalding Wall (BA05) is CTO at RoundsOnMe Ltd.

Max Spencer (T BA13) is a Research Assistant at the University of Cambridge Computer Laboratory. Max is a member of the Security Group.

Noam Szpiro (BA11) has co-founded @Corral and is based in the San Francisco Bay Area.

Iulia-Raluca Turc (N BA13) is doing an MSc at the University of Oxford.

Rahul Vohra (CHR BA05) is now LinkedIn Intro lead at LinkedIn. LinkedIn Intro is an iOS applications that allows iPhone users to route their e-mail through so that they receive background information on an e-mail sender or receiver.

Robert Whitehead (R BA12) is CTO at Improbable Worlds.

Events calendar

2014

February

Thursday 6th, 6.30pm
London Ringlet Bar
 Crosse Keys, EC3V 0DR
Kindly sponsored by Embecosm

April

Tuesday 1st, 7pm
Cambridge Computer Lab
Ring Annual Dinner and
Hall of Fame Awards
Queens' College, Cambridge

*Tickets cost £55. Please contact
 cam-ring@cl.cam.ac.uk to book*

Thursday 3rd, 6.30pm
London Ringlet Bar
Venue to be confirmed

June

Tuesday 3rd, 6.30pm
London Ringlet Bar
Venue to be confirmed

August

Wednesday 6th, 6.30pm
London Ringlet Bar
Venue to be confirmed

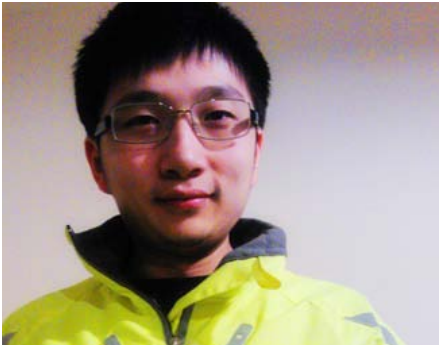
October

Wednesday 1st, 6.30pm
London Ringlet Bar
Venue to be confirmed

December

Monday 1st, 6.30pm
London Ringlet Bar
Venue to be confirmed

Visijax



Cycling around Cambridge prompted **Andy Li** to develop Visijax which he hopes will improve the safety and visibility of cyclists and reduce the numbers of cycling accidents.

TR: Andy, you started your company in your final year at Cambridge. What inspired you to start your own business?

AL: I think my inspiration was drawn from two sources. Firstly the Computer Science Tripos covered a wide range of interests and several business-oriented modules (taught in the second and third year) not only equipped us with basic business knowledge, but also encouraged all of us to become adventurous at some stage in our lives. I simply took the leap early. The second source of my inspiration lies deep in the roots of the Lab. Not only have so many present and past lab members brought their research and ideas into the commercial world, many turning their ideas into successful businesses, but more importantly they have also made the world a better place with their products and services. When I sat in the guest lectures I felt inspired.

TR: Can you tell me about the first projects you were involved in? What did you learn from those first experiences?

AL: The first project I was involved in was a consultancy job advising an overseas company in a takeover attempt of a British professional mobile radio (PMR) equipment maker. I was both advising the company as well as negotiating on behalf of their Board of Directors. At the time, it was both challenging and daunting, but during the process I gained a huge amount of experience that would otherwise have taken years to accumulate. The most valuable skills I learned included general business etiquette, company valuation and negotiation skills.

TR: Can you tell me about Visijax, your motion-activated electronic jacket, and how the idea was brought to fruition?

AL: Cambridge is a fascinating place that really inspires people. The idea of designing a flashing LED jacket with motion-activated turning indicators certainly came from my cycling experience around town, not least the daily commute to the Lab on the busy Madingley Road. After I had the initial idea it took me some time to work out if the project was going to be feasible and identify suitable technologies

before prototypes were made. It was difficult to get the first prototype made as I knew almost nothing about the textile trade. Visijax went through several iterations of improvement before it was deemed good enough to be released for mass production.

The second source of my inspiration lies deep in the roots of the Lab... When I sat in the guest lectures I felt inspired.

TR: What is the market size for your product today and what potential market share can you achieve?

AL: Smart clothing has been an area of significant interest from the early days of electronics, and we've seen so many examples in sci-fi films. However only recently has the size of electronics become small enough to wear. Key developments in conductive textiles and flexible electronics are also making a significant impact in the market. Many people have now identified smart clothing and wearable electronics as "the next big thing" and I certainly share this view. By positioning the business right we hope to become a major player in this segment when it really takes off.

TR: What does the Visijax retail for and why will people buy your product and not something else?

AL: Currently Visijax is sold for £50 through Amazon. The product we built is so unique that there simply isn't a like-for-like alternative in the market. We believe that the innovative safety features and mainstream pricing really set us apart from the competition.

TR: How do you get customers?

AL: At the moment our main sales channel is Amazon though often new customers simply come through word of mouth. We also attend

various cycle and triathlon shows throughout the year. With Visijax flashing on the stand we always manage to attract a large crowd and bring in the sales. Finally media coverage and reviews of our product also get us a lot of attention from around the world.

TR: What is your competitive advantage?

AL: Our biggest competitive advantage lies in the core technology that we developed. By putting state-of-the-art technology in conventional clothing, we are able to introduce a host of innovative product features that set us apart. The technology developed for our current generation product is at least three years ahead of the competition and we are already at an advanced stage of development for the next generation product. If we keep developing new technologies and innovative features with real benefits I am confident that we can keep, or even widen, our competitive edge.

The technology developed for our current generation product is at least three years ahead of the competition and we are already at an advanced stage of development for the next generation product.

TR: What risks are you facing?

AL: The biggest risk we're facing comes from our competition, many of which are the world's largest multinational corporations. As we continue to grow the business and build up our sales, we become more and more likely to attract their attention. With their huge resources it will be very tough to compete. In order to alleviate this risk we're trying to build a brand with Visijax and to establish it as a world leader in smart clothing. Furthermore I think there may be opportunities for us to collaborate with them at some point.

TR: What do the next 12 months hold in store and what are your plans for the future?

AL: Our main objective for the next 12 months is to improve the technical design based on our experience with the current generation product, and to develop a range of products with differentiating features as well as pricing points. As a smart clothing business it's not really possible to develop a one-size-fits-all solution for everyone, which is why we need to build out a product range that suits the taste and preference of different people. In terms of improving our technical design, we have learned a great deal in the last 12 months and

the new system is already at an advanced stage of development. Just to give you a taste of what's coming, our next generation products will be fully machine-washable.

TR: Finally, do you think more undergraduates are now thinking about starting on their own and, if so, what do you think has fostered the increase in entrepreneurship?

AL: I think more undergraduates with great product ideas should start up their own businesses. People are most creative when they're young — they dare to challenge the conventional and to think outside the box. When they start businesses so early in their careers, there's everything to gain and very little to lose. Imagine having worked your way up in a large corporation and then trying to start up a new business. If all fails, it's still not too late to go back into Google, Goldman Sachs or McKinsey.



Furthermore I do have a strong belief that in every economic crisis of the past it's not government fiscal policy or central bank stimulus that drives the economy out of recession: it's always innovation. Although I can't tell you whether more undergraduates are actually doing start-ups, I certainly think that they should.

Go to <http://visijax.com> for more information about Visijax.

RealVNC



Andy Harter explains how RealVNC is conquering the world, remotely.

TR: Andy, when The Ring spoke to you in May 2008 you said you were exploring different ways of commercialising VNC.

Then over 100 million copies of your free version of VNC had been downloaded. This has increased to well over 250 million copies and you have exploited the software to create new services in cars, media and telecoms.

Can you tell me about VNC in the automotive industry?

AH: We now have access to our digital worlds at home, in the office and when we're out and about via laptops, tablets and smartphones. But what about when we're sitting in a vehicle, perhaps as the driver? Cars are rapidly evolving to have high-resolution colour touchscreens in the dashboard and seat backs, but what do we want to do with the screens? Car manufacturers are unable to provide all the applications you might want — it's a losing battle if you think about the richness and immediacy of the App Stores. We've sold them the idea of using everything that's on your mobile device, but projected onto the big screen using VNC. It might be a navigation application, or a movie, or some must-have killer app that you downloaded to your smartphone yesterday. It's extremely promising, and we have a very significant share of the industry signed up. It's already available as an after-market upgrade for some cars, but later this year it will be rolling off the production line of several car makers. It's a huge market!

TR: Back in 2008 you told us a bit about your bespoke development work and OEM licensing. How has this side of the business developed in the last five years?

AH: Really well. The royalty-bearing license revenues from OEM business are a fabulous complement to our revenues from the shrink-wrapped remote access product. I've always said that in the longer term, they will overtake and dominate. Our technology is now under

license to about fifty different companies, including Intel, who have embedded it directly in their i5 and i7 processor chipsets, and to Google, who have embedded it in the Chrome browser. We're creating some new markets in consumer electronics, which is very exciting.

TR: Following RealVNC's unique double Queen's Award win in 2011, the company has picked up its third Queen's Award for its outstanding achievements in International Trade. What percentage of your sales is made outside the UK?

AH: It's always been around the 90% mark. This isn't unusual for a software product and licensing business. But what is more noteworthy is that since we are highly profitable, with no significant expenditure outside the UK, it's a boost for the balance of payments. The direct tax and national insurance from employment alone accounts for over half the treasury's income, so employing people in the UK and paying corporation tax out of income from abroad is a win-win for our economy.

We've deliberately grown the business organically without external investment. This is fantastic if you can pull it off.

TR: Unlike many other hi-tech UK businesses, you've chosen not to open offices overseas despite this. Why?

AH: Like many other aspects of the business, I've done what I know or think to be right, not just followed the standard path and received wisdom. This isn't deliberately to be perverse; it simply recognises that every business is different. A straightforward stand-alone product like VNC can be very effectively sold over the Internet and with a focused telesales team. We have a couple of shifts and a stretched

working day for sales and support. It's not 24 hours a day worldwide, but the overlap with important timezones is good enough. It's really efficient to use the building and facilities we have here, rather than set up an office in the US for example, which can be a huge distraction and drain. The OEM side of the business is a bit more complex, but it still suits us to work from the UK and travel when we need to. We've done seven-figure deals over the phone!

TR: RealVNC has also won the UK's most prestigious national prize for engineering innovation, the MacRobert Award. The judges said they believe RealVNC "could be a billion dollar business within five years." How do you feel when the company is talked of in these terms?

AH: It's a bit daunting! If some of the markets that we are addressing go the way we think they might, it is not inconceivable. Automotive and consumer electronics industries are measured in hundreds of millions of units, and our margins are extremely good because it's software. We don't need to be greedy on the unit royalty.

Building a fabulous workforce is not just about throwing money at the problem.

TR: Has the business developed in the way you expected back in 2008? Have there been any unforeseen challenges that you have had to tackle?

AH: We've deliberately grown the business organically without external investment. This is fantastic if you can pull it off, because you don't have a board full of people constantly fiddling with the business plan to achieve a fairly short-term return on investment. It allows you to have longer-term plans that are more strategic, and do things to an agenda and timetable which fits the real world. For example, we knew that smartphones and tablets would come long before they did and we anticipated the market. The downside, which is one of the challenges we face, is maintaining our own sense of urgency and momentum in the absence of external pressure, but I'll admit that it's a nice problem to have!

I don't think there is a hi-tech company in Cambridge that would say recruiting and retaining the best staff is not a challenge. Our approach, which has worked really well, is not just to provide a competitive package and great working environment, but to make sure that people have interesting work and as much genuine responsibility and ownership as they can handle. Time after time, we win and keep staff in some very competitive situations because of this. Building a fabulous workforce is not just about throwing money at the problem.

TR: Andy, you're also a Visiting Fellow in the Computer Laboratory, a department whose graduates have an impressive and envious track record of entrepreneurial activity. Where do you think this entrepreneurial strength comes from?

AH: It's a fundamental part of the DNA of the Laboratory. Maurice Wilkes was driven to build the world's first practical electronic computer that was put into service. It was more important to him that it was used, rather than be an academic curiosity. This set the tone, which has trickled down over the years, and which subsequent leaders such as Roger Needham and Andy Hopper have expanded upon. Notwithstanding the fact that it is the highest rated computer science department in the country according to the last research assessment exercise, and one of the highest rated departments across the whole University, consultancy, business and industry have never been dirty words in the department. The easy flow of people, ideas and resources in and out of the hi-tech cluster has been of tremendous mutual benefit — a genuinely symbiotic relationship.

Also, I think undergraduate teaching in the Computer Laboratory has always struck a good balance between solid academic foundations and practical experience, coupled with enough of the nitty gritty of starting and running a business. Of course Cambridge tends to select independent thinkers and problem solvers whatever the discipline, but the department has been particularly good at nurturing these qualities, which are fundamental properties of an entrepreneur.

TR: How do you think RealVNC will look in five years' time?

AH: Ask me then! But more seriously, I think we will continue to be surrounded by a multitude of heterogeneous devices with screens, and will always have a desire to do things remotely with them and between them. And this observation is a fairly good definition of what VNC is.

To find out more about RealVNC go to <http://www.realvnc.com>

Hall of Fame news

Acunu

Acunu has been shortlisted as a finalist in the Big Data category of The Tech Trailblazers Awards, the enterprise information technology start-up awards.

ARM

ARM has opened a new Design Centre in Noida, North India. The Design Centre will support ARM's leading Physical IP Division, which is focused on creating the building blocks for translation of a circuit design into actual silicon.

Bango

Bango has won the Mobile Merit Award 2013 in the Mobile Payments and Commerce category. The Mobile Merit Award recognises companies, individuals and technologies that have shaped the way in which the world communicates today.

blinkx

Online media group blinkx posted a big jump in half-year profits, lifting its shares by 13% and taking it close to a US\$1 billion valuation.

Blinkx, whose video search engine competes against the likes of Yahoo! Video and Google Video, generates revenue through on-line advertisers and says that 168 million people a month use its search technology in the United States

The company, which has partnerships with Web portal AOL and mobile device maker Samsung, is one of this year's top performers on the FTSE AIM 100. Its shares have risen by 180% since the start of the year, compared with a 30% gain for the wider index.

Bromium

Bromium has secured an additional US\$40 million in a third round of funding, increasing the total raised to US\$75.7 million.

Meritech Capital Partners led the round, while other participants included previous backers Andreesen Horowitz and Intel Capital. Other earlier backers High Capital Partners and Ignition Partners also participated.

DataCore

DataCore Software has won a 2013 SVC (Storage, Virtualisation and Cloud) Project Award in the Storage Project of the Year category for the installation at Quorn Foods (part of the Marlow Foods Group).

Linguamatics

Linguamatics has launched Linguamatics Health, a new clinical NLP suite that enables hospitals and research organisations to harness the information contained in unstructured fields of electronic health records and patient narratives to drive healthcare analytics advanced research and improved patient outcomes.

Masabi

Masabi has won UK Transport Product of the Year at Acquisition International's 2013 Business Excellence Awards.

Half of the UK's rail transport operators run Masabi's mobile ticketing and the company has released JustRide, their end-to-end ticketing technology, to an international market.

The sale of tickets using Masabi's mobile technology passed US\$100 million in October 2013.

Raspberry Pi

A crowdfunding project aimed to make the Raspberry Pi available to children as young as six reached its US\$100,000 goal on Kickstarter in just 18 hours.

Kano, an open-source computer kit, is designed to make coding as easy as assembling Lego. It can be used to build simple games or create music, sounds and HD video. The kit runs a variation of Linux and includes visual coding software called Kano Blocks that outputs Python and Javascript. Kano is "doing great work making the Pi more accessible to younger and less technical audiences," said Eben Upton, co-founder of Raspberry Pi.

Raspberry Pi has been awarded an INDEX 2013 Award in the Play and Learning category.

The INDEX awards are the biggest design awards in the world and are widely recognised as the most important.

RealVNC

PATEO Corporation, a leading Chinese manufacturer of embedded systems for the automotive industry, has selected RealVNC remote access and control software as a partner for MirrorLink™ certified in-car connectivity.

PATEO head units will be manufactured to include RealVNC's MirrorLink certified solution, VNC Automotive, to enable connectivity with all certified handsets.

Sophos

Sophos has been named CRN Security Vendor of the Year.

The award recognises the company's overall contribution to business development and commitment to understanding partner business needs through its 100% "channel first" reseller strategy. Now in their 20th year, the CRN awards represent the pinnacle of achievement in the UK market, rewarding outstanding performance in the IT channel.

Swiftkey

In September 2013, Swiftkey announced its Series B finance round, led by European VC Index Ventures, alongside existing partners Octopus Investments and leading Angels.

In November 2013 Swiftkey announced that Accel Partners had also invested as part of this finance round.

Xsilon

Xsilon has launched a Special Interest Group (SIG). The Hanadu SIG has been created as a forum for companies across the ecosystem to engage, evolve, develop and promote their Hanadu In-Home M2M connectivity technology.

Hanadu is a new generation of powerline comms technology that complements 802.15.4 radio solutions, offering closely integrated powerline/radio networks at 250kbps. Hanadu delivers whole-home coverage, efficient data-rate usage, low power usage and standards compliance. Its native support for the Internet of Things makes it the ideal platform for offering M2M services within the home environment.

The Hall of Fame Awards 2014 are open for nominations

The Hall of Fame Awards celebrate all that's great about the companies founded by the Computer Laboratory's graduates and staff.

From fantastic products and services to economic prosperity and service to the community, companies don't have to be big to make a huge contribution. Just take last year's winner Raspberry Pi.

The HoF Awards feature two categories: Company of the Year and Product of the Year.

Whether your company has been in business for 30 years or has recently started, please show it off and nominate it (nominations to cam-ring@cl.cam.ac.uk). Nominations are open until February 15th.

The shortlisted finalists and winners will be announced at the annual dinner that takes place at Queens' College on April 1st 2014.

Find out more about the Hall of Fame Awards at <http://www.cl.cam.ac.uk/ring/nominations.html>

Job listing

September

Espitora

- *Back-end programmer*

RideBubble

- *Web developer*

October

Cantab Capital

- *Python programmer*

Stratajet

- *Developers*

Thomson Reuters

- *Research scientist*

Saxonica

- *Software developer*

Guidance Navigation

- *Systems and sensor engineer*

Citigroup Global Markets

- *Quantitative market analyst*

November

iOra

- *Principal software developer*

IE

- *Software engineers*

secureVirtual

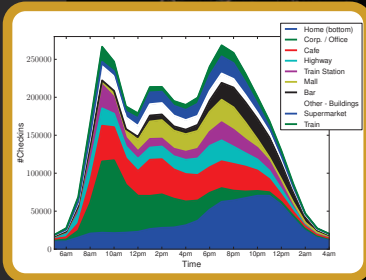
- *Technical director*
- *Microsoft architect*

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

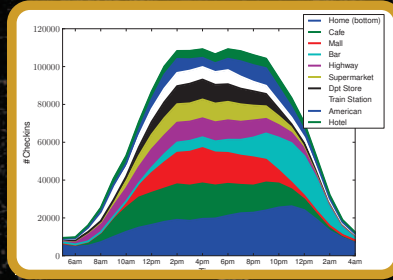
Human Urban Mobility in Location-based Social Networks

The constellations of the Milky Way have been guiding our ancestors for thousands of years. The stars have helped us to navigate, discovery, communication and navigation are still prominent to the advancement of our kind. The new means to humanity's exploration and cloud supported internet connectivity. A significant evolution in the past four years has been the rise of location-based social networks, unprecedented amounts and layers of information describing the location, activity and communication traits of millions of mobile users. These data challenge past theories in fields of urban transport, social science and geography, but they offer the opportunity for novel applications for urban users.

analysing the digital traces of mobile users



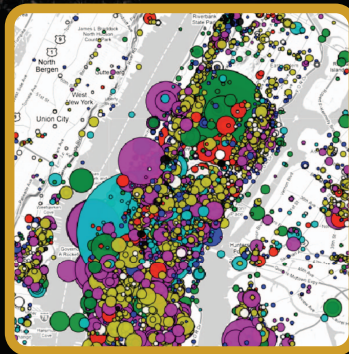
Temporal dynamics of user check-ins across the ten most popular venue categories observed during weekdays and weekends. Foursquare user activity is tracked with per second accuracy, live, via Twitter's Streaming API.



new york morning



new york night time



Urban activity comparison between morning and night hours in Manhattan. Each circle corresponds to a Foursquare venue. Colours are representative of different venue types: Arts (red), Education (black), Shops (white), Food (yellow), Parks (green), Travel (cyan), Nightlife (magenta), Work (blue). The radius of a circle is proportional to the popularity of each venue.



Places in London. Each yellow spot represents a Foursquare geo-tagged venue recorded in the capital city of England. Typically in a metropolitan area thousands of venues are being crowdsourced as mobile users voluntarily check-in and share their whereabouts. As of April 2013 Foursquare has registered approximately 40 millions users globally who have registered more than 3 billion check-ins across 50 million venues since 2009. These data has the potential to benefit research in social sciences or the development of applications for smartphone users.

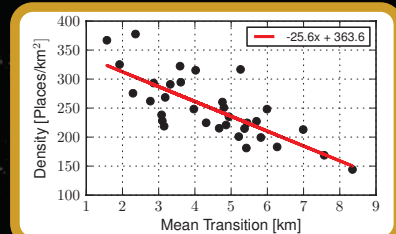
modelling urban mobility



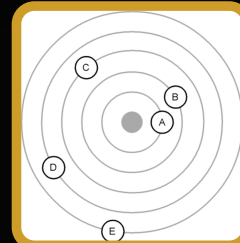
American Sociologist Samuel A. Stouffer (1900-1960).

Stouffer's law of intervening opportunities states, "The number of persons going a given distance is directly proportional to the number of opportunities at that distance and inversely proportional to the number of intervening opportunities."

Analysis the geo... The pro... shows t... centres.

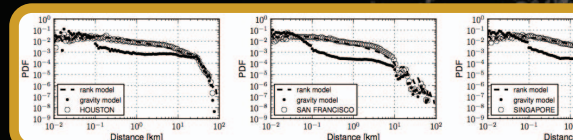


Urban Density and Area Size versus Movement. Scatter plot of the relationship between its mean human transition in kilometres. Each datapoint corresponds to a city. A longer mean transition corresponds to a larger city, indicating that the number of available places per area unit could have a key role in human mobility. The plot highlights a stronger correlation between density and mean movement length.



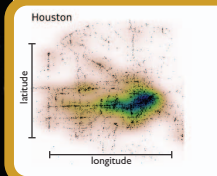
$$rank_u(v) = \{w : d(u, w) < d(u, v)\}$$

Rank-Distance. To shed further light on the hypothesis that density is a decisive factor in human mobility, for every movement between a pair of places in a city we sample the rank value of it. The rank for each transition between two places u and v is the number of places w that are closer in terms of distance to u than v . The rank between two places has the important property to be invariant in scaled versions of a city, where the relative positions of the places is preserved but the absolute distances dilated.



A Model for Human Urban Mobility. We have exploited the properties of the distance variable to verify Stouffer's theory on thirty-four cities placed in four continents. Foursquare data has offered a unique opportunity to test the universality of such large scale. As shown above, the rank based model fits perfectly the observed distribution of movements in all cities, outperforming a version of the gravity based model. The model is comprised of two essential elements depending on the city: the probability of transition from place u to place v .

Kernel Density Estimation in three cities. Heterogeneities observed in human mobility are due to geographic variations. Cultural, organisational or other factors do not appear to play a role in urban movements. The rank model, although simple, can cope with the complex spatial variations in densities observed in urban environments.



Networks: Analysis, Models and Applications

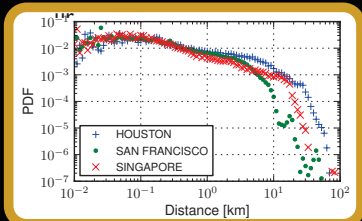
Navigate, govern the seas and discover new lands. In the rise of the 21st century, the primary goals are smartphone devices powered with sensors, advanced software and social networks. Systems like Foursquare enable the crowdsourcing of mobile users at a global scale. Not only they promise the large scale evaluation of data for the computer sciences. In the era of the mobile web, the stars are the mobile

Mobile Users are The Stars

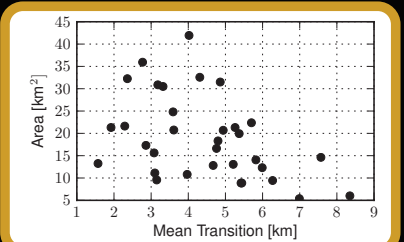


by Anastasios Noulas & Cecilia Mascolo

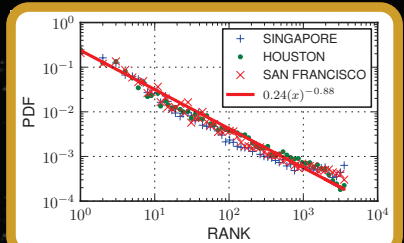
Movement



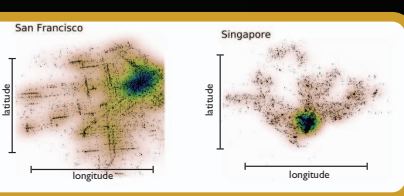
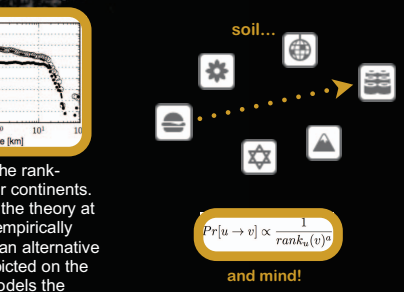
Measuring Urban Movement. For every user we measure geographic distance between successive movements. The probability density function plotted above for three cities shows that heterogeneities may exist across different urban



space density of a city, (left) and area size (right) versus population size of a city, while the red line is a fit that highlights the deviation from the expectation of a sparser urban environment. This has been confirmed by our measurements that show an impact on human urban travel. Stouffer's theory of urban growth in a city.



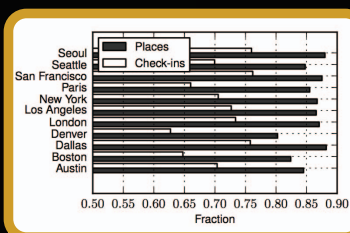
Rank Universality. We observe that the distributions of the three cities collapse to a single line, when we measure movement in terms of the rank variable.



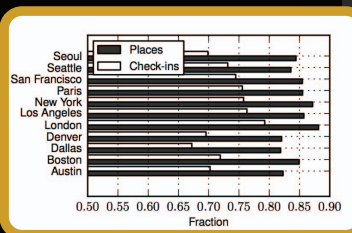
recommending new venues to mobile users



Application Scenario. Our mobile user, little Amy, has a historic record of previously visited places in the city. We would like to exploit this information in order to help her discover new, previously unvisited, venues in the city and recommend them to her.



The Thirst for Urban Exploration. In the Figures we depict the fraction of movements which correspond to new places in 11 cities. 80-90% of visited places are new places! 60-80% of check-ins occur at new places! The findings have been verified at two different location-based services; Foursquare & Gowalla.



A Random Walk with Restart Model for Location-based Recommendations. We propose a new model based on personalized random walks over a user-place graph (example shown above) that, by seamlessly combining social network and venue visit frequency data, obtains between 5 and 18% improvement over other models in ranking new places to mobile users. Its performance has been compared with a number of baseline approaches, including ranking venues by popularity or by geographic distance from a users home location, and with state-of-the-art collaborative filtering algorithms, including latent space models. Our results (enlisted below) pave the way to a new approach for place recommendation in location-based social systems and highlight the need for the division of novel methodologies to efficiently deploy new computer science applications related to local discovery and search in domains where geography and user movement matters.

Recommendation Method	Average Percentile Rank
Random Walk Restart	0.217
Popularity	0.228
Content Filtering	0.228
Matrix Factorization	0.281
PlaceNet	0.337
Home Distance	0.383
Social Filtering	0.392
k-Nearest Neighbours	0.443
Random	0.500

Silicon scanning reveals hidden backdoors in semiconductor chips

Sergei Skorobogatov

Introduction

With the globalisation of semiconductor manufacturing, integrated circuits become vulnerable to malevolent activities in the form of Trojan and backdoor insertion. An adversary can introduce Trojans into the design during fabrication stage by modifying the mask at a chip foundry. It can also be present inside third parties’ modules or blocks used in the design. Backdoors could be implemented by malicious insiders at the design house. Having a security related backdoor on a silicon chip jeopardises any efforts of adding software level protection. This is because an attacker can use the underlying hardware to circumvent the software countermeasures. If a bug is found in firmware programmed into an FPGA then it can be rectified by a firmware update. However, if the Trojan or backdoor is present in the silicon itself, then there is no way to remove the bugs other than replacing all the affected silicon chips or integrated circuits (IC) and the cost of such an operation is enormous.

The majority of chip manufacturers use the JTAG test interface as a standard port for IC testing. The original specification was expanded in early 2000s with programming abilities and security features to meet the FPGA market demands. It was important for manufacturers to use undocumented commands for granting access to the interface, because in some chips it provided access to the internal memory, usually holding the end user IP and secret data. JTAG, debug port or factory test interface can all potentially be used for scanning.

The JTAG interface is operated via test access port (TAP) pins which control the state machine (Fig. 1). It has two registers – IR (instruction register) and DR (data register) into which the serial data can be shifted and then executed. The IR registers is selected first and then the DR data can be shifted in.

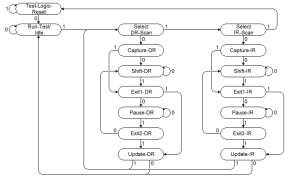


Fig. 1. JTAG TAP state machine

Experimental results

We demonstrated how a deliberately inserted backdoor and additional functionalities can be found in the ‘highly secure’ Actel/Microsemi ProASIC3 Flash FPGA (field-programmable gate array) chip used in both military and sensitive industrial applications.

The JTAG command field was initially scanned for any previously unknown commands by checking the length of the associated DR register (Fig. 2). Some registers were impossible to update with a new data (Fig. 3). All those hidden and non-updatable registers were found to be imprinted into certain locations in FROW memory which is a part of internal Factory settings. As we discovered later, the backdoor allowed writing to all these registers.

We used our own hardware setup for running experiments (Fig. 4). The outstanding sensitivity and performance of our pipeline emission analysis (PEA) method is owed to many factors. One of which is the narrower bandwidth of the analysed signal, another is the low latency that allows real-time analysis. Initially we analysed all the active JTAG commands using power analysis. Fig. 5 shows how AES authentication and Passkey verification traces look, while Fig. 6 shows traces of Array verification and Flash FROM reading commands. That way we were able to find the hidden commands used for backdoor access. Then we used PEA to extract the encryption and access keys to activate the backdoor (Fig. 7).

Alongside this backdoor there is another layer of security in the guise of data permutation to obscure information and make IP extraction less feasible. This can also be dealt with using a simple brute force attack, because permutation functions do not withstand differential cryptanalysis.

Further investigation of the backdoor key operation revealed that it unlocks many of the undocumented functions, including reprogramming of secure memory areas and IP access. There are some other hidden JTAG functions which give low-level control over the internal shadow memories and allow modification of hidden registers. Our experiments showed how some information can be found via systematic testing of device operations. The simplified outlook of the ProASIC3 security is presented in Fig. 8.

Table 1 summarises the security protection levels in the ProASIC3 devices according to our research findings. All security protection levels fall below expectations by not withstanding low-cost non-invasive attacks as we demonstrated.

To our knowledge, this is the first documented case of finding a backdoor inserted in a real world chip. Most silicon chips are now designed and made abroad by third parties. Is there any independent way to evaluate these products that are used in critical systems?

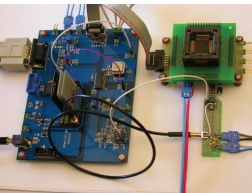


Fig. 4. Prototype board with sensor

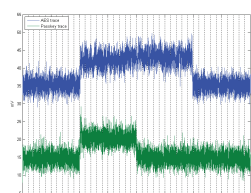


Fig. 5. AES vs Passkey JTAG power traces

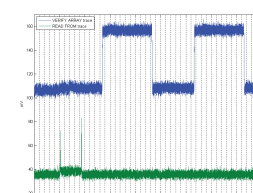


Fig. 6. Array vs FROM power traces

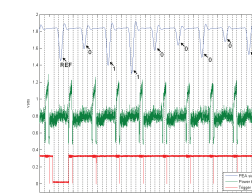


Fig. 7. Scanning for keys

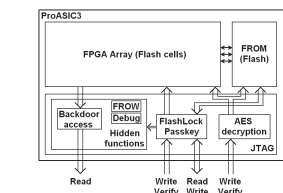


Fig. 8. Simplified ProASIC3 security

S. Skorobogatov, C. Woods: Breakthrough silicon scanning discovers backdoor in military chip. CHES Workshop, Leuven, Belgium, LNCS 7428, Springer, 2012, ISBN 978-3-642-33026-1, pp 23–40 www.cl.cam.ac.uk/~sps32/ 2013-03-22

Computer Laboratory news

Success at the ACM Programming Contest

Congratulations to the three Cambridge teams who excelled at the Northwestern European Regional Contest 2013 (NWERC).

The NWERC is integrated in the ACM International Collegiate Programming Contest and draws students from colleges and universities throughout Belgium, Denmark, Finland, Germany, Great Britain, Iceland, Ireland, Luxembourg, the Netherlands and Sweden.

The Cambridge teams, which included a number of Computer Laboratory students (Boris Grubic, Vlad Alexandru Gavrilă, Bogdan-Cristian Tataroiu, Eduard Kalinichenko and Oleg Oshmyan) came 2nd, 4th and 5th, which means that Cambridge has qualified for the ACM-ICPC world finals in June 2014.



Cambridge students at the award ceremony

Recruitment fair

The Supporters' Club recruitment fair, held on November 21st 2013, was a resounding success.

Fifty-four members attended the event (lack of space prevented more being there), which was held at the Computer Laboratory.

Exhibitors were kept busy all day by droves of students looking for information on both summer internships and graduate positions.



2014 recruitment fair

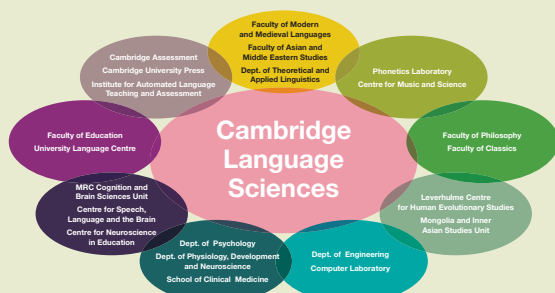
Such is the fair's popularity that companies are already booking for 2014.

If your company is interested in engaging with the Computer Laboratory and looking to recruit the brightest computer science graduates, please contact the Supporters' Club organiser at supporters-club-organiser@cl.cam.ac.uk for further details



Videos of the **Computer Laboratory's 75th anniversary celebrations** are now available on line from the Lab's home page at <http://www.cl.cam.ac.uk>.

Cambridge Computing — The First 75 Years, an extensively illustrated, highly readable and informative account of computing in Cambridge, from Babbage to the present day, is also available for download.

[illegible]

Our research community includes over **150 Principal Investigators**, many considered world experts in their field. The Department of Theoretical and Applied Linguistics is ranked **no.1 in the world** for the study of linguistics (*QS World University Rankings by Subject, 2013*), and linguistics research is undertaken in every faculty and department in the humanities, including Music, Philosophy and Divinity.

The Cambridge Language Sciences Strategic Research Initiative



Cambridge Language Sciences is one of a select number of Strategic Research Initiatives at the University, established in order to build on existing strengths and to tackle research challenges that can only be addressed by multidisciplinary teams of researchers. Our members are drawn from across the University, including Theoretical and Applied Linguistics, the Computer Laboratory, Engineering, Education, Modern and Medieval Languages, Psychology, Philosophy, Asian and Middle Eastern Studies, and Cambridge English Language Assessment. The cross-cutting research themes are *Language Communication and Comprehension*, *Human Language Technologies*, *Language Change and Diversity*, *Language Learning across the Lifespan* and *Cambridge English*.

Early-careers researchers

We have an active programme of workshops, talks and networking events for early-careers researchers to foster an interdisciplinary approach to research and to encourage interaction between departments. One of our goals is to raise funding for interdisciplinary PhD studentships.

We are currently developing **The Language Sciences Interdisciplinary Programme** for MPhil students. This is a framework which will offer shared teaching and supervision of research between departments, with different MPhil “pathways” depending on the background and interests of the individual student. The first phase of the programme is expected to be available from 2014-15.



"I was quite surprised that it was actually a lot easier to collaborate with someone who did not work on the same topic as I did at all – I think because it meant that we had to agree on a very basic and very precise question in order to make sure we were on common ground (rather than getting sidetracked by differences in ideology)."

Jessica Brown, PhD student
(feedback from a language
sciences workshop)

To find out more about Cambridge Language Sciences, please visit our website:

www.languagesciences.cam.ac.uk

If you would like to find out about future events, or you would like to let us know about your own areas of interest, we would like to hear from you. **Please contact the Cambridge Language Sciences Coordinator, Jane Walsh, at jaw75@cam.ac.uk.**

