Newcastle University

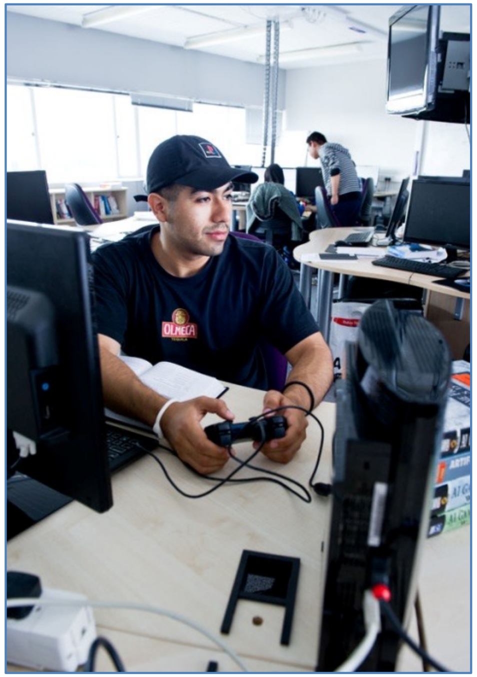
RESEARCH IN COMPUTING SCIENCE

Contact: John.Fitzgerald@ncl.ac.uk

Computing Science at Newcastle

- Founded 1957
- 1957/8 the first undergrad programming courses in the UK.

55 years on …



- ~ 40 faculty, 37 research staff
- ~450 UG, 100 PGT, 110 PhD students

Computing Science at Newcastle

Groups

- □ Biology, Neurosciences & Computing
- □ Concurrent Asynchronous Systems
- □ Dependability
- □ Digital Interaction
- □ Systems

Specialist Centres

- □ Software Reliability
- □ Cybercrime & Computer Security
- □ Digital Institute
- □ Regional e-Science Centre

Computing Science at Newcastle

- 38 live research projects, ~ £4.5M p.a. income
- Tend to be driven from application domains, business and societal challenges
- Wide variety of collaborators and funders
  - Notably EU, SHRC, BBSRC as well as EPSRC
- Some Strengths:
  - Flagship research in Dependable Systems
    - DIRC, Deploy, COMPASS
  - Cybersecurity & Cybercrime (more later!)
  - Digital Interaction & Social Inclusion
    - SiDE, Creative Exchange
  - Scalable Systems
    - E-Science Central etc.
  - Synthetic Biology, Neuroscience

Dependability: themes

Methods and tools for model-based design of Embedded Systems.

The first modelling and analysis framework specifically for "Systems of Systems"

© Bang & Olufsen 2012

Advancing formal verification technology: machine-assisted proof applying Artificial Intelligence to learn from experts.

$inv1: coalition \subseteq \{Bronze, Silver, Gold\}$

$ClearInfoGold(i) \equiv$
$grd1: i \in coal\_known[\{Gold\}]$
$grd2: i \notin cleared$
$act1: cleared := cleared \cup \{i\}$

Usable, machine-assisted Formal Engineering Methods for high assurance systems

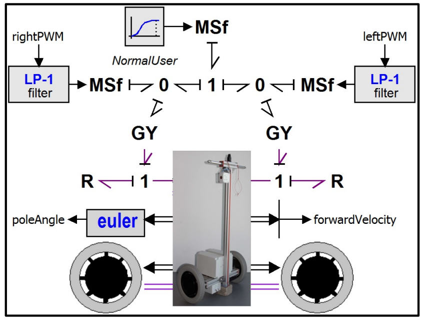
Contact: Alexander.Romanovsky@ncl.ac.uk

Dependability: recent highlights

- Lead EU €18M project on industrial deployment of formal methods: *"… a major contribution towards bridging the gap between formalists and practitioners in software development for dependable systems"* (Michael Jackson)
- Lead EU €8M project advancing the engineering of systems of systems (one of just two such projects in Europe)
- Renewed £0.9M EPSRC "Platform Grant" on Trustworthy Ambient Systems: National recognition of the value and vitality of the team
- Leading £0.5M EPSRC AI4FM project on artificial intelligence for formal methods and £0.4M EPSRC SafeCap project on increasing rail capacity safely
- Major developments in Secure Systems – see later slides!
- Industry engagement: BAESYSTEMS, Bosch, SAP, Siemens, Invensys Rail, Bang & Olufsen, Insiel, Atego
- **Knowledge Transfer** – especially in safety-critical systems – over 200 events and 15000 registrations! Computer Security & Resilience now a degree at BSc, MComp and MSc levels.

Contact: Alexander.Romanovsky@ncl.ac.uk

Trusted Cyber-Physical Systems



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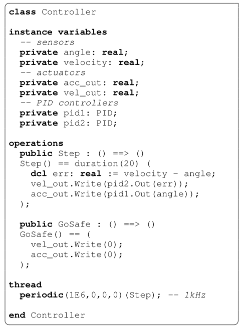
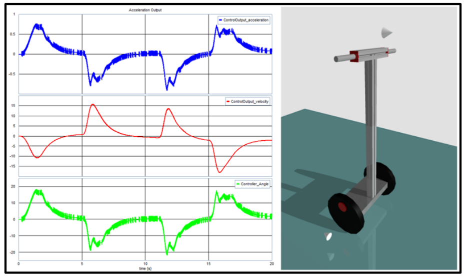


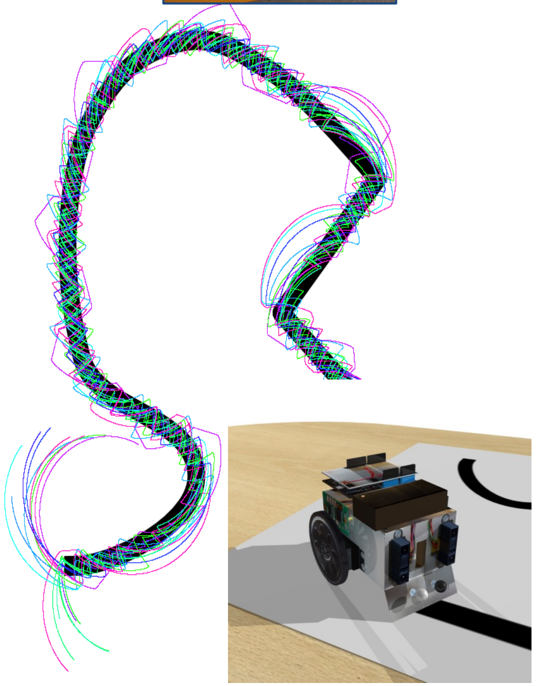
```
class Controller

instance variables
  -- sensors
  private angle: real;
  private velocity: real;
  -- actuators
  private acc_out: real;
  private vel_out: real;
  -- PID controllers
  private pid1: PID;
  private pid2: PID;

operations
  public Step : () ==> ()
  Step() == duration(20) (
    dcl err: real := velocity - angle;
    vel_out.Write(pid2.Out(err));
    acc_out.Write(pid1.Out(angle));
  );

  public GoSafe : () ==> ()
  GoSafe() == (
    vel_out.Write(0);
    acc_out.Write(0);
  );

thread
  periodic(1E6,0,0,0)(Step); -- 1kHz

end Controller
```

⇒



⇒

- □ Tight integrations of networked computing elements with the physical environment
- □ Developed new tools for collaborative modelling and co-simulation (discrete-time models of controllers with continuous-time models of plant)
- □ Support automated design space exploration
- □ Applied in transport, machine design, high-speed paper processing, and (high-speed) baggage handling!



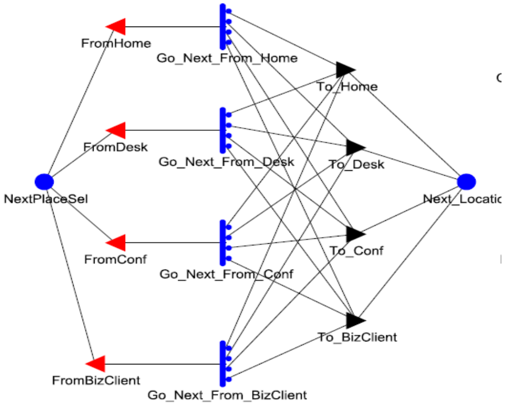
Contact: John.Fitzgerald@ncl.ac.uk

Cybercrime Centre

1. Emulators that find and demonstrate threats to safe contactless payment

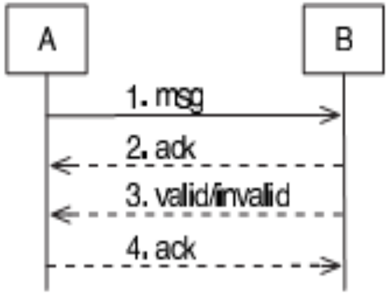
2. Breaking CAPTCHAs of social networking, blog and file hosting sites

3. Tools based on probabilistic modelling to come up with better information security policies



4. Picture 'passwords' that are easy to remember

5. Protocols that guarantee that services and payment are both exchanged and cannot be denied ('non-repudiation protocols')



Contact: Aad.vanMoorsel@ncl.ac.uk

Cybercrime Centre

Science of Security:
better science behind
security policies

- privacy research in £12M Social Inclusion hub
- £1M partner in first GCHQ Cyber Security Research Institute, focused on Science of Security
- €1.5M e-voting ERC starter grant
- coordinator of EPSRC-funded UK Network in Cybercrime
- partner in €10M EU FutureID project on identity theft
- industry and other projects: Hewlett Packard, IBM, Dstl, MoJ
- Interdisciplinary: Law, EE, Psychology, Business, etc

2012/13: we are hiring!
11 researcher posts open soon
at http://cccs.ncl.ac.uk

Contact: Aad.vanMoorsel@ncl.ac.uk

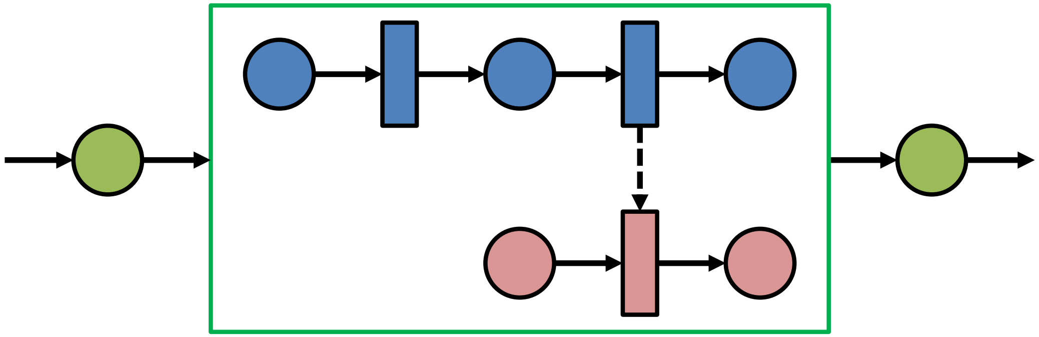
Concurrent Asynchronous Systems

Centre on the development and application of formal methods to modelling and reasoning about concurrent asynchronous systems

- Theory of concurrent computation
- Verification & correctness
- Microelectronics design
- Formal methods for dependability
- System synthesis
- Techniques and tools that directly contribute to creating modern distributed and concurrent systems, both hardware and software ones. Now also biological systems

Contact: Maciej.Koutny@ncl.ac.uk

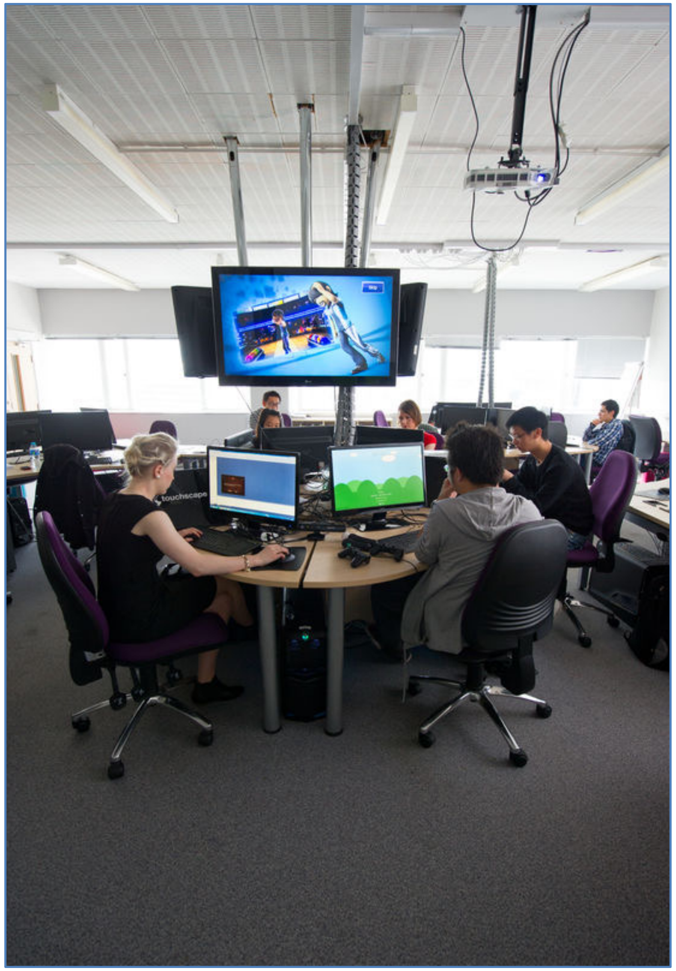
Concurrent Asynchronous Systems



- Petri nets:
  - model checking
  - unfolding
  - synthesis
- relationship between Petri nets and process algebras
- Petri nets and membrane systems
- Applications:
  - verification and synthesis of asynchronous circuits
  - formal techniques for biological networks
  - models and tools for genetic regulatory networks
- Active in the international CAS community. Recent conference organisation: Petri Nets 2011, ACSD 2011, CONCUR 2012, PATMOS 2012, TGC 2012

Contact: Maciej.Koutny@ncl.ac.uk

Game Lab http://research.ncl.ac.uk/game/



Systems Engineering Research for Video Game and Simulation Industries

□ Advancing real-time simulation technologies to solve real-world problems

□ Providing industry with highly skilled individuals who can exploit research to provide practical solutions

□ Research team works in conjunction with an MSc in Computer Game Engineering

□ Tablet, Phone, PC and console platforms including: PS3, PSP, XBox360, Android, IOS.

□ Industry Advisors include: Travellers Tales, Eutechnyx, Media Molecule, Evolution Studios, Ubisoft, NVIDIA, Crytek, CCP Games, Pitbull Studios, Activision, SEGA, Sony

Contact: Graham.Morgan@ncl.ac.uk

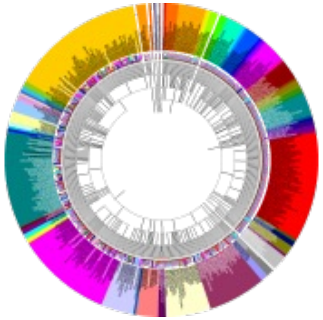
GameLab: some current projects

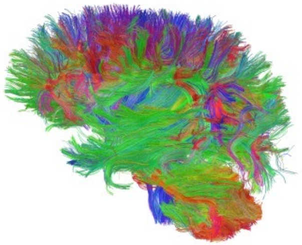
- **Informed Memory Allocators** Working with CCP (makers of EVE) we are developing memory allocators for multi-core environments
- **Rehabilitative Telemedicine** Working with Limbs Alive to develop remote delivery platforms for rehabilitative gaming, and with the UK National Health Service to develop rehabilitative gaming on tablet devices
- **Physics Simulation for Crash test Scenarios** Working with NewRail to develop simulations for rail crash analysis
- **SimEcopolis: An educational game for communicating sustainable urban development** Working with geographers we are creating a tool to aid in understanding urban flooding

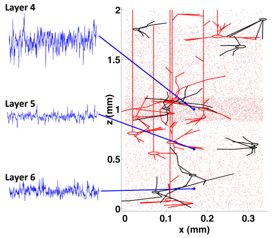
Contact: Graham.Morgan@ncl.ac.uk

Biology, Neuroscience & Computing

- Data integration applied to problems in bioinformatics, systems and synthetic biology
- computational intelligence and network integration applied to the design of synthetic genetic circuits
- research at the interface of computational and clinical neuroscience to better diagnose and treat brain disease
- use of ontological technology in biology, or more generally mechanisms for presenting and publishing scientific information
- understanding of information processing in complex systems, especially the nervous system, complex software systems, protein interaction systems and social interaction systems



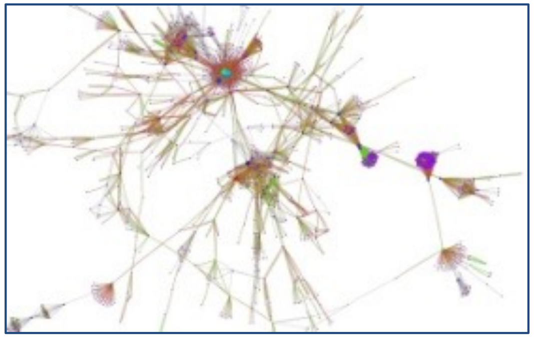




Contact: Anil.Wipat@ncl.ac.uk

Biology, Neuroscience & Computing

- Leading £5M EPSRC project on “An infrastructure for platform technology in synthetic biology
- “Is newer better? - Evaluating the effects of data curation on integrated analyses in *Saccharomyces cerevisiae*” designated an *Integrative Biology* HOT article
- ***Current projects include:***
  - Cloud-based NGS diagnostic pipelines (EPSRC),
  - an integration platform for epigenomic data (BBSRC),
  - Biomarkers for chronic fatigue (MRC),
  - Gut microbiome (EPSRC/GlaxoSmithKline),
  - Semantic data integration approaches for drug repurposing and synergy using Ondex (EPSRC/GlaxoSmithKline),
  - Synthetic bacterial communication systems (EPSRC/NSF),
  - Diagnostic markers for *Clostridium difficile* (EPSRC)



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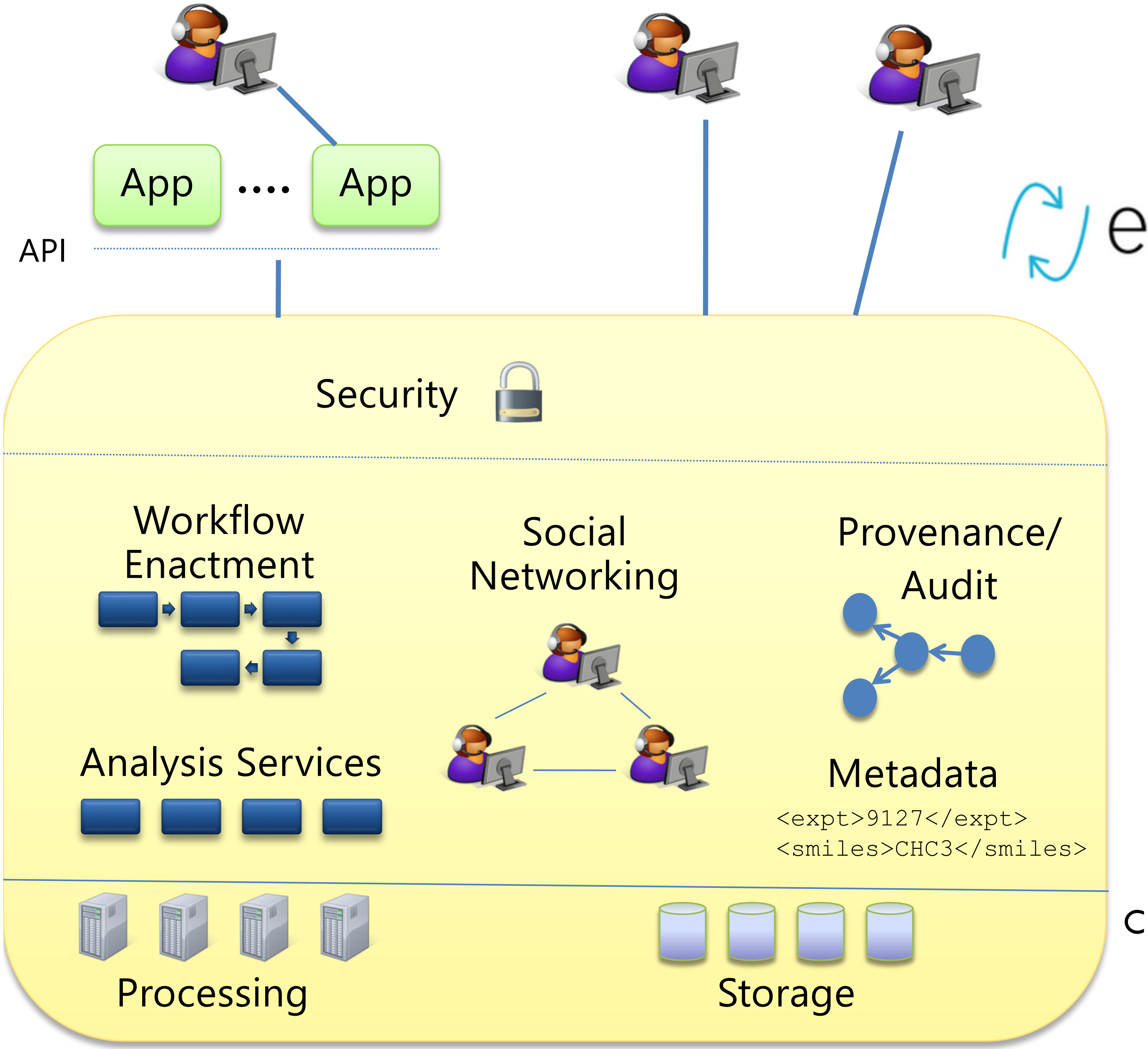
Cloud Computing

- □ Opportunity to revolutionise IT
  - On-demand resources + Pay-as-you–go
- □ But Major Barriers
  - Building Scalable Cloud-based applications
  - Security
  - Governance
- □ Our work to address this:

e-science central

Contact: Paul.Watson@ncl.ac.uk

e-science central



App .... App

API

Security

Workflow Enactment

Social Networking

Provenance/ Audit

Analysis Services

Metadata

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<expt>9127</expt>
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Processing

Storage

Cloud Infrastructure:
Amazon, Azure,
Private Clouds

SiDE

Social inclusion through the digital economy

How can we transform the lives of excluded people using digital technologies?

- 1 in 6 in UK suffer exclusion, e.g.
  - 25% over 65 by 2020
  - 10M disabled
  - growing youth unemployment

- SiDE: $20M Digital Economy Research Hub
  - Funded by UK Research Councils
  - 2009-2014
  - Newcastle & Dundee Universities

www.side.ac.uk

Contact: Paul.Watson@ncl.ac.uk

SiDE

	Activities			
Perspectives	Accessibility	Connected Home & Community	Transport	Creative Industries
Technology				
Society				
Business				
Users				
Design				

InclusiveDesign
ceg torg
Newcastle University Electric Vehicle Driving Laboratory
SiDE
Social inclusion through the digital economy
Digital Economy
Ambient Kitchen

Additional Material

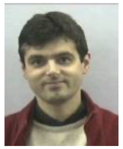
Authenticated Key Exchange (AKE)

- A foundational technology for all communication systems
- We designed two AKE protocols (resist all known attacks)
  - J-PAKE (Hao, Ryan'08): the first password-based AKE protocol based on Zero Knowledge Proofs; adopted by Mozilla Firefox, OpenSSL, OpenSSH and deployed to 450m users
  - YAK (Hao'10): the first PKI-based AKE based on Zero Knowledge Proofs.
- Broke several other people's protocols, including
  - A "totally secure communication system" (feature in Science)
  - A Password based key exchange protocol (in IEEE Standard)
  - A PKI-based key exchange protocol (in IEEE Standard)
- On-going sponsored research
  - EPSRC First Grant, Dr Feng Hao (PI), "Bridging theory and practice in key exchange protocols", 2012-2014.

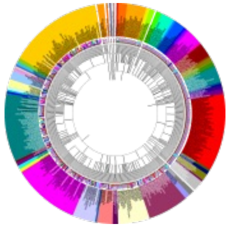
Electronic Voting

- Two broad categories of e-voting (Hao et al, 2010)
  - Decentralized e-voting
  - Centralized e-voting
- Our track records:
  - Open Vote Network (Hao et al,2010): the most efficient decentralized e-voting protocol proposed to date
  - DRE-I (Hao, Kreeger, 2010): the first centralized e-voting that is verifiable without any central authority; an international patent pending.
- On-going research:
  - ERC starting Grant, Dr Feng Hao (PI), “Self-enforcing Electronic Voting,” 1.5 million euros, 2013-2018.

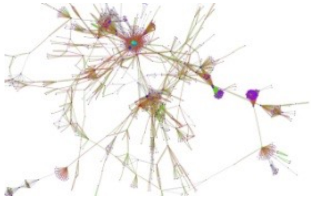
Biology, Neuroscience and Computing



Prof. Anil Wipat (Professor of Integrative Bioinformatics) (http://bio-nexus.ncl.ac.uk/pages/people/Wipat/neil.html)



- **Research**
  - Data integration applied to problems in bioinformatics, systems and synthetic biology
  - Computational approaches to the design and implementation of synthetic biological systems
  - Cloud and Grid based systems for the diagnosis and characterisation of microbial disease
  - Molecular biology of Gram positive bacteria
- ***Recent Highlights:*** Principal Investigator on EPSRC "Flowers Consortium" grant "An infrastructure for platform technology in synthetic biology", £5,007,845
- ***Current projects:*** Cloud-based NGS diagnostic pipelines (EPSRC), ARIES, an integration platform for epigenomic data (BBSRC), Synthetic biology infrastructure (EPSRC), Biomarkers for chronic fatigue (MRC), Gut microbiome (EPSRC/GlaxoSmithKline), Semantic data integration approaches for drug repurposing and synergy using Ondex (EPSRC/GlaxoSmithKline), Synthetic bacterial communication systems (EPSRC/NSF), Diagnostic markers for *Clostridium difficile* (EPSRC)



Dr. Jennifer Hallinan (http://bio-nexus.ncl.ac.uk/pages/people/Hallinan/jen.html)

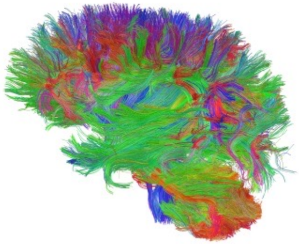
- ***Scope of the work:*** Computational intelligence and network integration applied to the design of synthetic genetic circuits
- ***Recent highlights:***
  - Investigator on EPSRC "Flowers Consortium" grant "An infrastructure for platform technology in synthetic biology", £5,007,845
  - Recent paper "Is newer better? - Evaluating the effects of data curation on integrated analyses in *Saccharomyces cerevisiae*" designated an *Integrative Biology* HOT article
- ***Current projects:***
  - CASE studentship with Microsoft Research, Cambridge on evolutionary algorithms for genetic circuit design
  - Directed evolution, image analysis and automated reasoning applied to microfluidics systems for synthetic biology

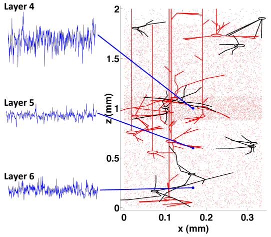
Biology, Neuroscience and Computing

Dr. Marcus Kaiser (http://www.biological-networks.org)

- Research at the interface of computational and clinical neuroscience to better diagnose and treat brain diseases:
- - Simulation and analysis of **brain development in health and disease.**
- - Simulation of **brain rhythms** in human tissue (*in vitro*/*in silico*).
- - Changes for **network diseases** (epilepsy, schizophrenia, and depression.

  Publications: *PLoS Comp Biol* 2006/2011; *PNAS* 2010; *Neuroimage* 2011
- Funding: EPSRC, BBSRC, Wellcome Trust





Dr. Phil Lord (http://homepages.cs.ncl.ac.uk/phillip.lord/)

- use of ontological technology in biology, or more generally mechanisms for presenting and publishing scientific information. I also developed the idea of the Knowledge Blog which has been supported by Ontogenesis Network, and has resulted in the start of a Ontology Encyclopedia. Part of this work recently appeared on the Guardian science blogs.
- worked on a wide variety of projects, including ONDEX which is a data integration framework for systems biology, and the CARMEN project, which is providing support for the sharing and resuse of neurosciences data and early projects such as myGrid and ComparaGRID.

Biology, Neuroscience and Computing

Dr. Peter Andras (http://www.staff.ncl.ac.uk/peter.andras/)

- I am interested in the understanding of information processing in complex systems. My favorite complex system is the nervous system, but I am also interested in complex software systems, protein interaction systems and social interaction systems.
- I try to uncover how such systems organize themselves in order to process information about their complex environment, how information is represented in their processes, and how they generate their actions to gain new information from their environment.