Welsh CS — strengths, weaknesses, and aspirations

Notes for a talk to the Science Advisory Council, 5 July 2012

IT, which we are all familiar with, is not CS. IT is the engineering that underpins almost everything, but CS is the body of scientific knowledge and questions (and challenges) about how to get computation to work well, and what its fundamental limits and capabilities are. For example, psychology is "just" a special case of computer science: what we can think, and how we think, are subject to the laws of computation.

Computing is everywhere, and when it works well it is often completely hidden from view, from ABS (car brakes) to hotel keycards (which use cryptography), pacemakers, mobile phones, the internet, electricity distribution, transport, retail, …

Many people program, but relative to the state of the art in CS, they are ignorant, and sometimes dangerously ignorant. The recent failure of IT systems in banks is a case in point: people thought the problems were trivial (and could be outsourced), yet the underlying challenges of dependability are unsolved and deeply challenging problems. The bank problems starkly show that money cannot buy solutions when we don't understand the problems. (The idea that the bank problems arose because they were saving money is misleading; why were they so ignorant about the difficulties that they thought saving money was acceptable? They confused their CS problems for IT trivia.)

CS is advancing very fast and is impacting, both supporting and intellectually driving, many fields, including scientific fields. To name but one example, quantum physics.

Issues the field recognizes include the under-representation of women in both CS and IT. The rise of computational thinking is showing how CS underpins almost everything — how we think and solve problems, including scientific problems. Knuth has defined science as what we can describe to computers; if you can't program it, your "science" is too vague (computational fluid dynamics, climate models, etc, are cases in point). ***Every scientific meeting should have a computer scientist***!

The high-profile successes like Google and Facebook stop us seeing beyond to the difficulty of computing. The many failures are invisible! And it's tempting to think that, say, Google is "easy" — yet it relies on deep computational issues (imagine eigenvectors of matrices of order a few billion).

In Wales we have some prominent strengths (e.g., the large RIVICS graphics project), but we have very little to show for ourselves. Compared to successful universities elsewhere, I'd say we are competent but lack confidence. We play a zero-sum "Welsh game" rather than play on international fields. We aren't collaborating, and we aren't going for serious funding. Our funding distribution, for example, is very different from (and much weaker pro rata than) successful universities like UCL.

The good news includes activities like the Welsh Crucible, and our efforts to support ECRs.

So, ***everything is a CS problem***.

I then discussed healthcare — the gap between promise and outcomes are very visible.

In the UK, about 70,000 people die each year unnecessarily in hospitals; it is estimated that 10% of this mortality is calculation errors — that is, computer science problems. (One would expect calculation errors to be significantly under-reported.) A routine installation of a computer system in a US hospital more than doubled mortality (see graph).

One of my aspirations is to establish a techealth centre, to address these problems. It would be internationally unique, and build on Swansea's existing strong reputation (such as the recent MRC ehealth award and David Ford's work).

I started with a nice picture of the Shalin Liu Performance Center in Massachusetts, where I had the day before given a keynote at an international dependability conference. I'd like one in Wales. I imagine we'd have an argument about whether it should be in Cardiff or not, and if not where. Well, what we need is not to transplant the Center, but to transplant the economic model, the positive thinking that we can succeed — and apply that to our ways of doing Welsh science.

Please see the *Times Higher* 5 July 2012 article "Lion rampant, sleeping dragon" comparing Scotland and Wales.

Harold Thimbleby — www.harold.thimbleby.net

The wonderful Shalin Liu Performance Center, Rockport MA — where I've just come from talking at

Computer Science

in Wales

1. Experience of Wales CS
2. Strengths & weaknesses
3. Future aspirations

Harold Thimbleby

- Emeritus Gresham Professor of Geometry
- Royal Society Wolfson Research Merit Award Holder
- Leverhulme Trust Senior Research Fellow
- 250 refereed papers; 52 keynotes in 22 countries
- Swansea University, 2005…
- UCL, Psychology & Computer Science

IT v CS

IT use

CS research

Programming

IT skills

Domain knowledge

EXTERNAL BEAM PLANNING: Norm Point Off-axis Distances and Off-axis Ratios for OMP Plans

Name:
ID:
Prep:
Date: 17-Jun-12

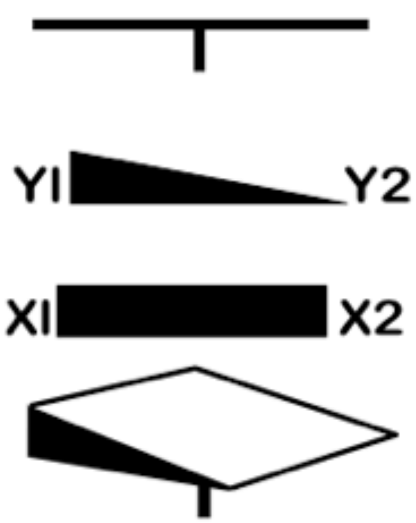
Chkd:
Date:

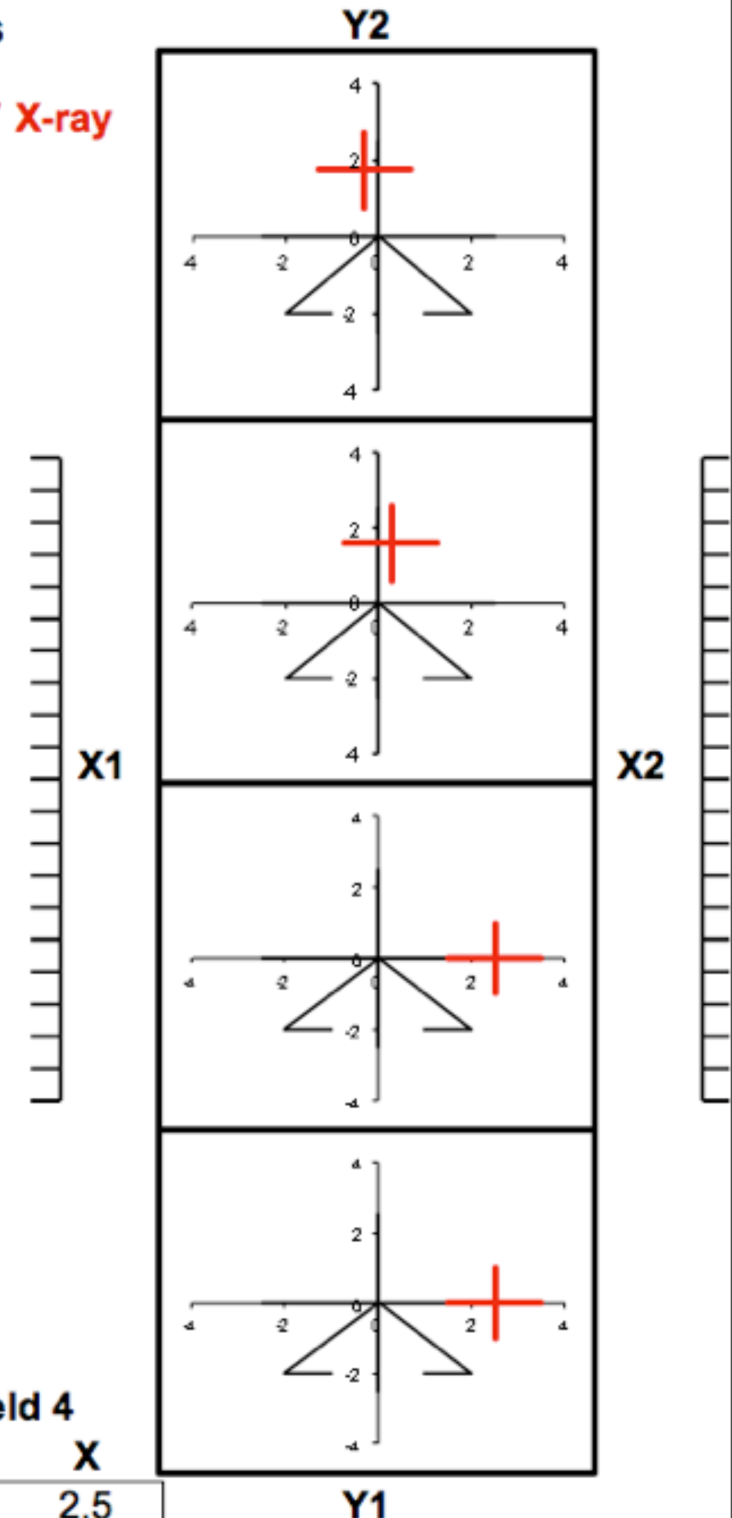
Orientation of Patient:
- HFS Head First Supine
- HFP Head First Prone
- FFS Feet First Prone
- FFP Feet First Prone

Modality: 6MV X-ray

Coordinates of Isocentre:	9.3	-0.3	-1.7	cm
Coordinates of Norm Point:	11.9	-0.3	-5.5	cm

	Field 1	**Field 2**	**Field 3**	**Field 4**	
Gantry Angle:	302	126	0	0	degree
Collimator Angle:	80	280	0	0	degree
Turntable Angle:	0	0	0	0	degree
Norm Point Depth:	5.0	5.0	5.0	5.0	cm
SSD for Norm Point:	99.2	90.7	98.8	98.8	cm
Open OAR_O:	1.018	1.017	1.026	1.026	
Radial Distance:	1.8	1.6	2.5	2.5	cm
In-plane Wedge OAR_{WY}:	1.183	1.168	1.000	1.000	
OAD in Y1-Y2 direction:	1.7	1.6	0.0	0.0	cm
Cross-plane Wedge OAR_{WX}:	1.002	1.002	1.014	1.014	
OAD in X1-X2 direction:	-0.3	0.3	2.5	2.5	cm
Combined Wedge OAR_W:	1.184	1.168	1.014	1.014	
Radial Distance:	1.8	1.6	2.5	2.5	cm





		Field 1		**Field 2**		**Field 3**		**Field 4**	
		Y	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**
Norm Point at Isocentre Level		1.7	-0.3	1.6	0.3	0.0	2.5	0.0	2.5
Off-axis Ratio	**OAR**	1.184	1.018	1.168	1.017	1.014	1.026	1.014	1.026

Microsoft Excel

Problems of acceleration

- Real programmers don’t understand domains
- Domain experts can’t program
- Everyone thinks IT is a consumer product
  “just buy solutions”
- Gap between research and impact is
  deincreasing
- Anyone old enough to be an academic is past it

Unknown ignorance

1. Abstract types
2. Assertions
3. Encapsulation
4. Invariants
5. Model checking
6. Modules
7. Precompiling
8. Refinement
9. Unit tests
10. Virtual machine

Strengths

- Advancing very fast
- Dependability… *for example*
- Pushing unknown boundaries
- High leverage
- Low entry cost
- “Virtual” markets

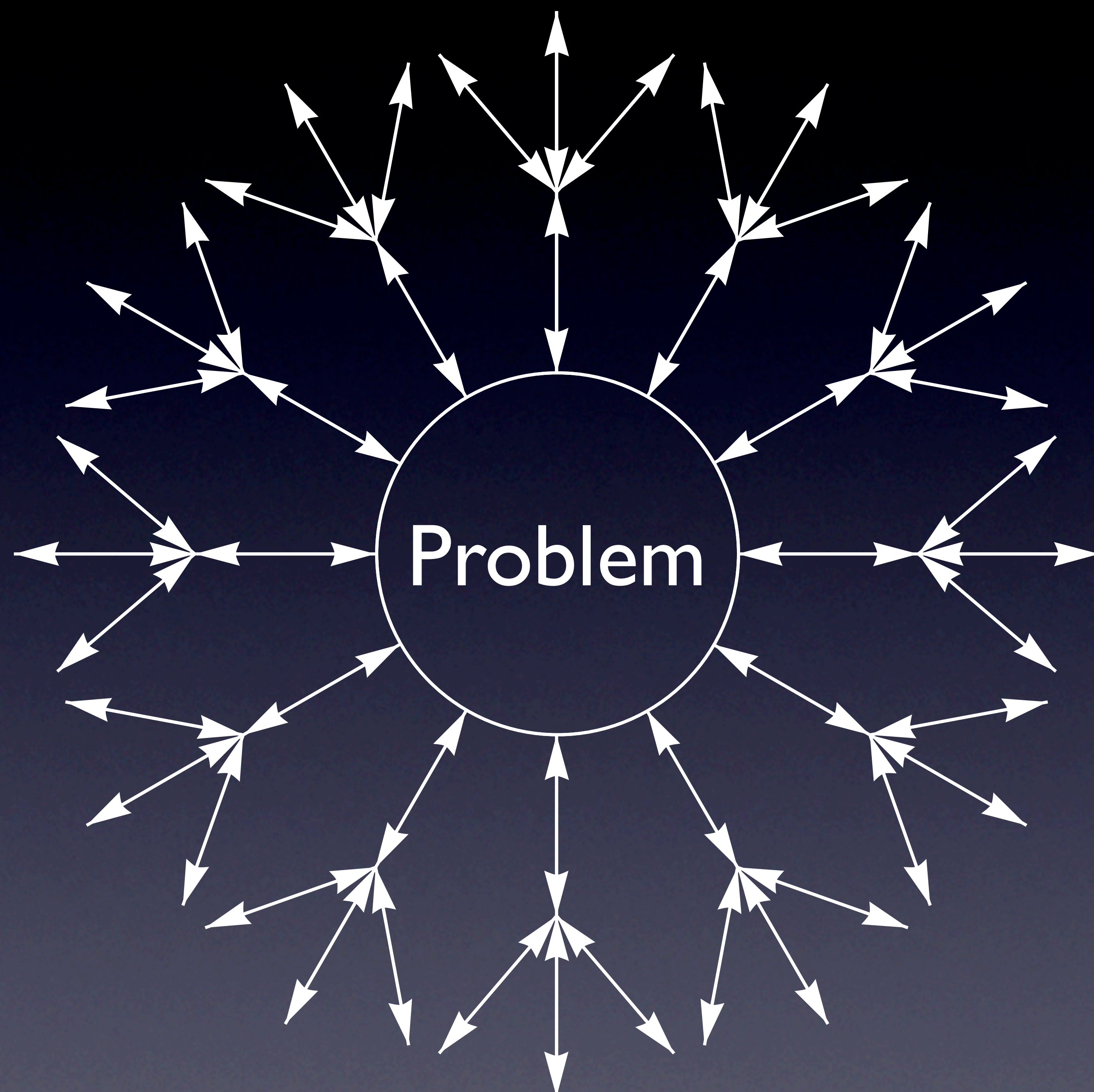
International excitement

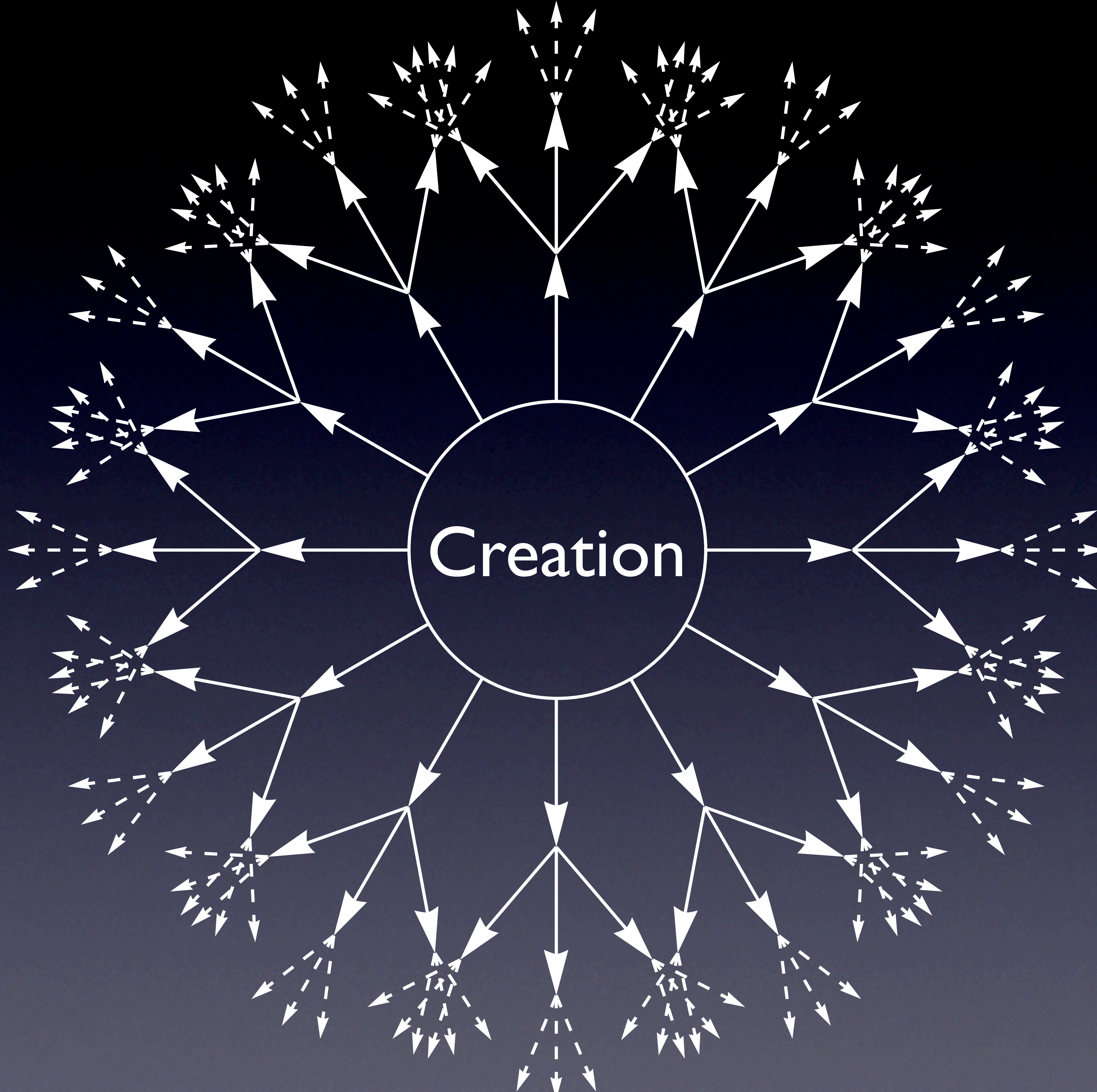
- Computing is universal
- Computational thinking
- School computing
- Women in computing (and STEM)
- CS underpins everything
- Pervasive computing (keycards, ABS…)

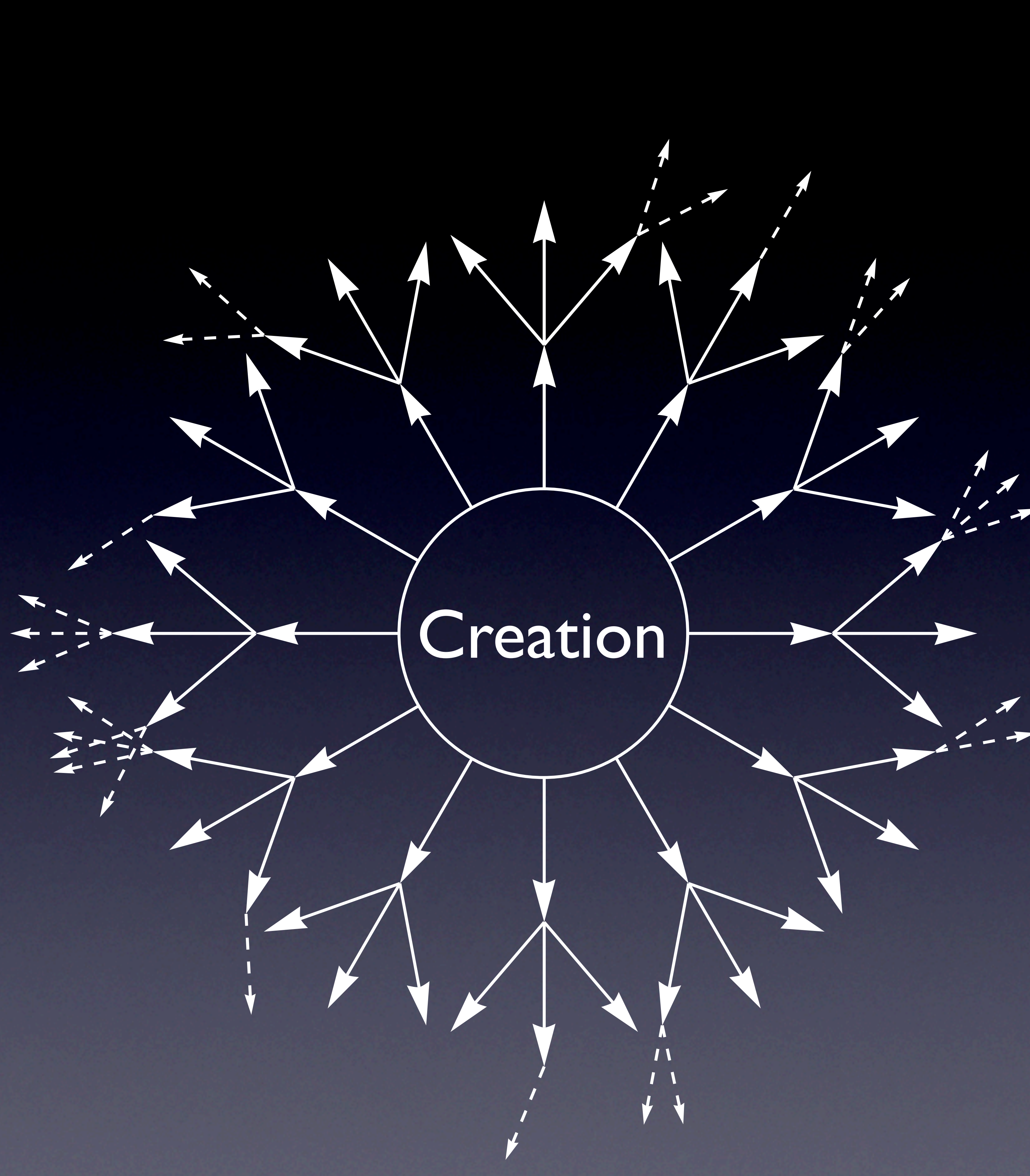
robotics, implants, genetics, cognition, drug discovery, quantum computing, haptics, mobile, …

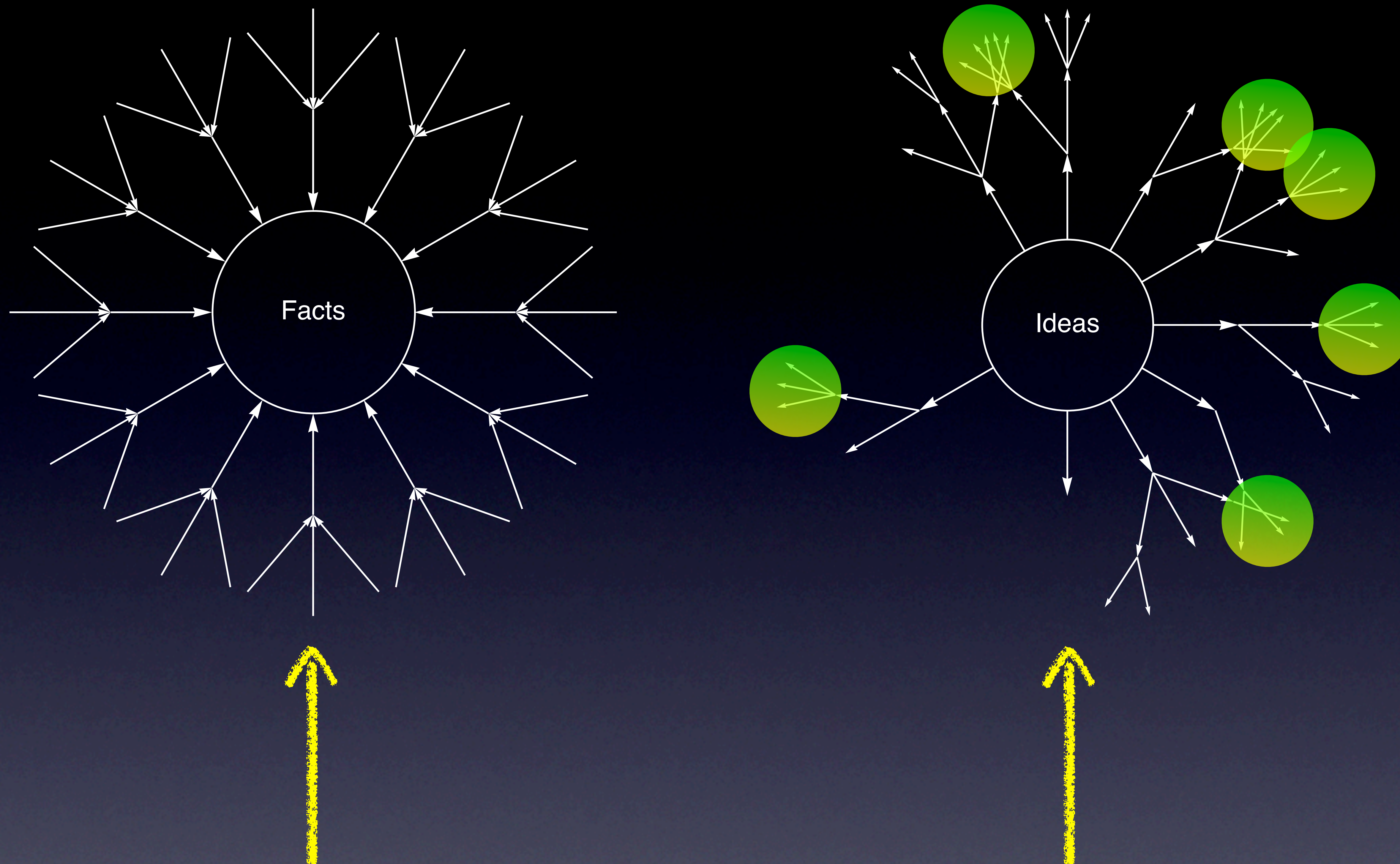
- IT *supports* sciences
- CS *drives* sciences, e.g.,
  - *physics — quantum computing…*
  - *biology — life, genomics…*
  - *chemistry — computational chemistry…*

- IT/CS+business
- IT/CS+manufacturing
- IT/CS+media
- IT/CS+children
- Facebook, Amazon, Google, iPads…


Problem


Creation


Creation



Science
(Kuhn's normal science)

Artificial science
(Herb Simon)

Artificial life
Bioinformatics
Financial computing
Computational intelligence
Software engineering
Geoinformatics
Machine learning
Mobile computing
Cloud computing
eCommerce
etc

Welsh CS strengths

Graphics, RIVIC

~50 people; Aberystwyth, Bangor, Cardiff, Swansea

Technocamps — computers unplugged

~20 people; Aberystwyth, Bangor, Glamorgan, Swansea

Health IT — HPC, CHIRAL

~14 people; Swansea & UCL, MIT, etc

Interdisciplinarity & applications

Zipfian productivity

MIT, Stanford… v X

- Emphasise amazing first year teaching
- Emphasise research connections
- Professional finance
- Student debt *(in multiple senses)*
- Huge alumni/sponsor awareness
- Cash spent on infrastructure, not faculty
- Lots of measurement

UCL v X (2010 data)

- X's proposals 1.1x more likely to be funded
- UCL submits 2.6x more per person
- UCL gets 2.4x the income per grant
- X has few submitters
- UCL income ~20x per academic

implies…

- Not interested
- Not measuring
- Failure feels very visible
- Confidential
- No action…
- Define ourselves by “academic purity” & “status”
  not by “calibrated excellence”

— *cognitive dissonance*

Bad news

- Not the rest of the UK
- Most of it isn’t Cardiff
- Zero sum games
- Low self-esteem
- Not thinking internationally

Good news (examples)

- RIVIC…
- Welsh Crucible
- ECRs — 90+10
- Get a CS person in every Welsh workshop
- *Can only get better*

Everything is an IT/CS problem

- Underpins everything
- Promises everything
- Under-delivers
- Systems are not ***dependable***

NatWest — visible failure
June 2012

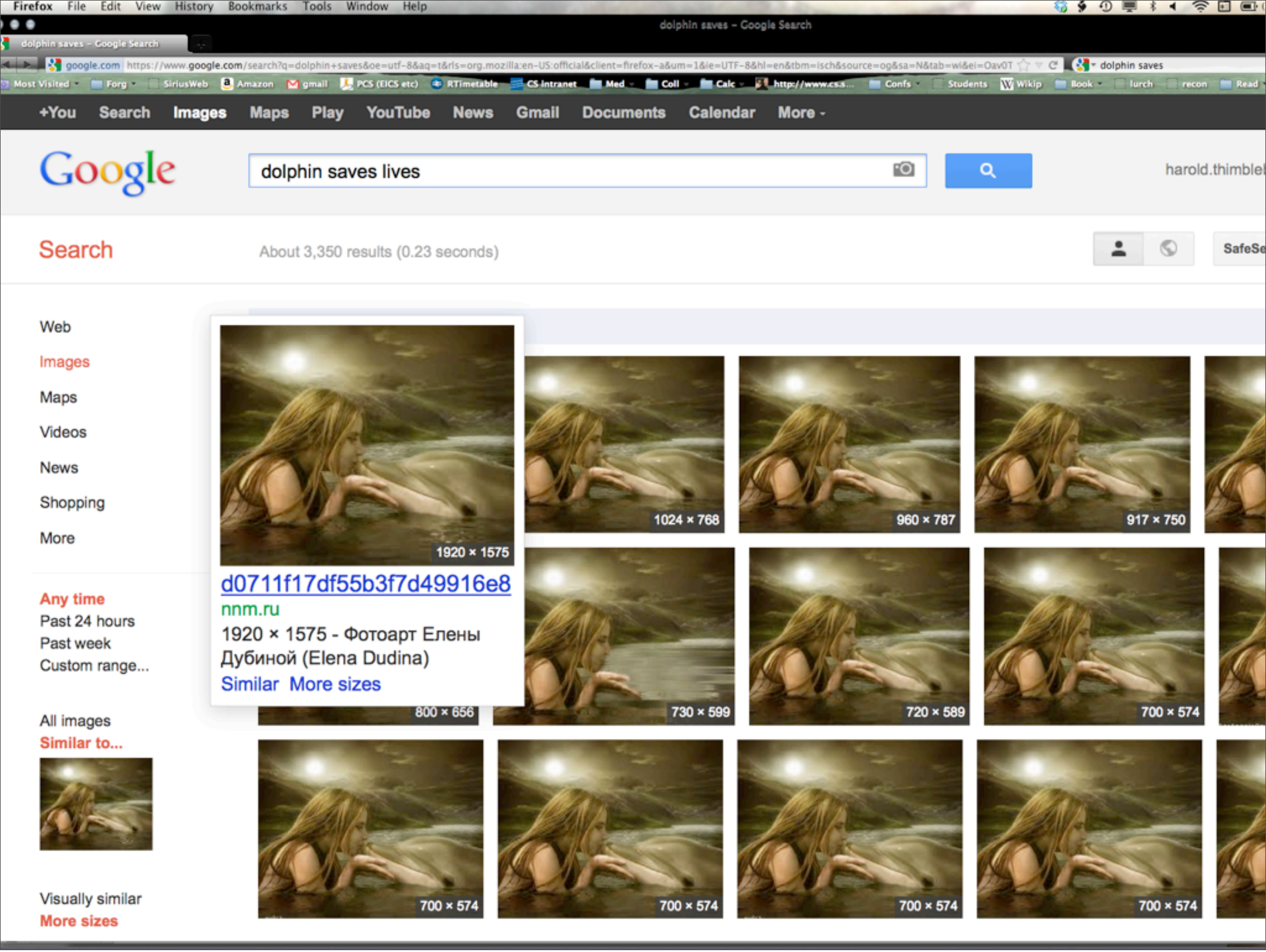
Ignorance

- Everybody over-sells market
- Everybody underestimates fundamental difficulties (*scientific challenges*)
- There are standards, nobody uses them

True or false?

- We are surrounded with successes
  Amazon, Facebook, Google, iPads, ABS…
- Money can buy solutions

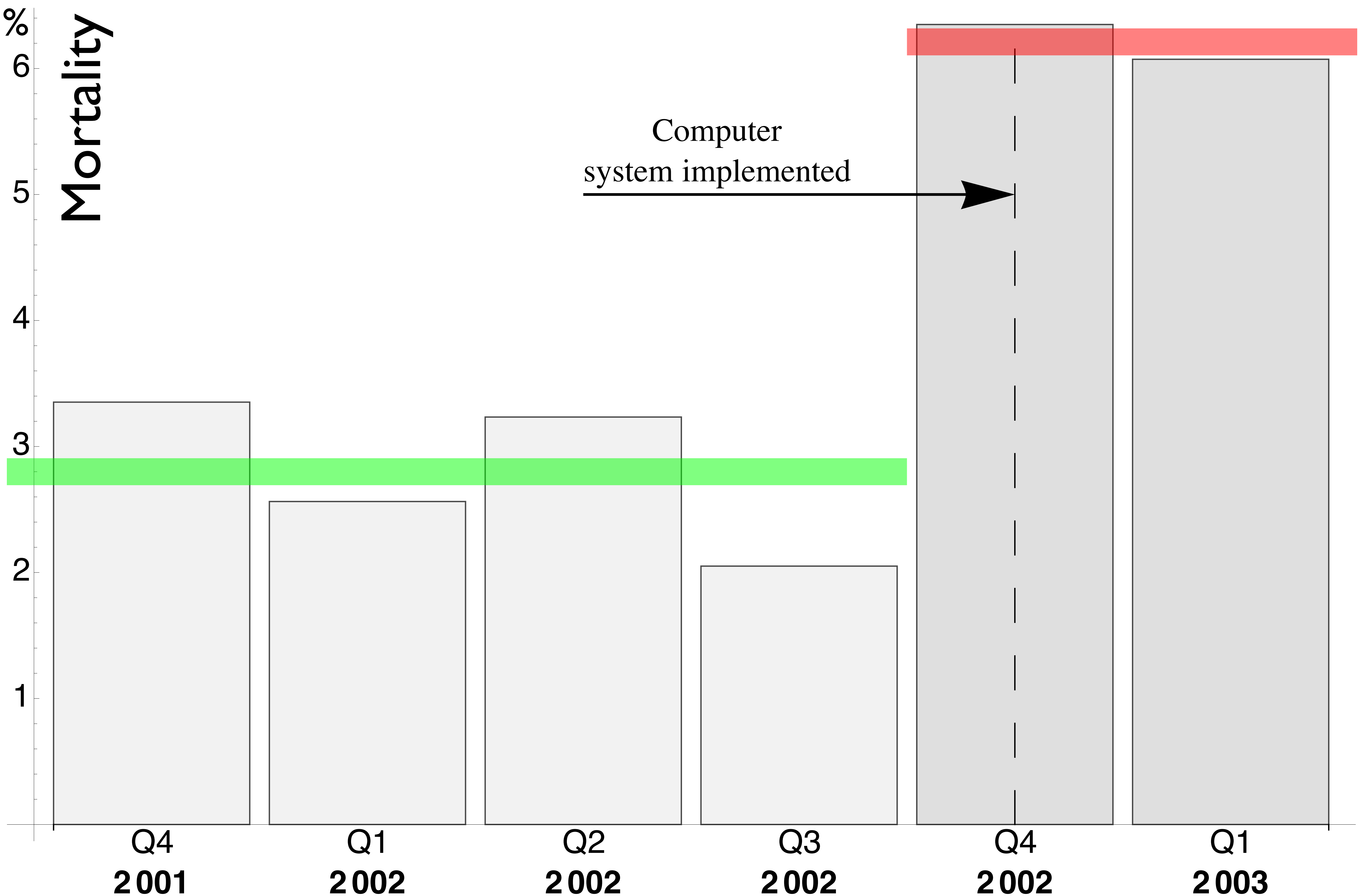
— attribute substitution


Firefox File Edit View History Bookmarks Tools Window Help
dolphin saves – Google Search
google.com
dolphin saves
+You Search Images Maps Play YouTube News Gmail Documents Calendar More
Google
dolphin saves lives
Search
About 3,350 results (0.23 seconds)
Web
Images
Maps
Videos
News
Shopping
More
Any time
Past 24 hours
Past week
Custom range...
All images
Similar to...
Visually similar
More sizes
1920 × 1575
d0711f17df55b3f7d49916e8
nnm.ru
1920 × 1575 - Фотоарт Елены Дубиной (Elena Dudina)
Similar More sizes
1024 × 768
960 × 787
917 × 750
800 × 656
730 × 599
720 × 589
700 × 574
700 × 574
700 × 574
700 × 574
700 × 574

Blindspots

- We can’t see the failures
- Money can’t buy solutions
- That’s why there are so many failures
- We don’t understand the science

Everything is an IT/CS problem


%
Mortality
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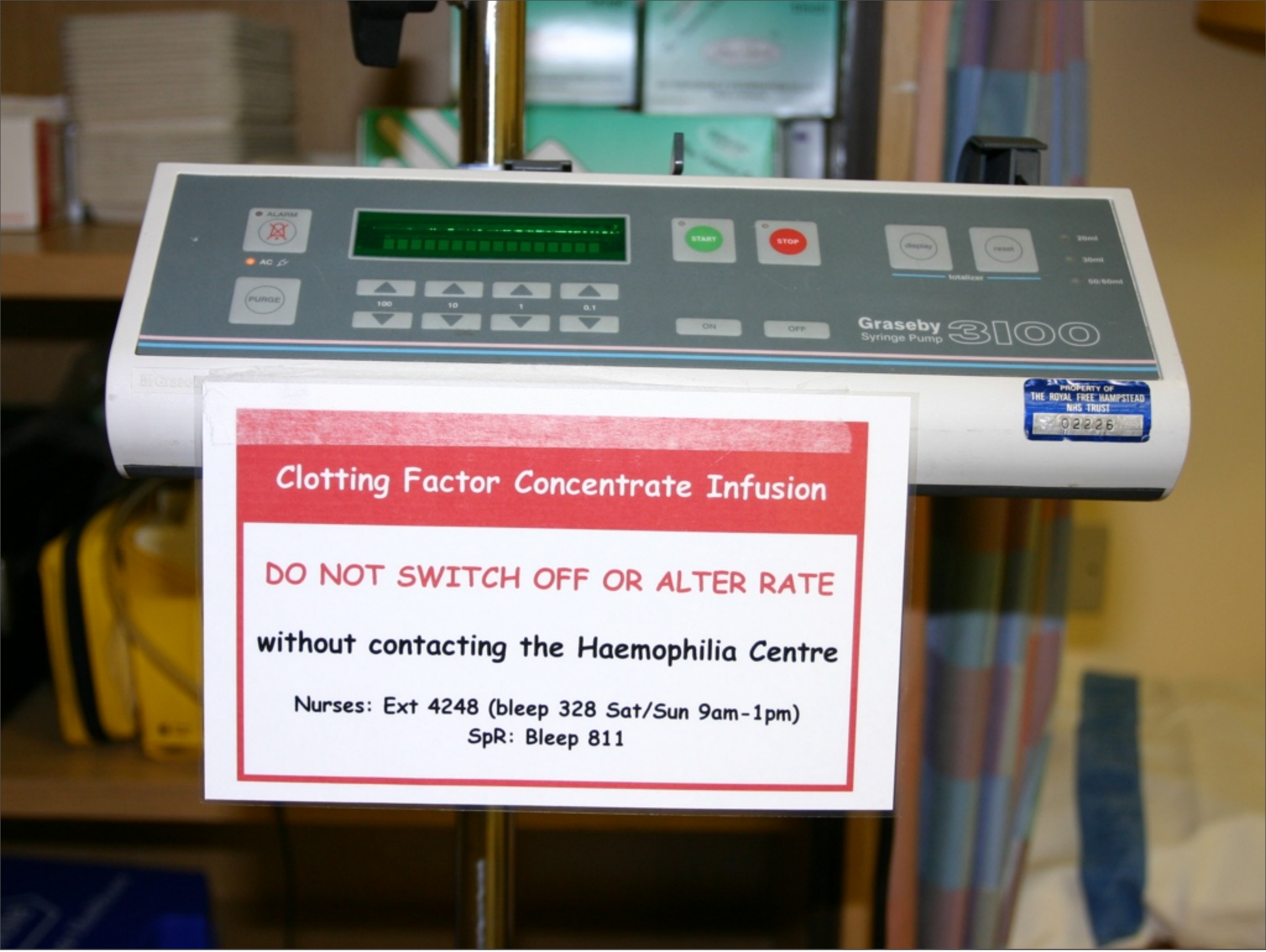
2002
Q1
2003


Clotting Factor Concentrate Infusion
DO NOT SWITCH OFF OR ALTER RATE
without contacting the Haemophilia Centre
Nurses: Ext 4248 (bleep 328 Sat/Sun 9am-1pm)
SpR: Bleep 811
Graseby
Syringe Pump
3100
START
STOP
PURGE
PROPERTY OF
THE ROYAL FREE HAMPSTEAD
NHS TRUST
02226

My aspirations

- High impact, high quality research
- Techealth Centre
- EPRSC fellowship

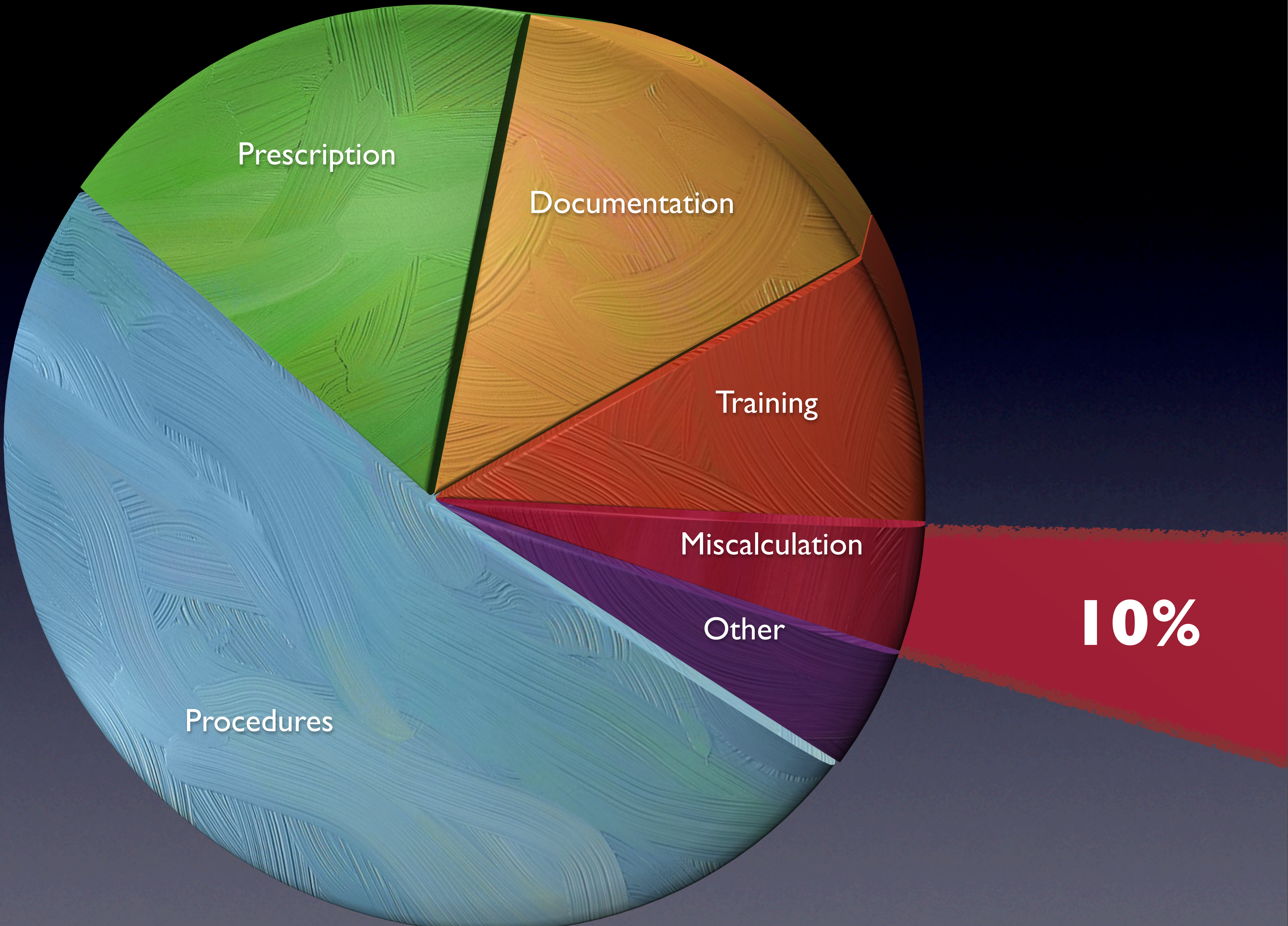
techealth
interaction
centre

UK data per year

- 72,000 preventable deaths
- 200,000 excess injuries
- 2,222 road deaths
- 30 electrical deaths

Top 10 health technology hazards

1. Alarms
2. Radiation
3. Infusion pumps
4. Cross-contamination
5. Device connectivity
6. Line misconnection
7. Fires
8. Sharps injuries
9. Prechecks of anaesthesia
10. Poor usability


Prescription
Documentation
Training
Miscalculation
Other
Procedures
10%


SUNNYVALE
California
6HXX125
VOLKSWAGEN

Analysis of infusion pump error logs and their significance for health care

Paul T Lee, Frankie Thompson and Harold Thimbleby

IT problems cost NHS at least £1,000 per year per pump

Abstract

Infusion therapy is one of the largest practised therapies in any healthcare or[illegible]n, [illegible]d in[illegible] pumps are used to deliv[illegible] millions of in[illegible] in the NHS. The air[illegible]ft indu[illegible] downloads in[illegible] 'b[illegible]xes' to [illegible] better systems and reduce risk; however, the same cannot be said about error logs and data logs from infusion pumps. This study downloaded and analysed a[illegible]ately 36[illegible] h[illegible] of [illegible]sion pump error logs from 13[illegible] infusion pumps [illegible] 2 [illegible]ars in one [illegible] acute hospita[illegible] to [illegible] 20[illegible]9 a[illegible]s; this [illegible] for approximately 5% of total infusion time, costing about £1000 per pump per year. This paper describes many such insights, including numerous technical errors, propensity for certain alarms in clinical conditions, l[illegible] and how [illegible] to an increas[illegible]tions. R[illegible] combined w[illegible] appropriate management of pumps to help identify improved device design, use and application is recommended.

Key words: Infusion pump alarm ■ Error log ■ Incident analysis

Background

Despite individual investigations into healthcare errors and incidents, there is negligible use or review of error logs in the healthcare sector. Staff re-training has often been cited [illegible] to improving healthcare error rates (Johnson [illegible] 20[illegible]). Although device logs can be accessed and downloaded to computers as and when required, this is often reserved for retrospective analysis of specific events rather than assessment of long-term user interaction and improved desi[illegible]. Neve[illegible] the u[illegible]e goal of incident analysis is preve[illegible] is to learn lessons from each event (Bita[illegible] and Nunnally, 2007; Medicines and Healthcare products Regulatory Agency (MHRA), 2010).

Poorly designed devices can lead to confusion, errors and dissatisfaction among health professionals (Dougherty, 2010). Human interaction is now being researched and publications are beginning to surface to help designers, manufacturers and users better understand each other's input to the process (Computer-Human Interaction for Medical Devices (CHI+MED), 2010; National Patient Safety Agency (NPSA), 2010; Thimbleby and Cairns, 2010; Money et al, 2011).

In an effort to help the medical device industry take account of human factors, a range of European standards, design recommendations and research protocols have also

Tuesday, 10 July 12

Healthcare
is an IT/CS problem

JOURNAL OF THE ROYAL SOCIETY Interface

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Reducing number entry errors: solving a widespread, serious problem

Harold Thimbleby[1,*] and Paul Cairns[2]

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[2] *Department of Computer Science, University of York, York YO10 5DD, UK*

Number entry is ubiquitous: it is required in many fields including science, healthcare, education, government, mathematics and finance. People entering numbers are to be expected to make errors, but shockingly few systems make any effort to detect, block or otherwise manage errors. Worse, errors may be ignored but processed in arbitrary ways, with unintended results. A standard class of error (defined in the paper) is an ‘out by 10 error’, which is easily made by miskeying a decimal point or a zero. In safety-critical domains, such as drug delivery, out by 10 errors generally have adverse consequences. Here, we expose the extent of the problem of numeric errors in a very wide range of systems. An analysis of better error management is presented: under reasonable assumptions, we show that the probability of out by 10 errors can be halved by better user interface design. We provide a demonstration user interface to show that the approach is practical.

halve the death rate

> To kill an error is as good a service as, and sometimes even better than, the establishing of a new truth or fact.
>
> (Charles Darwin 1879 [2008], p. 229)

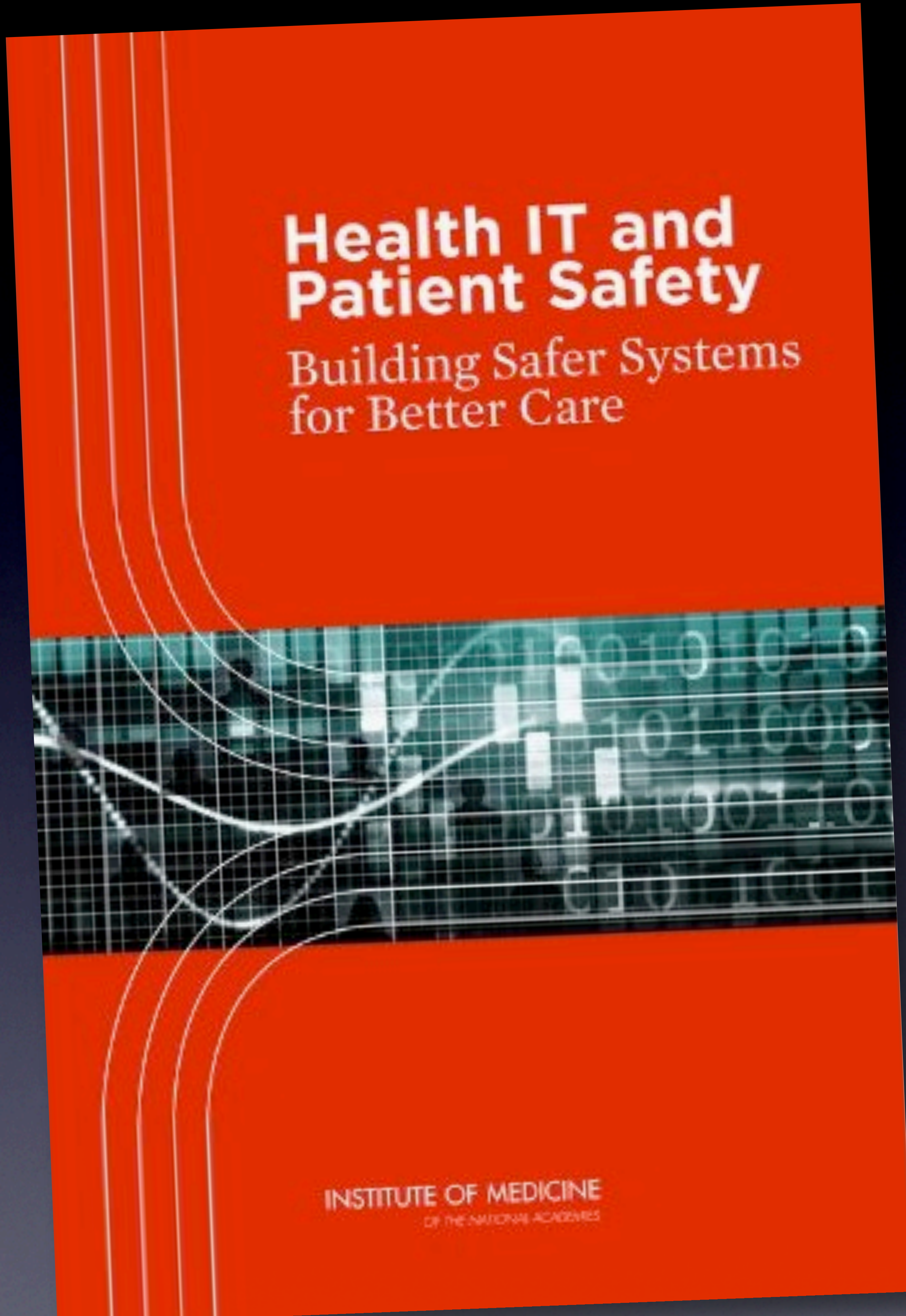
Keywords: number entry; human error; dependable systems; user interfaces

Typical problem

- Infusion pump errors — nobody knows how to do it
- Maths is hard; involves matrices of dimension 10^{10}
- Unsuprisingly, nobody else is doing this
- Our current work is reducing error by x10

Willingness To Pay

- ΔE = Pr(*event*)xPr(*avoid*)xΔQ
- Pr(*number entry death*) = 5×10^{-6} to 3×10^{-5}
- Pr(avoid) = 0.5
- ΔQALY gain = 7
- Δheadroom = £0.30 to £3.20 *per pump*
- 24,500 QALY = **£735M**



National Academies Press (March 2012)

Royal College of Physicians

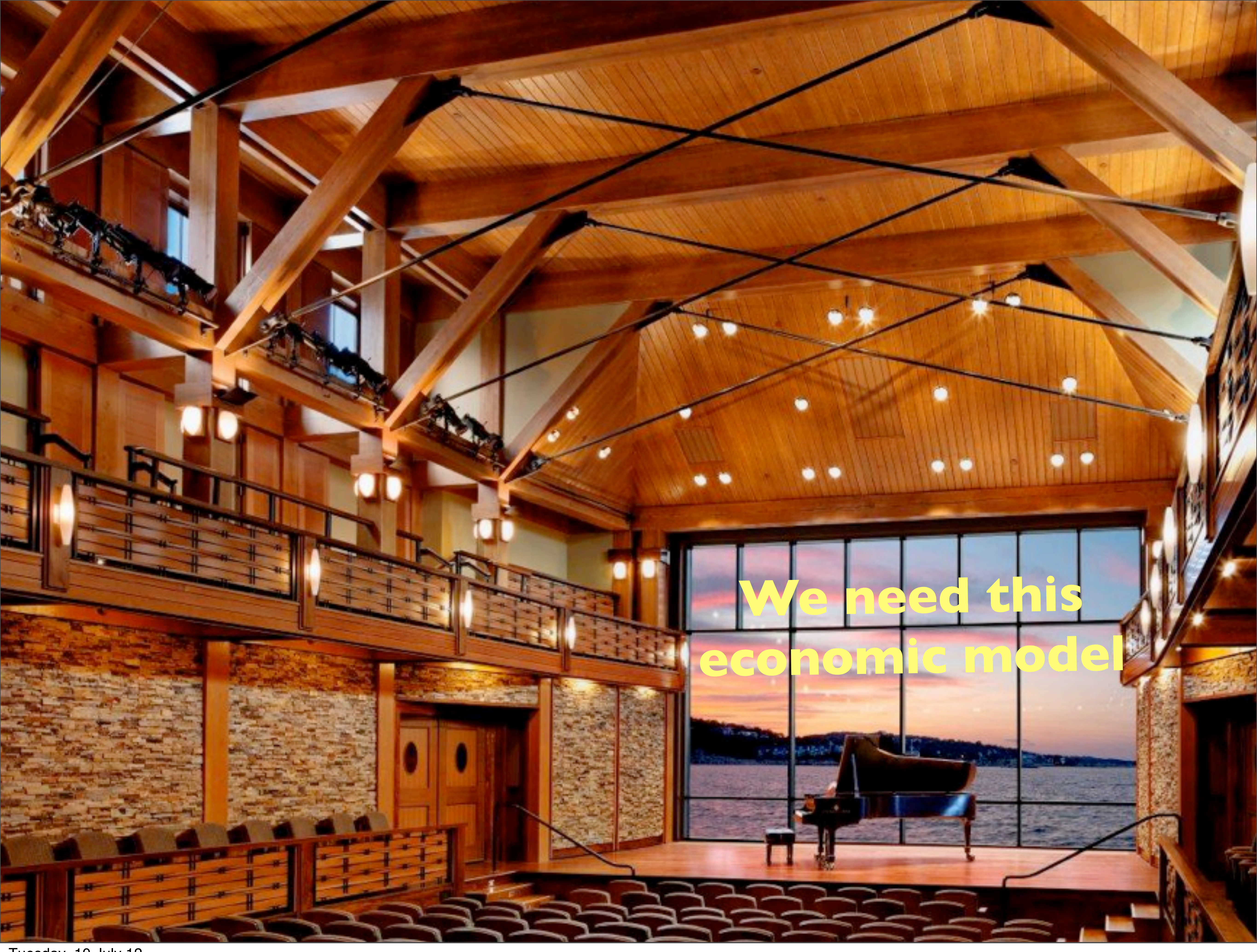
Mother-of-four dies after nurse administers TEN times drug overdose

Mrs Arsula Samson was being treated for pneumonia in the Good Hope Hospital, Birmingham, before she died on 14 March, 2010.

Staff nurse Lisa Sparrow wrongly pumped her with 50mL of prescribed potassium over half an hour instead of over five hours.

Instead of pressing the 10mL per hour button, the nurse admitted to the inquest that she tapped the 100mL per hour button.

techealth
interaction
centre


We need this
economic model

Partial summary

- IT v CS
- Both underpin economy
- There is real science *but it's hard to see*
- No effective Welsh CS community
- REF worries — Benjamin Franklin
- Over-conscious of Wales & Cardiff
- Weak industry links
- Weak community
- Tremendous opportunities
- Dunning-Kruger Effect