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Autonomic Computing - Creating self-Evolving Software Systems

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1. introduction
2. perspective - what am I talking about?
3. evolutionary systems
4. evolution
5. autonomic computing
6. ACCESS

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background

- Durham BSc Computer Science (1992-96)
 - software engineering / AI
- Oxford University MSc in Computation (1996-7)
 - project: intelligent agents for the web
 - parallel close-coupled evolutionary algorithm
- Loughborough PhD 'Immortal Software' (1997-2001)
 - Evolutionary Financial IT project with Schrodgers Bank
- Reading University
 - Research Fellow on DESEL (2001- 02)
 - Lecturer in Computer Science (2002 - 04)
 - First Grant Proposal - ACCESS
- Next - Antalya, Turkey
 - Property developer, property management, sales

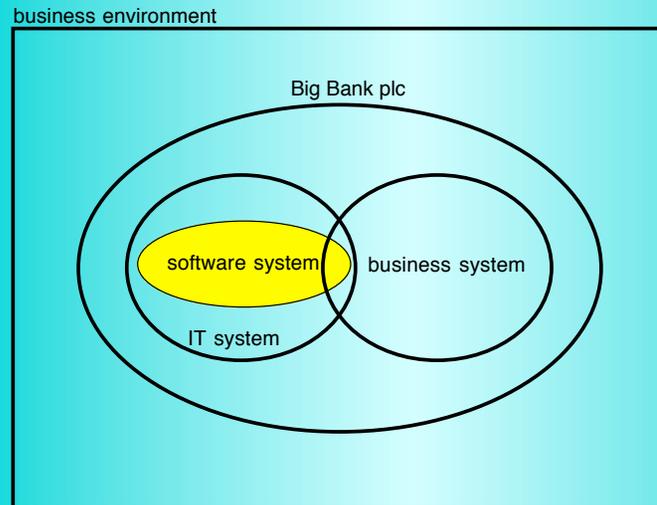
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ACCESS - facts

- Autonomic Computing - Creating self-Evolving Software Systems
- £113 000 grant (TL 300 billion)
 - £4k equipment, £9k travel, £100k for 2 studentsh
- First started October 2003, ends April 2007
- Project personnel:
 - Principal Investigator: Mike Evans
 - Co-Investigator: Rachel Harrison
 - Specification, DSLs: Diana Griffiths
 - Software markets: Tim Putnam

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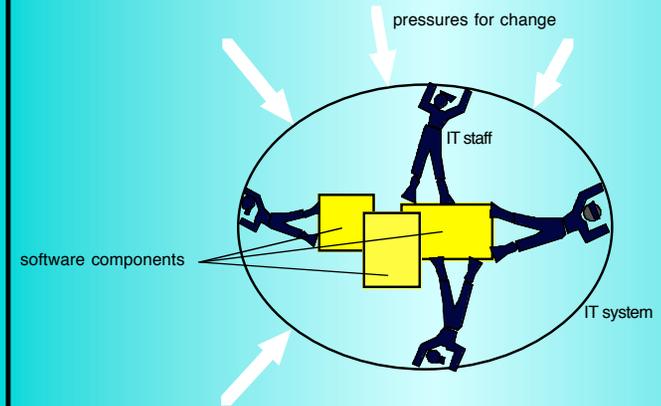
perspective



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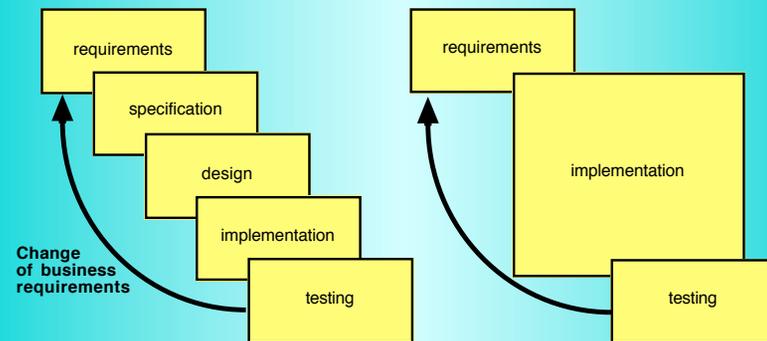
IT System = software + people

IT staff as shock absorbers in an IT system - between the pressures for change and inflexible software



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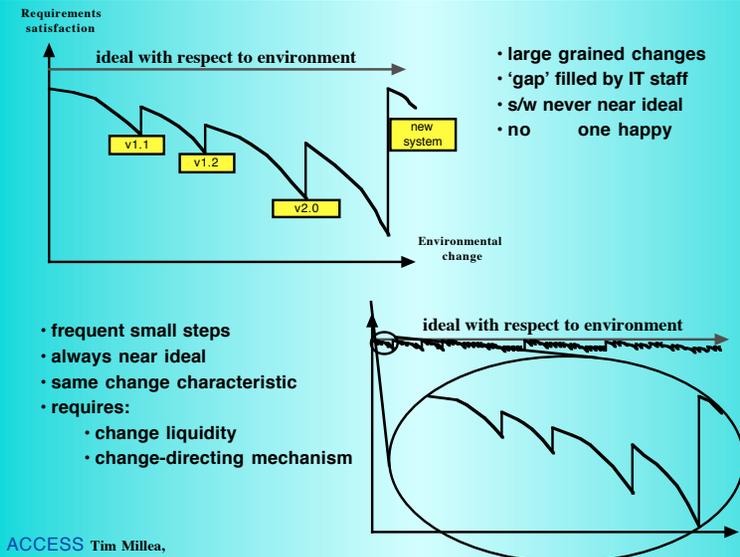
poor feedback



- poor customer-developer feedback loop
- customers and developers live in different worlds

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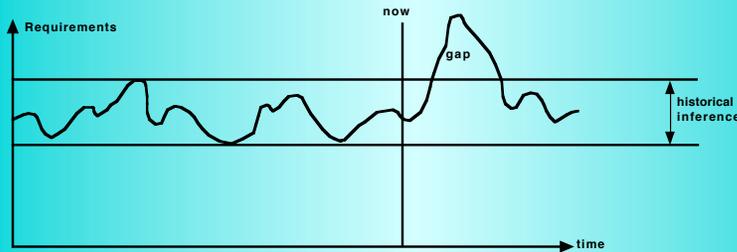
the requirements gap



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building-in flexibility / predicting the future

- historical inference
- use domain knowledge
- build upon static foundations



- structure vs flexibility
- align the structure with the dynamics of the domain

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aligning the dynamics

- hypothesis: every domain has its own set of atomic constants
- e.g. in the financial domain: transaction, debt, equity, sale etc.
- by identifying atomic constants, we infer that everything else in the model may change
- customer constructs system not from programming primitives, but from domain primitives
- graduation from atomic constants to dynamic applications, aligns software & application domain dynamics

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shortening the feedback loop

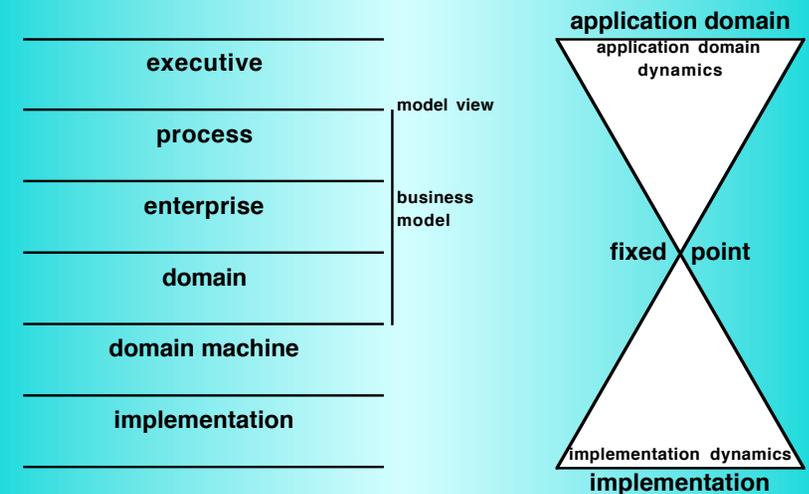
- raise level of system construction towards customer by automating development stages

Life cycle stage	Paradigm	Example
requirements	evolutionary	evolutionary algorithm
specification	semantic	executable model
design	component	component library
implementation	program	C, Pascal

- end user/customer becomes agent of change
- longer term ideal would be automatic evolution from requirements

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layered model of evolutionary systems



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alternatively - software market failures

- software evolution problems due to inefficient allocation of resource
- lack of regulation has led to:
 - 'software pushers' getting users hooked
 - forced upgrades
 - tied products
- regulation should provide
 - open standards
 - compatible OS and application frameworks
 - better competition
 - licenses meaningful to the user (eg. service standard & duration)
 - protection against upgrade coercion

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evolvability - the 3 Fs

Flexibility

- ability to change
- dimensions of change
- 'solution space'

Feedback

- directing change
- environmental interaction

Formality

- the 'rule book'
- maintaining correctness
- meta-structure
- limiting scope

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defining evolution

defn. evolution :

a process of feedback-driven (beneficial) change

$$E(s) \Leftrightarrow s_t = f(s_{t-1}, e_{t-1})$$

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why self-Evolving Software Systems?

- **no. of computers growing approx 40% p.a**
- **average complexity increasing**
- **managing it is currently a human activity**
- **labour demand outstrips supply**
- **forecast 200M skilled personnel required within 10 years**

UK e-Science autonomic computing research agenda

- **self-organising adaptive systems**
- **managed through specified policies and agreements between system stakeholders**
- **interoperability across domains**

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Autonomic Computing

autonomic - self-regulating functioning of central nervous system, e.g. heart beat rate, pupil dilation, perspiration, adjusted according to changing conditions and without conscious thought. By analogy,

autonomic computing systems:

- self-regulate
- self-maintain
- respond to changing requirements
- provide optimal service
- without end-user intervention.

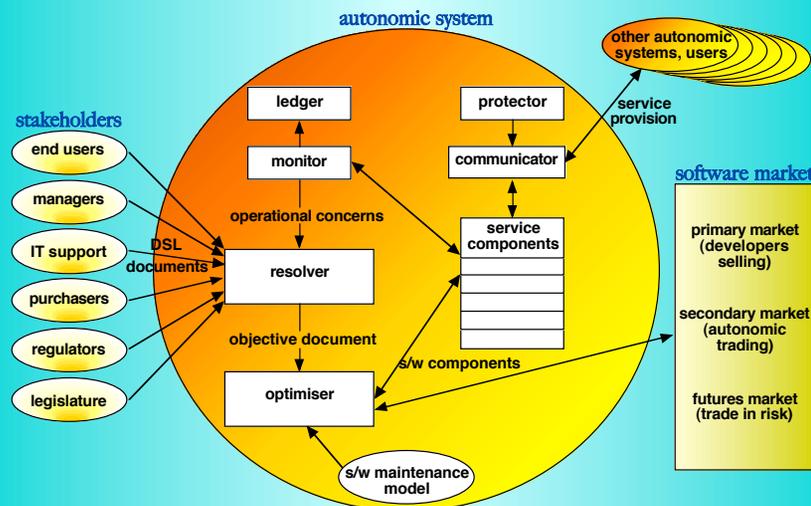
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IBM's 8 elements of autonomic computing

1. 'self-aware'
2. self (re)configuring
3. self-optimising
4. self-repairing
5. self-protecting
6. self-adapting
7. operate in heterogeneous world
8. hide internal complexity

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deliverables

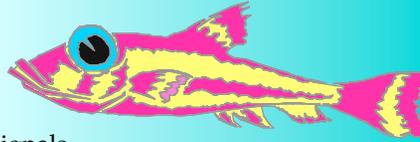
- Family of DSLs
- Domain calculus
- Tool to support the rapid generation of DSLs from domain calculus expressions.
- Theory of resolution and its application to deal with inconsistencies, uncertainties and compromise in expressed concerns.
- A model and implementation of a resource-efficient software market extending the service-oriented approach to machine trading.
- Evolutionary algorithm to optimise with respect to a set of resolved system concerns and the software market.
- Published output proving that we have created self-evolving software

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The Babel Fish

“The oddest thing in the Universe”

- Feeds on brainwave energy
- Excretes a telepathic matrix
- Combines thought & speech nerve signals
- Practically:
 - Stick one in your ear to understand any form of language
- “Nothing so mindbogglingly useful could have evolved purely by chance”



[From Hitch-Hikers Guide to the Galaxy”, Douglas Adams, 1979]

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summary

- **background**
 - Durham to Reading, evolutionary algorithms to autonomic computing
- **perspective**
 - software, people, feedback, inflexibility, requirements gap
- **evolutionary systems**
 - layered & ‘egg timer’ models
- **evolution**
 - the ‘3 Fs’, definition and equation - $\mathbf{E}(s) \leftrightarrow s_t = f(s_{t-1}, e_{t-1})$
- **autonomic computing**
 - meaning, research agenda
- **ACCESS**
 - TL 300 billion 3 year project started Oct 2003
 - funding for two PhD students and blue-sky conferences

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