

# Meltdown

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**Abstract.** One grand challenge in computer science concerns the development of unusual and non-classical approaches to computation and the development of computer systems. One branch of computer science is looking to biology for inspiration in the construction of computer systems. The development of biological systems uses a very different approach to computer machines. Networks of dynamic interactions drive the development of the organism. The DNA encodes not a blueprint for a fixed, static structure, but a dynamic, constantly changing structure which results in a changing structure. The challenge is to develop an equivalent computer system development approach. This science fiction prototype uses a story to highlight the contrast between traditional computing and an as-yet undefined approach modelled on developmental biology. The story describes how a new type of computing based on developmental biology and molecular genetics enables creatures to be made which exist in computerised ecosystems and are able to move through traditional systems correcting problems. The complexity of traditional systems in a hospital is such that information degrades and a 'meltdown' occurs. It is the IT manager's connection with a firm called 'Individuality' that results in the rescue of the hospital's systems. The story also speculates on the potential for emergent behaviour that might occur in an information environment whose complexity threatens to exceed our ability to understand and manage it.

**Keywords:** Information complexity, Bio-inspired computing, health systems, science fiction prototyping.

## Introduction

The entire information and communication technology edifice which supports modern society is built on a simple architecture of computing proposed by Von Neumann in the late 1950s. Microprocessors carry out instructions in a linear fashion which are concerned only with manipulating arrays of bits and moving the results around in registers. The power of computers lies in their ability to carry out such processes not only with repetitiveness but with an unimaginable speed of billions of instructions per second even in the most basic home computer.

It is this speed of processing which enables ICT (Information and Communication Technology) to create an illusion of movement, speed, interactivity and intelligence, in the same way as 25 frames per second creates the illusion of reality on the cinema screen. Hence all the intelligence we see in ICT is generated by machines that manipulate bits. But such an approach has its limitations. Every action of the machine must be programmed and tested laboriously. And if conditions change, the only adaptability comes from the anticipation of changes expressed in case conditions or if-

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then-else statements. Such a model of computing is brittle, likely to break down on a global scale, unable to cope with the increase complexity of information and communication. This is the old computing.

And yet it is not how nature works. Sentient systems in nature are built of from dynamic networks, Organisms are built up from developmental programs in the DNA which define not the final structure (if there ever is a final structure) but the developmental pathways which result in that structure over a period of time.

This story is about the contrast between the brittle computing which we depend on and a new computing modeled on biology which supports evolving compute-based organisms which, while all being of a particular species, are individuals in themselves and have a characteristic individuality. Human beings are all of the same species, with similar structure, but are all individual. We all have different noses. A nose is a nose, performing the same structural function, but our noses are all identifiably different. Contrast this with computer machines where individuality cannot extend beyond the programming of tailored interfaces.

The story is narrated by John, the Information Director for a large UK acute hospital who faces the loss of key computer systems in the hospital and seeks a solution from Peter, who runs an alternative computing company. In this story, the old style computing with which John is involved is contrasted with the new, naturally based computing championed by the enigmatic character, Peter and his Individuality company.

## 1. Background

In 2002, a workshop on the Biological Framings of Problems in Computing at the Santa Fe Institute for Complexity Sciences, led by Richard P. Gabriel, examined the limitations of computing systems. Current systems are brittle, need much maintenance. It was recognised that current computer systems have a uniform lack of resistance to virus exposure. All computer systems of the same type are open to the same virus attack. They provide no new solutions to problems. All computer systems solve a problem in the same way. There is an easy spread of errors. If one computer system is wrong, then all computer systems which conform to the design parameters of that computer will also be wrong, since current computers cannot easily cope with errors. Computer science research has focused on program proving and eliminating mistakes.

Biological systems work differently. In cells mistakes are assumed, and errors are corrected when they occur and defective cellular products broken down. Furthermore, developmental controls work at many levels. Homeotic genes switch on large number of genes in networks which enable the development of large structures such as legs or the segments of an insect. These ideas suggest alternative approaches to computing in which large structures could be controlled within a network (1,2)

A further study contrasted the individuality of biological cells with the uniformity of machine-based systems (3,4)

The application of biological approaches or metaphors to computing will go beyond neural networks and genetic algorithms. Current research uses an agent-based approach. For example, the Cosmos approach generates a pool of alternatives and then selects from that pool (5) Rather than the random generation of alternatives from a pool an approach can be envisaged in which the system is designed as a dynamic network of interactions, as suggested by, for example, the development of sea urchin

embryos. The resulting networked development process would be more resilient and adaptable. The network structure would offer some 'springiness and give', rather than immediately breaking. Furthermore, slight changes made in the dynamic developing network will enable variations to be quickly generated while retaining the prime structure and function.

The problem is that such an approach involves designing and developing a system of immense complexity. This could be done using existing supercomputers to support the process.

The development of the creatures that Peter creates would require an approach which can deal with the complexity of a dynamically growing system. However this might be done, it is clear that an understanding of molecular biology and developmental biology suggests very different ways of building and maintaining systems. The possibilities for computing based on a biological framing are only increased as we gain more knowledge of genomes through their complete sequencing and understand more of the complex control systems that operate in cells.

The story below suggests that there may be an alternative approach to developing computer system which remains unexplored.

## 2. Meltdown

### Phase 1

They call it an information meltdown. Heat and light is generated as my mobile is flooded with irate messages from everyone, the chief executive fuming, the finance director simmering and even the cleaner worrying about a sudden absence of rotas and no access to quality assurance. But that is really nothing as the chaos spreads, and the consequences cease to be administrative. Any technological safeguards fail, and options are reduced to the electronic equivalent of pouring water on the stricken servers from helicopters.

I sense it on Friday afternoon. Reports of a couple of missing patient records and a few wrong diagnoses. Nothing that we couldn't deal with. Locate the record in backup and restore. But I feel a slight unease, having requested the records and left that to the night shift, I do not feel completely happy about going home.

And there was Sarah, nine months pregnant. It feels like twenty and the desire for relief and delivery spreads to me. The torrent of information, ideas about birth and birthing pools and hospital facilities swims against the current of technical material that heats up my mind. And I've not told her of my Dad's state, nor the friends invited over for Friday drinks.

I sit on the hospital bus, pocket my badge and hope that I can remain unrecognised. It is surprising how often staff I've never met want to talk to the Information Director. Usually to complain bitterly about the domination of computer systems in their lives, the sense of loss of control which is elicited by the screens that control every minor function in the hospital.

Sarah's greeting is muted. I put it down to tiredness and the strain of the load she is carrying. She wants to tell me about the information she's found out about the pools, the positions. I want to tell her about the nagging suspicion I have about hospital information provision. But I don't. The mere thought of the explanation needed defeats me. And then there's the unplanned supper. And the need to talk about the neighbours

and the problems with trees and drains. And the half-finished baby's room. Carrie has had her baby. Joanna is under observation because of her diabetes. Weight loss would help. You would have difficulty knowing whether she was pregnant or whether it was just fat. A discourse on nappies and nappy buckets. What her green friends have told her. Sources of non-allergenic wipes.

"Will you shut-up?"

My mind blocks it out. But I've spoken.

Sarah looks at me. Shock cascades to anger. Her blonde hair appears a fiery red. She shrieks at me between the tears and flashes of anger.

"Aren't you interested?"

"Of course I am"

"You don't sound it".

"I know"

"You know do you? So it's deliberate."

"Yes, I mean no."

"Are you arguing again?"

"No. Sorry. I'm just overloaded. Too much to think about. Work is difficult"

"Am I supposed to care?"

"I guess not"

"You realised this is bad for the baby"

"Sorry, yes. I'll get fish and chips"

"I don't want fish and chips"

I wander out. The skies are clear, A sharp fox dashes across the road and then stops to sniff the verge. Two cars streak past. Orion is clearly visible in the sky. Cassiopeia, Taurus. The major stars are summaries of the billions of stars multiplied by billions of galaxies. I have information overload above me. All I want is a blank slate, an island of calm. But even the walls and the trees are concentrations of information and patterns. There's no escape. I cancel Friday drinks.

## Phase 2

I'm called on Sunday afternoon. The problems with PAS are spreading and some orders from the wards are not getting through. I leave a note for Sarah. She's sleeping. The hospital is in its Sunday best. Calm blue skies. Bustling news shop. Families parading in with flowers to visit relatives at the best time of day. Downstairs, the computer rooms and IT offices occupy a former delivery suite. The floors are skid-proof and the gas lines still in place. Laughing gas would be a happy addition to the office. Could never persuade the technicians to reconnect it.

I examine the log from the helpdesk. An increasing number of corrupted patient records. I can see where the failure of order comms starts. I can't understand why. .

"It looks like some kind of corruption. Some of the data is mixed up" Raj is somewhat worried. He hardly ever calls me in. I sit down to examine PAS, sipping bitter coffee from the WVRS. Looking at patient records it seems a lot more are corrupted than I initially thought.

"A virus?"

"Why? The firewall's fine. Anyway I've scanned already."

"It's as if the data's melting. Getting mixed up. Flowing down the drain like dishwater."

Strange metaphors from Raj. He's usually more specific.

“It’s Sunday. No planned admissions. We’ll just reboot. Warn staff and take PAS offline.”

Raj gets on with it. I take a call from Sarah.

“It’s started”

“Have you rung the hospital? I’ll come home and drive you there”

“What’s happening with you?”

“Thanks for asking.”

“Uh?”

“I mean it. Worrying here. Some data loss. Raj will hold fort while I come and get you”

### Phase 3

I’m firmly informed that we don’t need plastic on the car seat, the waters have already broken. I settle Sarah down in the maternity suite. Much improved from the skid-free ward the computers are in. I can stay with her. But the midwife says it might be a long wait.

“I’ll be upstairs then.”

I give my extension and walk down the corridor. There’s no hurry. But Raj thinks differently. He’s sprinting towards me. The reboot didn’t work. OK, PAS rebooted to some extent but it’s in an even worse state. Seems to be mixing up records. Most patient records are not making sense. There’s deletions and additions. We can’t let any Medical Records staff near it.

Back at the office I examine screen after screen of semi-meaningless characters.

I take a call from the labs. The lab system seems to have caught a cold. It’s not just that it won’t connect with PAS, it’s churning out complete rubbish.

“What have you done with our system?”

I can’t explain how I feel. I can see what’s coming. A cold shiver runs through me. I’ve seen this before.

Raj shrugs his shoulders. It’s order comms now. There seem to be endless connections. Hospital systems are no longer simple isolated boxes but networks of information flowing between wards and offices and theatres, connecting between different servers and boxes. And connecting between hospitals.

Sarah calls. The contractions are a bit closer.

“I’ll be there.”

“The trouble is every systems connected”, I tell Raj.” I don’t know where this will end. “

In the birthing suite I log on to the main network to watch the chaos spread. Meaning drains from system after system. I’ve lost the maternity system. And the monitoring systems on the ward slowly disintegrate. The entire hospital will grind to a halt in an hour. Intensive care will cease to operate.

As Sarah groans and starts to manage her breathing, I’m on the phone to the CEO.

“We’ve lost all the systems now. I’m isolating the hospital; so that the damage can’t spread to the National Network. We need to activate business continuity and run the hospital without IT.”

“Is that wise? “

“We have no choice.”

“But without IT lives will be put at risk. We’ll be operating like a hospital in the middle of the jungle. What will happen to ITU?”

“ITU have manual procedures. They’re just have to transfer to them.”  
“John, what’s going on?”  
“We have an information meltdown.”  
“And what the hell’s that?”

#### Phase 4

Sarah’s in a world of her own. You can see the concentration on her face as she leans against the wall, or moves to all fours or sits on the exercise ball. And I’m in my own world. People are already running round with bits of paper. I can imagine in ITU the systems being switched of, wires detached and the blood pressure sleeves coming off.

It was my old Systems lecturer that suggested IT complexity would eventually defeat our attempts to manage information, Complex interactions would give rise to emergent behaviour. It was something to do with the Santa Fe Institute that he had spent some time at. Interactions will be more than the human mind can envisage and systems across the Internet will effectively do their own thing, beyond human control. We will have to stop controlling every interaction, every instruction and change the way we use IT.

Even he didn’t envisage an information meltdown. Not that a meltdown needed the entire complexity of the Internet. It could happen within the warm confines of a hospital. Too many system interactions meant that systems and data start interfering with each other. Like a quantum experiment. And the effects are unexpected and inexplicable.

Raj tells me the NHS has cut us off from N3 and only seconds later the phones go dead. We’re really on our own now. Admissions stop. We ask visitors to leave the hospital. The press office hots up. Before we know it we’re be swarming with journalists.

Sarah works steadily. I’ve never see anybody work so hard. Each breath and contraction thought through. I try to tell her I’ve got to go out. She tries to grasp my hand.

“I’ll be back as soon as possible. There’s no phones. People will start dying soon.”  
She hasn’t heard me. I feel her alarm as I let go of her hand.

I follow the confused stream of people out of the hospital. A flood of information has been replaced by no information. Nobody’s been told why they have to leave.

Just down the road, I know there’s taxis waiting on a side street. I grab the first one.  
“Fifteen Belvoir Street, as fast as you can.”

#### Phase 5

I pay the taxi driver my last few coins. It was worth that to hear about his life. A divorce and remarriage in quick succession. Addiction to golf. And the state of the taxi business. Sounded almost as chaotic as PAS.

Peter answers the door. Tall and thin. A thoughtful giant. I’ve known him from university. If he’s surprised to see me he doesn’t show it.

“Peter, I need your help. I need some of your programs.”

“Information meltdown?” More of a statement of fact from Peter than a question.  
“It was only a matter of time.”

“We’ve lost most systems. No phones. No ITU.”

"I'll have to open the offices."

Peter levers himself into the low-slung sports car. Uncharacteristic in size and behaviour. I've never seen Peter rush. And the pull of acceleration which occurs when Peter puts his foot down is uncharacteristic. I'm curled up in the passenger seat, knees under my chin, dreading an accident which would drive my patellas into my skull.

"I think I know what to do," Peter says.

Doesn't encourage my confidence.

"We'll have to send some of my animals into the network. These will deal with PAS first. Then we'll get some stability back."

My mobile rings. The CEO is beside himself.

"Where are you? Raj says you've disappeared."

"I'm working on a solution. Be back in an hour"

"You must say on the premises. You have your duty"

I send a message back and the connection goes dead.

"Forgot to close the network. I hope the meltdown doesn't spread through the mobile network."

"Difficult to tell," Peter says. "Everything's mobile nowadays"

We stop in front of a tall, glass fronted building. The offices of *Individuality*

"I haven't been in your office before."

"Now's your chance to find out more"

#### Phase 6

The lobby has a relaxed atmosphere. A large screen shows a forest scene. I can feel the breeze. I look twice. Small creatures are moving about between the trees. Their gaudy colours contrast with the pastel greens. But the creatures are active. They root through the undergrowth, they sidle up to the front of the screen and seem to look at me.

"We'll use my office", Peter says. "I've got an environment there"

The offices of Individuality are a hive of activity. The display I saw in the lobby is reproduced everywhere. Large screens, some extending from the floor to the ceiling show exotic environments – deserts, oceans, reflective cityscapes. And they're all populated by creatures, moving probing.

"I didn't realise computer graphics is your main business"

"We don't do computer graphics. That's old computing. We hire a company to make things look nice. We're interested in the living entities in environments. That's our work. This is the world of new computing." Peter sits down in front of a massive screen that dwarves even his stretched frame.

"Old computing is about machines. Artificial Intelligence is just that, artificial. However clever a robot looks, it's just running through a series of logic instructions and doing what its told. That's why it's a machine. Old computing creates an illusion of intelligence and reality because billions of instructions can be processed in a second. Old computing just churns over calculations. Old computing is brittle. It can't adapt. If something goes wrong with one machine, it goes wrong with the lot. Because they're just programmed."

"So what's so special about new computing"

"It's based on life, John. Living systems don't just execute a set of instructions. The DNA defines a development path. And abilities to think, to make decisions emerge as that development path proceeds. In old computing you define the functions of the

system. In new computing you define possible development pathways towards functions. The functions emerge. “

“So what the advantage of that”

“Too many to describe. New computing is based on networks of dynamic interacting elements. Pathways. Connections. They develop over time. But they're all individual. Within some boundaries, they're different. If one breaks down, the rest don't. It's different from old computing. You design the development pathway, not the final product.”

“Doesn't that mean you don't know what will emerge,”

“You have a plan for the basic outcome. And the spheres of behaviour. We know what domains will be defined. But there is room for bounded variations. We're all human, but not everyone has your damn funny nose.”

I ignore the jibe.

Peter studies his screen. “We'll use some worms.”

“The last thing I want at the hospital is worms in the computer!”

“They're really friendly; well, as much as a worm can be. They will make their own way through your old computer systems, sort out the records. Clean out the gunge that has brought your systems to a halt and deposit all the rubbish on what we call a compost server. They're like the healthy red worms that create the rich soil from the contents of your compost bin. Your systems are getting over complex, John. Too many connections Too much data, Meltdown is about hitting the limits of old computing. The brittleness. The non-adaptability. The lack of software evolution without a bevy of programmers.”

“And I guess the answer's in new computing?”

“Of course. It's the shift from machines to creatures, from the mechanical programming of functions to the designing of development pathways, networks of interactions which will lead to robust, adaptable functions. It's the transition from machines which give the illusion of intelligence by sleight of hand to real intelligence. Networked intelligence. Emergence intelligence. That's what new computing is about”

“You're a real evangelist, aren't you?”

“I have to be. Old computing fanatics get scared out of their wits when they face the any uncertainty and unpredictability.”

A few numbered worm-like creatures about the size of a man's hand, segmented, twisting, appear on the screen. Peter waves his hand at them and they respond. He transfers then to what looks to me like a USB. But I'm learning that in the world of new computing, nothing's what it seems.

“I'll have to come over with you, to find the right server”

## Phase 7

I remember Sarah.

“Sarah's in labour. I've no idea what's happening. We better get moving.”

Peter sweeps out. We pass various worlds of sentient creatures. I'm uncomfortable that they look as if they know we're there. Swimming to the edge of their screens. Turning round. A few with eyes that seem to follow us like the proverbial portrait.

The new computing specialist jams himself into the old sports car. I have to hold the creatures. The container is tank-shaped and weighs more than I expected.

At the hospital we take a side door. Raj is still in the IT suite. But the screens are blank. He doesn't ask where I've been. Nor who Peter is.

“We’ll start with the PAS server”, I say.

“No, better to ease the worms in. They need to start with something less massive. They will be able to decide whether they need more worms and whether to reproduce. Find some of the richer garbage.”

Raj is clueless as to what is happening. But he suggests the QA server. Once the QA server is booted up, Peter connects the box up with the server. He gets out some kind of glove which, I speculate, gives him some control over the worms. The box has a small screen, like a window into a wormery. I can see the worms moving about. And then, rapidly, the worms are gone and the box is left with an undulating azure screen.

“Now we just wait”, Peter says “They will follow their noses. They will spread to other servers as they are attracted to particular data. As they move on each server will be restored”

We can see the QA server start to change. Flashes of blank screen leads to start of menus that seem to run themselves and then the usual well-structured records expected before meltdown appear.

“Do you want me to boot up another server?” Raj asks.

“No, the worms will see to that. Look they’re spread to Order Comms. Wise worms I expect they’re leaving PAS to last.”

#### Phase 8

I reckon you need a PhD in Biology just to understand some of the concepts. Peter’s whole business at Individuality is based on a detailed understanding of how biological systems work at the molecular level, the cellular level, the physiological level. These hierarchies of systems are built into the creatures he leases to a variety of organisations. I’m relieved that, whatever these worms are doing, they are composting the crap data, the mixed up records and reducing the uncontrollable complexity. I can see PAS start to return. Meaningful records replace the gobbledygook that was a scene out of ‘the Matrix’. I don’t understand what’s happening. I exist in the world of old computing. But I’ll trust the computational biologist who produces these creatures based on mind-blowingly complex networks.

“I’m going to see Sarah. You can try and convert Raj to new computing.”

Peter smiles.

Raj looks confused. “What’s new computing?”

“Don’t ask. Just trust”

But the biology I’m interested in is the home birth suite. I head from the old maternity suite and the brittle servers that occupy the space, to the new birthing suite where Sarah has disappeared from the birthing room. I find her in a side ward.

As computers are lighting up, Sarah is lit up, sitting cradling a bundle of boy. It’s getting towards six o’clock. My sense of relief gives way to exhaustion. I need a holiday. Clear blue skies, cool drink by the pool, new-born son cooing from his car-seat. I’ll buy that.

### 3. Conclusion

The use of Science Fiction Prototyping enables an idea to be explored without needing to focus on implementation details. It also allows a context to be set. The context gives the technical idea more embedding in human behaviour and society. The placing of an

idea in context and in a story provides an opportunity to reflect on the idea without getting bogged down in details of possible technical implementation.

Additionally the story supports discussion of an idea. An idea which is abstract, or difficult to articulate can be exposed and reflected on. The avoidance of technical details also makes the discussion of an idea, its validity and usefulness, more accessible to a wide range of stakeholders. Involvement in understanding the potential of an idea and its development is much easier on the basis of a story that connects with a wider audience and requires less technical competence.

The idea expressed in this story will need to be developed in detail. Born of a dissatisfaction with the way computers operate, a fascination with the complexity and beauty of biological development systems and a suspicion that the methods use in biological systems could be implemented in a silicon system, it will need to be developed from the study of a range of mechanisms of biological development.

Furthermore, a story allows themes to be pursued. In this story there is a theme of information overload. For John, there is too much information, at home, at work even in the night sky. The theme of complexity can be pursued, and a contrast built up between the old computing John represents and Peter's new computing. The presence of Sarah offers a note of extra complexity. Computers can't deal with emotions and subtle communication (although there is no evidence that the creatures Peter has developed have got this far). Additionally a theme of life and new life is presented, to highlight the lifeless, machine nature of even the most sophisticated artificial intelligence program.

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