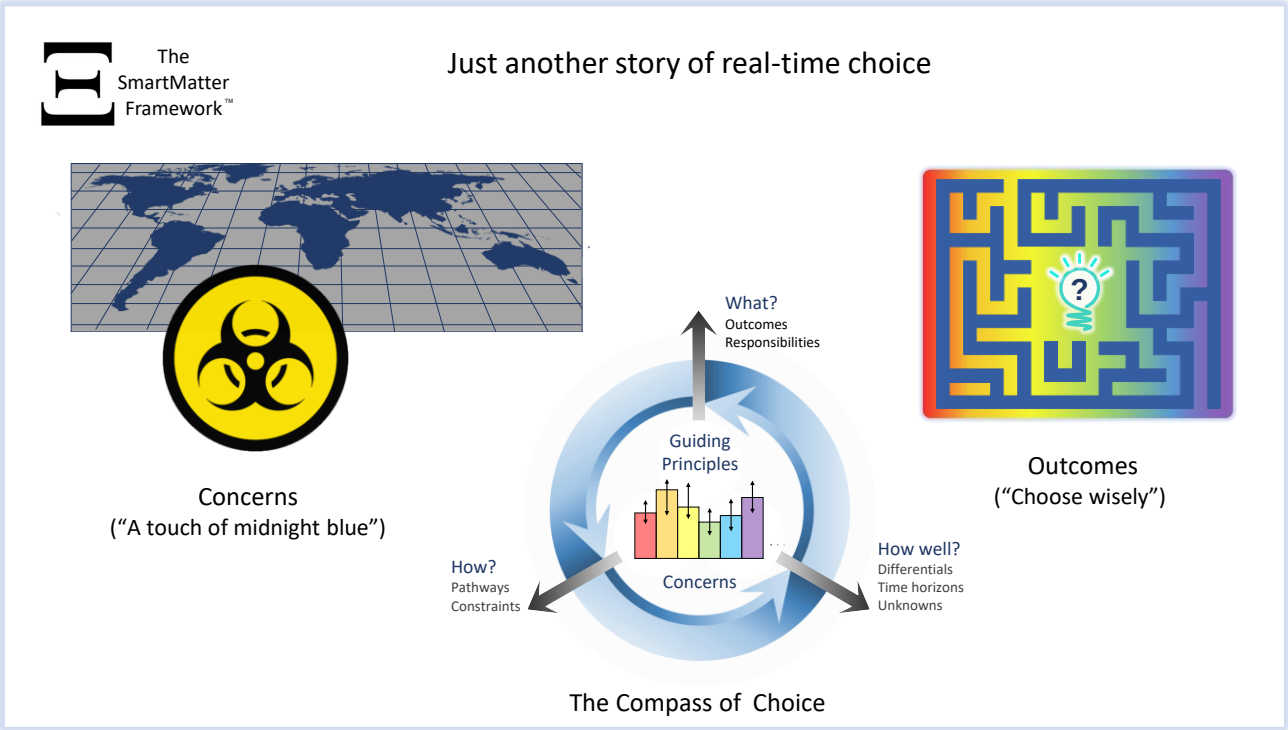
Backwards from Midnight

HM Brindley

The SmartMatter Framework™



A touch of midnight blue

I'm tired of the bad news.

Let's face it - our planet is in trouble and we are the cause. Despite all our work, we have not recovered the situation. We have not even slowed the rate at which we are ruining our only home. This is simply unsustainable. We risk going gently into a future nightmare of hard choices and desperate measures.

Just another story of real-time choice

We need to understand more about how we make decisions. Because decisions have brought us to this place and, one way or another, decisions will take us from it.

The TangleMaze pattern

The model of choice as a real-time process shows that a human being is an agile, self-adapting real-time decision-maker with an open-ended repertoire of context-dependent strategies. At the same time the model indicates that a human being makes error-prone, resource- and time-constrained decisions based on information that is incomplete, misleading, or simply wrong (1,2).

"TangleMaze" is an evocative name for this amazing pattern of choice as a real-time process. The pattern arises because every human decision-maker must self-assemble their own fully personalised meshwork of knowledge models from their own unique context. The TangleMaze is an open-ended, dynamic pattern which is simultaneously kaleidoscopic and creative, ambiguous and contrary…

The upsides to the TangleMaze pattern might well account for our ability to dream up solutions to unforeseeable problems. The downsides might account for many other things.

Why is this relevant?

The description and naming of the TangleMaze pattern are the first steps in a model-based analysis of the problem of global sustainability. The analysis story continues with a recap of the modelling approach perspectives. Next is a high-level review of the current global situation, followed by a critical evaluation of key solution success factors. Then, several real-world case studies are individually mapped to the model of real-time decision-making. These case studies help to characterise the sustainability problem and its likely causes. Finally, all the themes from the different case studies are combined to pinpoint the core concept of one possible solution.

The story format helps to streamline the stepwise presentation of the analysis results. More details are appended as Tales 1-6.

The story perspectives

This story of decision-making and sustainability is told through many different perspectives. The diagram above illustrates and summarises the story. It represents a mapping between the problem scenario and the domain of possible solutions. The mapping activity was carried out with the help of the Compass of Choice (2).

The Compass of Choice

The Compass of Choice is a pattern-based knowledge “toolkit” for problem-solving, built on a model of choice as a real-time process. It is structured as an extensible collection of perspectives which can be scoped and described as information becomes available. The perspectives work together to give a consistent and integrated description of a decision-making scenario. This is rather like the way that a geographical information system presents different “overlay” views of the same physical location.

The problem-solving approach is based on the mapping of concepts to perspectives, hence the use of the Compass metaphor. The theme of mapping is continued in the diagram, where the Concerns and Outcomes perspectives are shown as individual maps which have been “folded-out” from the main body of the Compass.

Concerns

A concern represents a factor which biases the outcome of a decision-making process in some way. A concern may be attributed to one or more stakeholders. Since “stakeholder” is a role-based concept, the term may refer to anyone involved in a scenario.

The diagram shows the Concerns perspective of the Compass in the form of a map of the Earth. The angular form of the map is a reminder that any model is only a representation of reality, not a proof. A sombre mood is evoked by the grey and midnight blue colouring of the map. The concerns of global sustainability are represented by the biohazard warning label.

Outcomes

In the diagram, the Outcomes perspective is shown as a maze of pathways. Many of the pathways lead to dead-ends - this represents the trial-and-error nature of the problem-solving process in a new situation with many unknowns.

The question mark stands for unknowns and the activity of searching for answers. The lightbulb represents any outcome of the searching activity, such as an idea or choice. The rainbow colours evoke a positive mood and represent the diverse nature of possible outcomes.

A grim story

The challenge of global sustainability has been compared to a war. This comparison gives a fair idea of the scale and urgency of the problem. Unfortunately, it also conveys the less helpful impression of an enemy to be defeated. The phrase "Sustainability Emergency" avoids this implication, but it fails to provide a clear description of the emergency or the responses which are needed.

Calling emergency services

Let's reframe the Sustainability Emergency as a global-scale healthcare crisis. The Compass of Choice provides access to information patterns and modelling techniques which help to structure this high-level review.

For more details see Tale 1 – The Mapping Patterns.

Observations

The degraded quality of the Earth's life-support systems is less apparent at short time horizons than at long ones. However, legacy data from previous centuries is patchy in coverage, format, quality, and provenance. This has made it hard to grasp the full extent of the crisis and to establish the priorities for action (3,4,5).

Stakeholders

We have a diverse collection of human stakeholders whose concerns are hard to reconcile. There are also stakeholders who cannot voice their concerns, such as the future generations who are set to inherit whatever situation we leave them. Harder to recognise as stakeholders are non-human organisms and the Earth itself. These entities are typically regarded as resources for exploitation, or characterised as "environmental services".

Deliverables

Many people around the world are working towards global sustainability. There are high-profile goals, measures, and calls for action – think of the 17 Sustainable Development Goals and the 169 Targets of the United Nations (6). But our activities are not being orchestrated by a deliverables-focused plan. That is, there is no integrated description of the sustainable outcome to be delivered and no description of the stepwise "interim" deliverables on the pathway to that long-term outcome. There is no common understanding of the "acceptance criteria" for delivered outcomes or the penalties for missed deadlines.

Prospects

The problem of global sustainability is unprecedented, and yet global-scale risks are not being addressed in a strategic manner. "Business-as-usual" strategies ignore the fact that we are dealing with a complex web of unknowns. Insecurities of all kinds may be driving the observed rise of defensive, parochial attitudes at the very time when we need to work together.

Not a pretty picture

To summarise, we have a mass of grim detail about the problem of global sustainability, but we have no coherent vision of a sustainable Earth. The list of known concerns fails to recognise the fact that many stakeholders have been overlooked or mis-characterised. Without suitable recognition of all stakeholders, we have wasted time debating

narrow-band issues. Many of these debates have been dominated by short-term financial interests rather than broader and longer-term concerns.

Since we lack an integration perspective, actions have not been effectively coupled to deliverable outcomes. As a result, our efforts lack the alignment needed to turn the situation around. We have reached the point where untested "geoengineering" ideas are sometimes floated as "patches" which might buy us time until longer-term solutions are invented.

Not a happy ending

Most people would agree that existential risks are best managed from a whole-of-enterprise integration perspective. The challenge lies in the loaded question of exactly *which* enterprise should supply the preferred perspective. In the past, this debate has often led to war.

Homo sapiens is Latin for "wise man". Honestly? The evidence makes you wonder.

A different story

In a situation full of unknowns, old assumptions and past experiences become unreliable guides. So, let's question everything (7,8). This review of key solution success factors is structured around the cardinal perspectives of the Compass of Choice.

Outcomes and responsibilities

Inexpensive? Good quality? Delivered rapidly? Supposedly, outcomes are never all three at once. Too bad for that assumption – we need a solution which is feasible, available, affordable, and custom-fit for purpose. The solution must also have an intrinsic appeal and provide tangible benefits which encourage its adoption by people everywhere.

Pathways and constraints

Supposedly, deliverable plans should be tightly managed according to scope, quality, effort, resources, and timelines. Too bad for that assumption – we need to orchestrate the rapid development and deployment of a global-scale emergency response, without detailed prior knowledge of the deliverable outcomes, and with the smallest practicable overheads.

Differentials, time horizons and unknowns

Goals are supposed to be specific, measurable, achievable, relevant and timeboxed. Too bad for that assumption – we need to recognise that the most important things can never be quantified, and that we have a very limited understanding of the situation parameters including the critical deadlines we face.

Guiding principles, concerns and context

Some things can be questioned and yet found to be justified. This is particularly true of guiding principles – they may seem unaffordable in a crisis, but experience shows that this is when they are most valuable (9). So let's state upfront that a balanced outcome will require the clear identification of all stakeholders, and that the concerns of each stakeholder will have to be addressed in a principled and context-sensitive manner.

This is quite some wish-list. It's just as well the potential for unknowns means that there's always room for hope.

A detective story

Why are we finding it so hard to turn our concerns into sustainable outcomes? The clues we need to solve this puzzle come from the analysis of real-world case studies.

Themes of the Record-based Perspective

Every biological decision-maker has a need for information. As a result, a human decision-maker can be modelled by *approximation* to a needy, risk-sensitive information processing system which absorbs, stores, and emits streams of messages. Owing to the risk of unknowns in any situation, a decision-maker must both rely on and doubt the information available at any given moment. Thanks to their message-sending capabilities, human decision-makers have many different ways to satisfy their needs. They also face the threat of optimisation traps built from their own satisfaction strategies (1). Ultimately, this is because the choice of strategy is itself a concern.

For more details see Tale 2 - The Record-based Perspective. Themes: information, doubt, and the concern of strategy.

A working diagnosis

In combination with the record-based perspective, the TangleMaze pattern lets us state a “working diagnosis” which links the global sustainability problem directly to human decision-making.

Working diagnosis: The Sustainability Emergency is a global-scale optimisation trap.
Cause: The downsides of the TangleMaze pattern.

This working diagnosis is unique because it is based on a traceably derived model of choice as a real-time process. The modelling approach supports the detailed analysis of multiple case studies. Each case study scenario is mapped to the model of real-time decision-making to produce an output model which is specifically tailored for that scenario. The shared basis of the different output models allows the direct comparison of the results from each analysis. When considered together, the results reveal broad themes of human decision-making which are relevant to the problem of global sustainability.

Themes of the Infodemic

The elevated risk posed by the COVID-19 epidemic has resulted in people sending enormous numbers of health-related messages, of very variable content quality. Models of information governance have not kept pace with recent technological advances, so it is unclear how to address this concern of content quality. The rise of online scams, identity theft and other information-centric crime has encouraged people to doubt the messages they receive, and to question motives and integrity.

For more details see Tale 3 - The Infodemic. Themes: runaway messaging, insecurity, and immature governance.

Themes of the Knowledgebase

The available collection of human knowledge is overwhelmingly vast, and it is growing larger every second. As a result, most people now specialise and develop in-depth expertise rather than attempt to maintain a more generalist outlook. Barriers to communication and learning have arisen as people have built domain-specific vocabularies, techniques, and models. This means it is now harder than ever to find common patterns and spot disconnects within and between different knowledge domains.

For more details see Tale 4 - The Knowledgebase. Themes: too much information, not enough integration.

Themes of the Specification

Early systems development projects were remarkably prone to failure – over budget, over time, or cancelled outright. Poor communication hampered stakeholder understanding and fostered unrealistic expectations. Attempts to detail the processing rules for every situation produced overly complex and poorly structured specifications which were difficult to understand and implement. The computer-based information systems that resulted from these efforts were unmanageably brittle - they were difficult and expensive to maintain under the pressure of ongoing enterprise change. All these problems eventually trace back to patterns of human decision-making.

For more details see Tale 5 - The Specification. Themes: poor communication, unrealistic expectations, excessive complexity, and brittleness to change.

An adventure story

The themes from the case studies lend support to the working diagnosis. But what is the remedy for a global-scale optimisation trap built from our own decision-making strategies?

About that touch of midnight blue

Choose wisely – but *how*?

The reason we struggle to turn our concerns into sustainable outcomes is because it's impossible to ask a specific question about unknowns (1,2). Fortunately, human decision-makers can use their experience, emotions, and imagination to escape from this impasse. One way is to work backwards from unacceptable outcomes, and then work forwards towards acceptable ones as opportunities arise.

Adversity might foster ingenuity, but what *exactly* must we do to avoid a global catastrophe? *If only we knew…*

Of knowledge and understanding

The strategic value of timely information is well known (10-13). Knowledge management, decision support and executive information systems have been around for decades. Content management and delivery underpin our modern information systems and the Internet. We have easy access to vast amounts of information – a commodity which you can give away and still keep for yourself. In terms of the key solution success factors, an information-centric strategy ought to be able to deliver the outcomes we need.

But we just don't seem to know enough to solve the problem of global sustainability.

This is because information alone cannot address the downsides of the TangleMaze pattern. The real answer lies in the context-sensitive application of knowledge to human decision-making. That is, in the ability of human decision-makers to learn, understand, choose, and take action towards desirable outcomes.

The good news is that we already know a great deal about a proven remedy for the downside features of the TangleMaze pattern. The bad news is that most people aren't even aware that this remedy exists. The people who are aware of the remedy don't realise how it might be applied outside its current domain. Ultimately, any one person doesn't know what they don't know – it's just another story of real-time choice.

Themes of the Realisation

Computer-based information systems are all about the enablement of human decision-makers. Delivery of these systems requires expert management of various risks to systems integrity and continuity. Experience has shown that most of the risk factors eventually trace back to human decision-making. The result is that the domain of Systems Engineering contains a wealth of patterns for effective teamwork, improved communication, enterprise integration, and stakeholder satisfaction.

Every computer-based information system is a constrained realisation of a knowledge model which is amenable to rigorous testing. This means that we have accumulated a vast library of "test results" about the ways in which human decision-makers go about solving problems. The upshot is that we have an extensively tested collection of guiding principles and methods for building fully realisable conceptual models that are system-oriented, person-centric, and sustainable over time. This is a gamechanger.

For more details see Tale 6 - The Realisation. Themes: the patterns of an unexpected gamechanger.

The quest for sustainability

People around the world are making error-prone, resource- and time-constrained decisions using data, conceptual models, analysis techniques and assumptions which are incomplete, misleading, or simply wrong. This has resulted in a Sustainability Emergency – a global-scale optimisation trap which has emerged from the downsides of the TangleMaze pattern.

We must find new ways to help people everywhere make more effective decisions. And we must keep on finding new ways to help everyone do this. Because once we achieve global sustainability, we will have to maintain it over time and in the face of unforeseeable problems.

What if…there was a consistent way of mapping between different knowledge domains? Such a thing might grow to be a fully generalised problem-solving toolkit - a paradigm-shift generator. We could use it to construct an enterprise integration perspective for all human knowledge. We could use it to empower people everywhere to make more effective decisions...

This is the core concept of the SmartMatter Framework – the Open Knowledge Reference Model which underlies the Compass of Choice. I'll tell you more about it in my next article.

We don't yet know how to solve the sustainability problem. But over the centuries we've solved many other problems. And with those solutions we can now build pathways to the answers we need.

Once upon a time…

…someone got so tired of all the bad news they decided to find a remedy. They collected some well-tested pieces of the TangleMaze pattern and built a map-making kit and a Compass. Then they went in search of more useful understanding…

To be continued

The SmartMatter Framework™

HM Brindley
Knowledge Architect

Tale 1 – The Mapping Patterns

The Compass of Choice provides a graphical "interface" to an extensive reference library of knowledge patterns (2). Many intractable problems can be conveniently reframed and addressed with the help of evidence-based structured methods from two key knowledge domains.

The first domain is Medicine, where the Clinical Process is the "business" of healthcare from the perspective of the clinician (14). The second domain is Systems Engineering, where information modelling techniques support the delivery of strategic outcomes by means of enterprise-calibre information systems (13,14).

Parties and accountabilities

Medicine and the Clinical Process. Clinicians aim to deliver differential healthcare outcomes for their patients. Any given clinician may see many different patients, and any given patient may see many different clinicians. The roles present at various scales of aggregation, from a single individual in a "clinician-as-patient" scenario, all the way up to a team of clinicians treating a "population" - a collection of individual patients.

Systems Engineering patterns. The Contract pattern serves as a flexible record-keeping template for professional knowledge workers. The Contract Pattern is related to analysis patterns for Parties and Accountability. The "Object-of-Care" pattern is useful for describing scope boundaries in terms of contract-style responsibilities. "Stakeholder" is a role-based term for anyone affected by a deliverable outcome – it can be generalised to include those responsible for producing that deliverable outcome.

Observations, measurements, and associations

Medicine and the Clinical Process. Clinicians use a patient's healthcare record to capture observations of all types, including signs, symptoms, test results and medical history. This information is used to make a diagnosis. That is, a clinician associates a given collection of those recorded observations to a specific "clinical key" – a list of the generalised features that characterise a particular healthcare problem, disease, or disorder. The various associations, diagnoses, subsequent treatment plans and resulting outcomes are also captured as observations over time.

Systems Engineering patterns. The Observations, Measurements and Associations patterns are the basis of Extensible Information Records of many different kinds, including the Patient Healthcare Record.

Plans, actions, and deliverables

Medicine and the Clinical Process. Based on the diagnosis, the clinician draws on their knowledge of the available treatment protocols to offer their patient a personalised treatment plan. This plan lays out the expected stepwise delivery of healthcare outcomes for that patient – these are estimated from the outcomes already experienced by a collection of other patients. A feature of every treatment plan is the real-time constraint that each step must deliver a fully viable "interim" outcome for the patient. As the steps of the plan are carried out, the actual observations are recorded and compared to those which were expected. Small differentials between planned and actual observations may require some form of minor adjustment to a delivery step.

Systems Engineering patterns. The Plan, Protocol, Methodology, Action, Deliverable and Accounting patterns are well-known and often used in conjunction with the Contract Pattern (14-16). An Action is an observed activity. A Deliverable is the named outcome product(s) of an activity. The Deliverable Plan pattern describes a collection of outcome deliverables organised according to a time-based perspective. The Action Plan pattern focuses on activities and so may lack the outcome focus of a Deliverable Plan. More elaborate plan patterns such as the Statement of

Work and the Work Breakdown Structure combine Actions and Deliverables along with other elements such as Responsibilities and Constraints.

Risks and concerns

Medicine and The Clinical Process. Risk management is the core activity of healthcare, and a fundamental risk lies in the unknowns. Clinicians help patients to address the risk of adverse personal health outcomes by offering them treatments. In other words, they provide strategic advice about the patient's health risks, develop health risk management plans, and deliver personalised treatment "projects" for healthcare outcomes.

A patient's healthcare record is an extensible store of generalised observations which supports traceability between clinical observations and measurements, diagnoses, treatment plans and clinical outcomes. But since observational data may be unreliable or incomplete, any part of this record may have to be reconsidered at any time. In the event of unexpectedly large differentials between planned and actual observations, a major change to a treatment plan may be required. New observations may provide more insight into the patient's problem and perhaps result in a changed diagnosis and a new treatment plan. For all these reasons and more, every clinician must rely on the available observations whilst simultaneously doubting them (17).

Any one clinician can only know so much, so they or the patient may seek opinions from other clinicians. If the patient has a problem which is not well-understood, they may be able to find out more from research studies. A significant concern is that the current medical consensus can be very slow to change - the result is that valid new ideas are ignored or rejected for many years. Recent victims of such consensus-based optimisation traps are the now-accepted concepts that bacteria can cause stomach ulcers, and that viruses can cause cancer (18).

Systems Engineering patterns. The Prospects pattern is an enterprise security and continuity pattern. The Prospects pattern is another name for the generalised Risk Management pattern – this is because risks may be positive, negative, or simply unknown. The Risk Management pattern is often specialised to focus on negative risks. The Opportunity Management pattern focuses on positive risks. The Portfolio pattern helps to model and estimate an enterprise's overall exposure to the risks in a collection of individual contracts. The Separation of Concerns pattern helps to decouple problem requirements from solution specification and implementation. Real-time systems make extensive use of the Safety pattern (19).

Enterprises and enterprise integration

Medicine and the Clinical Process. When a patient presents with complex healthcare needs, a team of clinicians will work together to offer an integrated treatment plan. This produces a better outcome for the patient than the situation where each clinician works independently of the others. The quality of any healthcare outcome is a question of context-dependent fitness - attempts to quantify outcomes risk losing sight of each patient as a unique individual in their own unique circumstances. And yet treatment pathways are subject to real-world constraints which cannot be ignored. The challenge is always to find an acceptable point of balance - this requires an open and informed discussion of what exactly comprises a satisfactory outcome for each and every patient.

Systems Engineering patterns. The Architecture Description and Enterprise patterns describe dynamic real-time systems in the form of models (13,20,21). The Contract pattern supports end-to-end traceability between stakeholder concerns, stepwise delivery, and satisfaction with outcomes. The Open pattern appears in many different forms, such as discussions between individuals, flexible workflows, and adaptable standards for technology.

Tale 2 – The Record-based Perspective

Decision-making has been modelled as a real time process which repeatedly loops over and chooses amongst competing demands in order to decide upon some course of action (1,2). In the model, each demand represents a time-sensitive request for satisfaction of a need. Here, the modelling work shows that the same model supports a record-based perspective which resembles a generalisation of the Patient Healthcare Record from the Clinical Process.

For more details see Tale 1 – The Mapping Patterns.

The need for information

A living organism has a need for information - it underlies such basic characteristics as homeostasis, “respond to stimuli”, “grow and develop” and “adapt to environment”. So, let’s *approximate* a biological decision-maker to an information processing system which absorbs, stores, and emits streams of messages (derivation not shown). The decision-maker’s message store can be imagined as an extensible information record made up of different types of observations. A given collection of those observations may be associated to another given collection, and that association may itself be stored as an observation. This builds up a complex meshwork of observations – a mapping which can inform a context-sensitive stream of decisions and actions.

For more details see Tale 1 – The Mapping Patterns. Observations, measurements, and associations.

The fitness of doubt

There is always the potential for unknowns in any situation. In the record-based perspective, this means there is always some risk to the fitness of any given association to explain the relationship between a collection of observations. The risk is twofold – firstly, when a specific association is compared to the other possible associations immediately available, and secondly, over time as new observations are stored to the record.

Owing to this risk, every observation always has a context-dependent potential to affect the outcome of the current real-time decision-making process in some way. The observations are therefore concerns which may be modelled as time-varying demands for attention. This is consistent with the modelling abstraction that a need is a type of concern, and it demonstrates that the record-based perspective aligns with the previous representations of the model of choice as a real-time process (1,2). It also shows that a decision-maker must rely on their available observations whilst simultaneously doubting them, just as René Descartes wrote several centuries ago.

For more details see Tale 1 – The Mapping Patterns. Parties and accountabilities. Risks and concerns.

The concern of strategy

Now we can model a human decision-maker by *approximation* to a needy, risk-sensitive information processing system which absorbs, stores, and emits streams of messages. Self-evidently, a decision-maker may have the capability to communicate with others by sending messages via its external physical context. As a direct result, such decision-makers can use many different strategies to satisfy of their needs – for example, they can co-operate rather than compete with each other. They also face the threat of optimisation traps built from their own satisfaction strategies. Ultimately, this is because the choice of strategy is itself a concern for the decision-making process (1,2).

For more details see Tale 1 – The Mapping Patterns. Risks and concerns.

Tale 3 – The Infodemic

The COVID-19 epidemic is unprecedented in the modern world. One result has been the outbreak of an excessive number of health-related messages, of highly variable content quality. The phenomenon so closely resembles an emerging infectious disease that in September 2020 the World Health Organisation declared a COVID-19 "infodemic" (22).

In this case study, the modelling work focuses on the healthcare messages sent by a collection of human decision makers in a volatile, uncertain situation. Message content quality is a concern because misinformation may bias a decision-maker towards ineffective or potentially harmful courses of action.

Let's illustrate the case study model with an example – a comparison of the two very different sent messages "Wear a facemask in public" and "Facemasks can be harmful". Each of these published healthcare messages carries the stamp of its own sender's unique context. Each person who receives the two messages then self-assembles their own personalised interpretations - their responses will depend on their own unique context and the level of trust they assign to each message.

In some ways the infodemic resembles a global-scale flocking or swarming phenomenon - one which shows many features of the TangleMaze pattern (23). Upside features include the efforts of people worldwide to send healthcare messages intended to minimise the harm caused by the epidemic. On the downside, some people may send unreliable healthcare messages under the impression that they are true, whilst other may find reasons to spread false messages deliberately. Downside messaging is potentially lethal – for example, it can lead to people drinking bleach or bootleg alcohol (22).

<u>Theme: Runaway messaging.</u> Timely access to good quality information is a challenge which people have faced for centuries. These days, the challenge is compounded by the enormous volume of messages being sent and the speed at which those messages can be transported between highly networked decision-makers.

<u>Theme: Insecurity.</u> We are now exposed to a relentless deluge of information and misinformation. The rise of online scams, identity theft and other information-centric crime encourages people to question motivations and integrity.

<u>Theme: Immature governance.</u> Models of information governance have not kept pace with recent technological advances. Message transportation services have no concern for the quality of the information they transport. Attempts to impose quality controls on information are often viewed with suspicion - the middle ground between freedom of speech and authoritarian control is very hard to find.

Tale 4 - The Knowledgebase

Our existing global knowledgebase is a priceless legacy, a collection of knowledge models built up from millennia of lived and recorded human experiences. In this case study, the modelling work focuses on a "sent message" which is a specific published instance of a knowledge model – an example is an academic paper in a journal. This published knowledge model carries the stamp of the author(s) own unique context(s). Every reader then self-assembles their own personalised interpretation of that knowledge model, and may publish their own version in turn. This is how our knowledgebase advances over time - its meandering progress exhibits both upside and downside features of the TangleMaze pattern.

One downside feature is that it is possible for knowledge models from different authors to be incompatible. A current example of this is in Physics, where it is not possible to integrate and reconcile several knowledge models (24). Since each of these models works extremely well in "standalone" mode, this problem may be an example of an optimisation trap.

Knowledge model review processes also show features of the TangleMaze pattern. Journal-based peer review can be effective - one downside is that it is unavoidably reliant on the personal knowledge of each individual reviewer. A knowledge repository which uses a crowd-sourced editing and review process shows different features – for example, Wikipedia allows anyone to delete accurate information or add misinformation (25).

A longstanding downside feature is that the knowledgebase is traditionally organised into the top-level domains of Arts, Sciences and Humanities. This domain classification structure hides the underlying similarities between many knowledge models (26). A knowledge model in one domain may persist in a legacy form for decades because the techniques to update it reside in a seemingly unrelated domain. This was recently demonstrated by the reworking of Maslow's Hierarchy of Needs using an information modelling approach (1).

<u>Theme: Too much information.</u> The available collection of human knowledge is overwhelmingly vast, and it is growing larger every second. As a result, most people now specialise and develop in-depth expertise rather than attempt to maintain a more generalist outlook.

<u>Theme: Not enough integration.</u> Barriers to communication and learning have arisen as people have built domain-specific vocabularies, techniques, and models. This means it is now harder than ever to find common patterns and spot disconnects within and between different knowledge domains.

Tale 5 - The Specification

In this case study, the modelling work focuses on computer-based information systems. Each of these machines absorbs, stores, and emits streams of messages which eventually trace back to human decision-makers. From one modelling perspective, this means that these machines can be regarded as just another part of the external physical context which allows a human decision-maker to communicate with others by sending messages.

Here's a different perspective. Every computer-based information system represents a knowledge model which has been published in the form of an extensible information record mapped to a hardware platform (2). This means such a machine represents the output results of a collection of decisions made by human decision-makers. It is therefore a solid-state and specification-constrained instance of the TangleMaze pattern. The downsides to this pattern would probably account for the fact that the history of information systems engineering is littered with projects that failed in one way or another (27-31).

Theme: Poor communication. The development of a computer-based information system requires clear communication between all stakeholders. In the early days of computing the available communication options were poorly suited to the task. Natural languages were found to be flexible but imprecise. Formal coding languages and mathematics were precise but required specialist training. Early diagramming methods failed to capture critical aspects of the system specification.

Theme: Unrealistic expectations. A computer-based information system is an expensive investment - stakeholders frequently had high expectations but ended up disappointed by the delivered outcome. For example, the various stakeholders often failed to describe their outcome requirements clearly, made unwarranted assumptions, or vastly underestimated the resources needed to deliver the expected outcomes.

Theme: Excessive complexity. A computer-based information system is a rule-following machine. Stakeholders often created large, complex, and poorly structured collections of information-processing rules. Adding more rules to cope with unusual exception and error situations only increased the overall complexity of the specification.

Theme: Brittleness to change. A real-world enterprise experiences ongoing internal and external changes, which means that its computer-based information systems must also face those changes. It soon became apparent that the early systems were brittle – they could not be altered easily or cheaply. For example, minor changes could start failure cascades, knowledge was lost as stakeholders moved on, and proprietary implementations could not be ported to improved hardware.

Tale 6 – The Realisation

This case study follows on from Tale 5 - The Specification, so the focus of the modelling work remains on computer-based information systems.

Themes: For examples see Tale 1 – The Mapping Patterns.

An unexpected gamechanger

To overcome the remarkably high failure rate of early projects, systems engineers became expert managers of risks to systems integrity and continuity. Computer-based information systems are all about the enablement of human decision-makers, so it is not very surprising that most of the risk factors eventually trace back to the downside features of the TangleMaze pattern (30-32).

Every computer-based information system is a realisation of a knowledge model – one which has been translated into a solid-state, specification-constrained form that is amenable to rigorous testing (2). This means such a machine represents a "testbed" for human decision-making. And we have already accumulated a vast library of "test results" about what happens when thousands upon thousands of human decision-makers make millions of individual decisions about how to go about solving problems. In fact, over the past few decades we have carried out what amounts to an enormous, well-blinded and extensively replicated field investigation into the TangleMaze pattern.

The upshot is that we possess an extensively tested collection of guiding principles and methods for building fully realisable conceptual models that are system-oriented, person-centric, and sustainable over time. Hard evidence for the practical effectiveness of this body of knowledge is everywhere around us, in the shape of modern information-enabled devices of all kinds.

A showcase for patterns

A modern Information Technology (IT) Consultancy project showcases this knowledge and the outcomes which it can deliver. An IT Consultancy project is typically established under a "Head" contract for services. The head contract outcomes can be expressed in terms of risk-responsibility models. This modelling approach extends to the computer-based information systems which fall under the Head contract. An integrated family of models can be used to describe the entire existence of an information system, from the initial idea though to retirement (13-15). The result is a Head contract supported by a collection of back-to-back subcontracts which traceably detail the layered, many-to-many relationships between stakeholder concerns, interim deliverables, and satisfactory outcomes.

On such a project, people work together to create, deliver, and maintain information-enabled capabilities for an enterprise client. These capabilities are based on an enterprise integration perspective which co-ordinates the stepwise transformation of client team structures, workflows, and task automation. The capabilities and the integration perspective are built with the help of flexible methodologies derived from the experiences gained on many previous projects. These methodologies are generalised "recipes" for deliverable outcomes and pathways which can be tailored to suit the unique needs of each client.

Effective communication between all stakeholders underlies this team-based delivery of professional services. The clear description and open discussion of stakeholder concerns helps to build a shared understanding of the client's situation and the outcomes needed to address those concerns. Various checks and balances provide ongoing feedback about satisfactory performance and stepwise achievement of contracted outcomes.

These guiding principles and methods enable people around the world to build information-enabled capabilities which were unheard-of only a few years ago, and to deliver levels of client satisfaction which lead to ongoing repeat business (33,34).

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