Chapter 2 Introduction to decision making

“When you are face to face with a difficulty, you are up against a discovery.” Lord Kelvin

The maths professor and the government

In an information society the key laws are those governing information and these can be found in unexpected places generating unintended effects.

Following the huge impact of the Bletchley Park code breakers in World War II, many countries imposed strict controls on the export of cryptographic products, for national security reasons. The basic idea is to prevent criminals, terrorists and hostile foreign powers from getting access to codes which they can use to communicate and plot in secret. That seems like a fairly sensible objective but broad-based, complex rules, regulations and laws applied to complex information systems can and often do have a strange and distorted effect at the level of the individual.

In the autumn of 2003 mathematics professor Daniel Bernstein's long running legal dispute with the US government finally ended. Professor Bernstein had created a small program which could be used to teach some of the basic mathematics and programming of codes. However, he was unable to use it for teaching or research, without first clearing it with the government. Otherwise he could be breaking US arms export regulations,[1] especially if there was any likelihood that there might be a foreign student in his class. Technically he also needed government clearance to discuss his program with other research colleagues at international conferences.

Bernstein's interest in cryptography was triggered when, as a student, someone hacked into his computer. It was in 1990, whilst still a student, that he wrote the original US government-offending mathematical functions and program. He became aware of the government restrictions through networking with others interested in cryptography and decided he should ask for permission before publishing his work.

His first problem was tracking down who precisely in government he needed to ask for permission but he eventually found his way to the appropriate office.[2] Officials informed him he would be risking a stretch in jail if he did make his work public without a formal grant of approval from the government. His application for such approval was quickly turned down essentially because his mathematical functions and program were considered to constitute dangerous weapons.

Bernstein appealed the decision with no success. Then by 1995, by which time he was a professor at the University of Illinois in Chicago, he had become so frustrated with the process that he decided to mount a legal challenge with the support of the digital rights campaigning group, the Electronic Frontier Foundation (EFF). The basis of the case was that computer programs were a form of speech. Communication through computer programming languages should be considered to be equivalent to communication through English, French or any other recognised language and should therefore be subject to protections granted to speech by the first amendment to the US Constitution. To the surprise of many US District Judge, Marilyn Hall Patel, agreed with this proposition in 1996 and ruled in favour of the good professor, as did an Appeals Court three years later.

The case dragged on for a further four years with attempts to have the arms export regulations relating to cryptography declared unconstitutional but by then there had been a shift in the politics. Arguably the restrictions had been loosened and the US Department of Justice made an undertaking to the court not to prosecute Professor Bernstein or other legitimate cryptography researchers for publishing their work. Given these assurances that the regulations would not be enforced against Bernstein, the original judge, Marilyn Hall Patel, sided with the government and technically dismissed his complaint.

Now Bernstein, having innocently fallen into a bureaucratic minefield, then deliberately set out to test and change the limits of the US regulations governing cryptography. This was because he and many other security experts believed those regulations to be ineffective and in many ways contrary to the interests of US national security, by undermining the ability of US researchers to collaborate on cryptographic research, for example. By inhibiting the collaborative work of cryptographic experts the government was inhibiting progress in the field. The striking thing about the case from the perspective of this current study, however, is that a teacher effectively needed to clear the teaching of basic maths and computer programming with the government and the process he had to engage with was complex and opaque, as well as time consuming and expensive.[3]

Introduction to decision making

Everyone makes decisions from the moment they wake up in the morning until they go to bed at night. These range from the simple decisions to brush your teeth or take the usual route to work, to the more complex such as considering whether to change schools or jobs or what our responses to the threat of terrorism should be.

Know-how

In making decisions we go through a set of thinking and other processes consciously or subconsciously. When we go through the automatic routine of scrubbing our teeth it is because we have decided we would rather avoid having preventable dental treatment at some point in the future and are prepared to invest some time and effort each day, along with the money we have spent on toothpaste and toothbrushes, to achieve this outcome. It is a rational decision but to some degree subconscious because it is just part of our daily routine.

In fact, most of what we do is at the level of cleaning our teeth i.e. ‘habit’ or ‘know-how’ of one sort or another. Babies learn to walk, talk and recognise their mum and dad through an intense process of trial and error. Young children survive the shock of realising the universe does not revolve around them without reading a library of self-help books, when, for example, they first start having experiences outside of their immediate family, such as starting school. All the time they are making huge numbers of subconscious decisions in an attempt to get their muscles to move in a coordinated fashion or reacting to the feedback supplied via the complex social dynamics of the playground, in order to engage better the next time. They are constantly assimilating knowledge of the patterns of the world around them and developing skilled responses to enable them to survive and satisfy their curiosity and need for e.g. social interaction. Know-how in decision making essentially gets automatically programmed into our brains through experience and it is valuable not just at the level of deciding to put the kettle on to make a cup of coffee but also in much more complex decision making situations.

This is ably demonstrated by the joke of the old engineer being called into to fix a ship's engine when the problem has defeated the most able ship's company personnel. The engineer does a long and thorough inspection of the engine, takes out a small hammer and lightly taps it at one point, whereupon the engine magically springs back to life. He later sends the ship's owners a bill for £5100 which they complain about. All he had done was to tap the engine once with a hammer. [Interestingly enough, in advance of him doing the job, the owners would probably have been willing to offer him significantly more than this to get their ship back in service.] So the engineer itemises the bill:

- Engine inspection £95
- Tapping with hammer £5
- Knowing where to tap £5000

The knowing where to tap is the know-how. It is difficult to articulate what it is and even more difficult to measure it. We tend to know it when we see it – the skilled carpenter or sportsman, the successful business woman, the popular child in the playground – but we do not often think about it as just the ability to get on with the multitude of life's decisions. We all use our own unique know-how all the time, whether we're aware of it or not, in making the decisions large and small that get us through the day.

Rational decision making

There are a large number of different types of decisions and ways we go about making those decisions as individuals or as part of some group. In a rational decision making process we systematically follow a recognised series of steps to identify various options open to us and then choose one.

Benjamin Franklin once wrote to Joseph Priestley:

"When those difficult cases occur, they are difficult, chiefly because while we have them under consideration, all the reasons pro and con are not present to the mind at the same time, but sometimes one set present themselves, and at other times another, the first being out of sight. Hence the various purposes or inclinations that alternatively prevail, and the uncertainty that perplexes us.

To get over this, my way is to divide half a sheet of paper by a line into two columns; writing over the one Pro, and over the other Con. Then, during three or four days of consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, for or against the measure.

When I have thus got them all together in one view, I endeavour to estimate their respective weights; and where I find two, one on each side, that seem equal, I strike them both out. If I find a reason pro equal to some two reasons con, I strike out the three . . . and thus proceeding I find at length where the balance lies; and if, after a day or two of further consideration, nothing new that is of importance occurs on either side, I come to a determination accordingly.

And, though the weight of reasons cannot be taken with the precision of algebraic quantities, yet when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to make a rash step, and in fact I have found great advantage from this kind of equation."[4]

So, when making tough decisions, Franklin went through the rational process of making a list of pros and cons and then weighing these against each other.

Security specialist, Bruce Schneier[5] offers another rational five-step decision making process, which he believes applies universally to any decisions about security, including the regulation and deployment of technology for security purposes. He asks a series of questions:

1. What assets are you trying to protect?
2. What are the risks to these assets?
3. How well does the security solution mitigate those risks?
4. What other risks does the security solution cause?
5. What costs and trade-offs does the security solution impose?

Project managers and engineers are familiar with another rational approach:

1. Survey the situation.
2. Specify the problem.
3. Identify a series of alternative options to tackle the problem.
4. Assess the alternatives.
5. Choose one and implement it.
6. Monitor the outcome and adjust action in accordance the relevant feedback.

7. If the 'solution' works move onto the next problem. If not go back to the beginning.

These approaches represent variations on a theme which most of us will have used at some stage. They all rely on the gathering and assessment of accurate information or facts about a situation in order to make a rational choice about the best course of action. Because the decision situation is usually in a state of flux we often find we have to go through the steps more than once. So if a parent decides to get a child a computer games console for Christmas and a more modern version becomes available, then the decision situation has changed and the decision process needs to be revisited.

Complexity in decision making: garbage can situations

These rational approaches are much richer than a superficial list of the steps involved will make them appear but they have been criticised as ignoring or underestimating the complexity and real-world uncertainty and confusion involved in actual decision making.

James March [6] has written[7] that real-life decision situations are often better characterised by the 'garbage can' metaphor than artificially rational steps. Many decision environments display fuzziness, complex interactions between the people and machines involved, problems, solutions, opportunities, changing technologies, social norms, and organisational, legal and economic contexts. These are all mixed up together in a garbage can at a point in time and the relationship between a problem, a solution and a decision maker may have more to do with them coming together in the same place at the same time, than any rational process.

March says[8] that people constantly have a range of issues, professional and personal, competing for their attention. The deadline for contract negotiations on a big project is looming; your partner is suffering from a degenerative illness; one of the kids is being bullied at school; you forgot to put the cat out and it makes such a mess when it's shut in the house all day; your partner has an all-day appointment at the hospital; the car would not start this morning and there is a public transport strike so you were late for work; on top of that you forgot your sandwiches, so what are you going to do for lunch; one of your team noticed a major last-minute hitch with the contract but believes there is a computer vendor with exactly the right system to deal with that; you did not get your caffeine fix first thing this morning because of the problems with the car and it is annoying you, as is that fly buzzing around the conference room; you do not trust lawyers and are not sure that some members of your team have been as thorough as they should have been. In complex decision environments it is impossible to know or shut out everything but the relevant issues, then analyse these through some rational process to come to the 'right' decision. Real life is much messier than that.

Bounded rationality in decision making: satisficing

So if the real world is so messy and there is too much extraneous noise in complex decision making situations to act entirely rationally, what can we do? Well we could apply a rational approach to the limited amount of apparently relevant data we can extract from the situation. If the assessment of a variety of bidders for a government telecommunications contract suggests that two of the companies could meet the requirements within the required budget, then randomly picking one through the flip of a coin would lead to a 'good enough' choice.

You can probably think of a few occasions, in a personal and professional context, where you have made a decision like this. When I got my latest mobile phone, I gave the vendor a clear specification of what I was looking for, was shown two matching that specification and randomly picked one. It does the job I need it to do, most of the time. Occasionally the battery runs out at inconvenient times. Decision theorist, Herbert Simon,[9] coined the term 'satisficing' for this partly rational, just-good-enough approach to decision making.

The British radar technology in World War II was inferior to that of the Germans, so much so that when the Germans captured a British radar set in 1940 it was declared so obsolete as to be useless.[10] The technology, however, was good enough, as part of an integrated system, to collect the raw data on approaching enemy aircraft. This raw data from their chain of radar stations and visuals from the Observer Corps was passed on (via radio telephone and teleprinters) to headquarters and an integrated set of operations centres, where it was assessed, filtered, analysed and turned into useful information at varying levels. This then facilitated the scrambling of the right fighter squadrons and even more specific instructions to be radioed to the RAF pilots once in the air, to enable them to intercept their enemy at the earliest opportunity.

The Germans had better information technology (radar). The British had the better information system (radar, human intelligence, signals intelligence, and an integrated, purpose-developed system, allowing the situation to be viewed holistically, as well as delivering the right information to the right users, at the right levels, in a useful format and in sufficient time to act on it). The better information system prevailed in the Battle of Britain in 1940 and it got built in time largely due to the decision of those involved to use technology that was just good enough to get the job done.

Factors that influence [digital] decision making

Amongst the factors that influence decision making, the personal values and relative power basis of key decision makers are fundamental. The UK government's decision to introduce a biometric identity card system provides an illustration.

Personal values and power

Winston Churchill abolished identity cards in 1952. In the wake of the 11th of September 2001 attacks on the US, the then Home Secretary,[11] David Blunkett, embraced a plan to reintroduce them. He invested a lot of energy in pursuing it, as have his successors, Charles Clarke and John Reid. The proposal for the high tech system came about at a time (2001/2) when the government was facing serious questions on terrorism and immigration. The idea appealed to Mr Blunkett, someone with a strong belief in the need for government to be taking big decisions to tackle complex problems. He was also in a position, at the time, to make it happen. Note that this plus the fact that terrorism and immigration are incredibly complex issues fits the temporal link theory in March's garbage can process.

Values are strongly held personal beliefs about what is important and about how the world *ought* to be.

A value is a belief that something is good or bad. For example, some people believe the music of the Beatles is better than Mozart's or that abortion is morally wrong under all circumstances.

Personal values are critically important when it comes to interpreting information. This is very important to keep in mind in digital decision making (DDM). People can have very strong feelings about technology, particularly when it gets enmeshed in complex issues like terrorism, other serious crimes, immigration, and civil liberties.

If a government minister, or anyone else, strongly believes some action is the right thing to do, it is difficult to get that person to question that belief. The most powerful actors also tend to have the means to act on their beliefs.

There is an extra complication in the context of powerful actors. People like prime ministers, presidents and chief executives tend to be surrounded by people whose jobs depend on keeping the boss happy. They therefore have an incentive to tell the boss what she wants to hear i.e. to reinforce her beliefs. The good ones know this and compensate accordingly.

A friend of mine once worked for a company where the general manager held a production meeting twice a week to check on developments in the factory. The meeting included directors, foremen (they were all men at the time), charge-hands, managers, engineers, finance, operations and logistics people. It always featured the general manager picking a victim and blaming them for anything that happened to be going wrong, that day, week or month. Before every one of these meetings, unbeknownst to the general manager, there was always an informal meeting of the usual victims, at which the participants got their stories straight. They would joke about whose turn it was to be the victim that day and literally make up a story of how things were going in the factory to avoid the abuse in the main meeting becoming too vicious. The general manager liked to know things were going well and he was managing a dynamic, world class factory, so by and large that is the story he got told, even when there were serious production problems.

It is important to understand the power dynamics, the personal values and the agendas of the most powerful actors in any DDM situation. Government ministers have an interest in being seen to be doing something in the wake of a terrorist act, such as the London bombings in 2005, so, for example, will support the creation of extra security at airports.

Thinking traps

The thinking trap can be a barrier to even bounded rationality in decision making. Geoffrey Vickers described it thus:

> "Lobster pots are designed to catch lobsters. A man entering a man-sized lobster pot would become suspicious of the narrowing tunnel, he would shrink from the drop at the end; and if he fell in he would recognise the entrance as a possible exit and climb out again – even if he were the shape of a lobster.
>
> A trap is a trap only for creatures which cannot solve the problems that it sets. Man-traps are dangerous only in relation to the limitations of what men can see and value and do. The nature of the trap is a function of the nature of the trapped... we the trapped tend to take our own state of mind for granted – which is partly why we are trapped."[12]

He goes on to note that we can only start to climb out of our self-made thinking traps when we recognise that we are in a trap and start questioning our own limitations and the assumptions that led us there.

When I was in industry I believed that the engineering department was the most important part of every company. It took me a while to realise that everyone thought their own department was the most important and that for the business to function it needed most of those departments working together. It is common for a particularly high level of animosity to exist between the engineering and marketing departments, for example, both unable to communicate with each other because they each use different professional jargon.

I also used to find it hard to accept that lawyers were prepared to act for people or organisations who had allegedly engaged in ethically questionable practices. Yet it is a fundamental tenet of a just society that people accused of even the most heinous crimes are entitled to a fair trial.[13] Both of these thinking frames – 'the engineer is the best'[14] and 'only *good* people should be entitled to legal representation' represented traps in my thinking inhibiting a wider understanding of organisational behaviour and the legal system.

Complexity: the technology

At the heart of computer technologies lie hardware with millions of tiny electronic components and software programs with millions of lines of code, which together constitute some of the most complex machines that have ever been built. That very complexity is a key factor in the success or failure of digital decision making processes involving these machines.

Influential Yale University professor, Charles Perrow, thinks that some complex technologies and the complex systems of which they form a part, such as nuclear power plants, are so prone to failure with catastrophic effect that we should abandon them completely.[15] Perrow describes the partial meltdown of the reactor core at the Three Mile Island nuclear power plant in 1979 as a 'normal accident', the inevitable result of the complexity of the plant system, and the tight coupling of its component parts.

The complexity means no one can fully understand the system and the tight coupling means that failure in one component can have a ripple effect, leading to a string of other components failing like dominoes falling over. The complexity also leads to parts of the system, including the human actors,[16] interacting in unexpected ways (because they are interlinked in unexpected ways) resulting in the emergence of properties of the system which would not have been predicted in advance.

At Three Mile Island part of the cooling system had been isolated for some maintenance. In accordance with standard practice, compressed air was being used to clear a blockage. The blockage proved to be stubborn and difficult to shift and the operation was taking much longer than usual. A small amount of water leaked back through the compressed air pipes into the control instruments triggering a shut down of one of the plant's three main cooling systems and of the electricity generating turbines. A stuck pressure relief valve in the reactor core cooling system then went undetected partly because of misleading and hidden indicators in the plant's control room.[17] Operators in the control room were left with the erroneous impression that pressure was building up dangerously in the reactor core cooling system, which if it failed would leave them with no means of cooling the reactor and preventing a total meltdown. So instead of pumping more cooling water into the system they drained water away, in order, so they thought (and with very good reasons), to prevent the core cooling system failing catastrophically. It is difficult to imagine the stress endured by plant operators faced with a nuclear disaster and a power plant system behaving in ways they could not understand despite their significant combined level of experience.[18]

It was not until more than two hours later, when a new shift supervisor, Brian Mehler, arrived on the scene, that the problem with the valve was discovered and they began to pump more water into the system to prevent a disaster. Mehler modestly says he merely "brought a fresh pair of eyes to the room" but he was able to enter a highly stressed environment and test his theory about the valve to a natural conclusion. His colleagues had also considered the valve as a potential problem but within a couple of minutes of the start of the incident over one hundred alarms were going off in the control room. In the confusion of frenzied activity, a temperature reading on the valve had been either considered to be within the required limits or reported erroneously to the people in charge.

This again was partly down to serendipity. The pressure valve was known to have a small leak which could not be easily fixed, so the computer linked to the temperature indicator on the valve line had been programmed not to give any readings over a specific limit, 280°F. Mehler noted the temperature, still felt it was unnecessarily high and asked for the valve to be isolated. Almost instantaneously the system began behaving in predictable fashion and they were able to bring the water levels up thereby avoiding a disaster.[19] According to a US Presidential Commission report on the accident the nuclear core had been less than an hour from total meltdown.[20]

Complexity: the situation

I have drawn attention above to some of the key factors influencing decisions – personal values, relative power, thinking traps and the complexity of the technology but there are quite a number of others which I would group together under the heading 'complexity of the situation'. These include:

- The decision makers
- Decision criteria
- Time
- Dynamic (changing) nature of the situation
- People affected
- Law
- Decision making models (such as cost-benefit analysis etc)
- Decision environment (organisational, ecological, economic, social, political and physical).

Take the Challenger space shuttle disaster at the Kennedy Space Center at Cape Canaveral in Florida, on 28 January 1986, for example. The technical cause of the accident was the failure of rubber O-ring seals in one of the booster rockets. The freezing temperatures at the launch meant that the rubber was not capable of doing the sealing job required. Escaping gas destroyed one of the key fixtures securing the booster rocket to the main fuel tank and burned a hole in the side of the tank. The out-of-control rocket swivelled around its upper fixture, crashing into the top of the fuel tank and leading to a massive fireball. The space craft broke up. It was just 73 seconds into the flight.[21] Engineers at Morton Thiokol, the company which made the booster rockets had strongly advised against launching in those temperatures and company managers, as well as those at NASA, were later vilified for acting against this advice.

The launch had nearly happened the day before the accident, when technical problems led to it being abandoned during countdown and reset for the following day. Shortly thereafter, at NASA's request, Morton Thiokol engineers had a meeting about possible problems with the performance of the O-ring seals in the freezing temperatures forecast for the next day. There was a history of hot booster gases burning through O-rings, the most significant damage occurring on a shuttle flight in 1985, when the launch temperature had been the lowest on record, 53°F. Morton Thiokol engineers and management agreed they should not sanction a flight below this temperature. At a teleconference later that evening, however, under pressure from NASA to agree to the launch, Morton Thiokol took a 'management decision' to agree it should go ahead, in the face of their engineers' objections.

John Young, NASA's chief astronaut, in an internal memo following the accident said:

> "There is only one driving reason why such a potentially dangerous system would ever be allowed to fly – launch schedule pressure."

NASA was regularly criticised and ridiculed in the media and by politicians for launch delays and excessive spending. This particular flight had drawn a lot of media attention from all over the world because it was to include the first teacher in space, Christa McAuliffe. It does seem unlikely, though, with the attention of the world's media more intense than it had been for many years that NASA managers would have risked the flight, if they had any serious doubts about its safety.

Diane Vaughan, in her book, *The Challenger Decision*,[22] characterises this misplaced confidence in the safety of the mission, in spite of the clear technical advice to the contrary, as a 'normalization of deviance'. She tells a convincing story of how, since the Apollo moon landings, the history of NASA has been one of budgetary constraints which led to design trade-offs in the shuttle they would have preferred to avoid. In spite of the fateful decision, which with hindsight proved to be so disastrous, she also discovered many examples of cases where NASA managers had made very expensive decisions purely in the interest of safety. Crew training, launches frequently abandoned on safety grounds in spite of launch schedule pressure, huge numbers of complex procedures and safety checklists and the fact that they talked at length to Morton Thiokol on the eve of the launch point towards an organisational culture which clearly did not neglect safety.

Critically, after previous problems with the O-rings, the booster rockets had been tagged with a formal NASA 'launch constraint'. This meant the O-rings were a recognised safety concern serious enough to prevent a launch. Critically also, NASA had developed a formal 'waiver' procedure – a procedure that allowed NASA personnel to ignore normal rules and procedures, when they needed to. Under the waiver procedure five shuttle missions had proceeded, even though the problems with the O-rings were known.[23]

In these circumstances it is possible to see a false confidence in the safety of the O-rings developing. The argument is that it has not failed catastrophically in the past, so it will not do so the next time either. Hence Vaughan's conclusion that NASA slowly evolved into a state *where they had actual formal procedures allowing crucial safety issues to be ignored.* This she characterised as the normalisation of deviance. That any organisation should draw up procedures to bypass other formal organisational procedures, particularly those involving safety, might seem completely barmy but it is extremely common. It is a well known, ironically *unwritten* rule of every organisation that the way to bring the place to a grinding halt is to work to the letter of organisational procedures. This is why ‘work to rule’ is one of the standard tactics in the armoury of any union involved in an industrial relations dispute.

The Challenger shuttle type of situation always has multiple causes beyond the immediate technical failure or series of failures (in this case the O-ring, rocket fixture, out of control rocket, disintegration of shuttle). The organisation rationalised, and then tolerated serious safety problems due to launch schedule pressure, arising from the prevailing social, organisational, political[24] and economic environment. The disaster points to the immeasurable importance of informed decision making at the heart of complex systems.

Lessig’s constraints[25]

There are a lot of things to consider when making decisions about complex systems:

- Rational approaches
- Satisficing
- Values, relative power and agendas of the decision makers and stakeholders
- Thinking traps
- Complexity of the technology and the situation
- Decision criteria
- Time
- Dynamic (changing) nature of the situation
- People affected
- Law
- Decision making models (such as cost-benefit analysis etc)
- Decision environment (organisational, ecological, economic, social, political and physical).

How is it possible to gather them up in some kind of coherent way in order to make sense of them? Lawrence Lessig uses a fairly simple but powerful model. Lessig says there are four main constraints[26] on the decisions we make about how to behave:

- Law
- Social norms

- Economics
- Architecture or built environment.

To some degree we have already seen the effect of economics and social norms in the Challenger story but it is worth revisiting these in the context of Lessig's model.

Law

Government uses the law to dictate unacceptable behaviour. Law acts as a threat. If we break the law we may get caught and punished. For example, the law says cigarettes should not be sold to children. If someone sells cigarettes to children they can be prosecuted.

Social norms

Social norms dictate that a group of friends will meet in the pub every Friday night or that we should be polite in our dealings with other people. When I first came to the south of England to work I did not realise that strangers do not usually speak to each other on trains or buses. If I did attempt to engage someone in conversation I was often met with surprise or suspicion. Social norms, like the law, punish deviation after the event.

Economics or market forces

Market forces also regulate behaviour. The price of cigarettes should usually make them inaccessible to a child even where there are people prepared to sell them to children. The price regulates the behaviour at the time of the transaction. If children have no money, they cannot buy cigarettes through conventional outlets.

Architecture or built environment

'Architecture' or the built environment – i.e. how the physical world is – also regulates behaviour. If a room has no doors or other openings then we cannot get in or out of it. Architecture regulates behaviour when we are trying to engage in that behaviour. If a building has steep steps at the entrance and no other way in, it is difficult for a wheelchair user to enter the building unaided.

The idea of using architecture to monitor behaviour has been around for a long time. America's Pilgrim Fathers laid out their towns, buildings and town squares in such a way that the Puritan inhabitants could keep a constant watch on each other. For practising Puritans, at that time, allowing friends, family and the rest of the community to pry into their private lives was routine. Good behaviour in private was considered to be essential for society. Religious leaders believed people could not be trusted, however. Good behaviour would only be guaranteed if everyone was kept under constant surveillance and they knew they were being watched.

Combine these values, which still exist today, with the availability of pornography on the Internet and you get yourself a business opportunity. A company called NetAccountability, in the autumn of 2002, set up a service whereby people can have a morally upstanding friend or family member monitor their web-surfing habits. The monitor receives regular comprehensive reports of the websites that person visits. If someone is aware he is being watched he may think twice about visiting inappropriate sites.

Robert Moses was a prolific 20th century New York City planner.[27] He probably would not have had a great deal of time for one of the core messages of this book – the need to involve ordinary people in decision making about technological infrastructure. Moses was committed to getting things done and if that meant demolishing certain neighbourhoods to build roads then so be it.[28] He built highway bridges along roads to parks and beaches in Long Island which were too low for buses to pass under.[29] Hence certain parks and beaches were accessible only to car owners, many of them white middle class or wealthy. Poor people without cars, mainly African Americans, Latinos and other minorities, were obliged to use other parks and beaches accessible by bus. Hence social relations between the poor and the affluent were regulated – regulation through architecture.

It should be noted that Moses categorically denied that there was any racist intent on his part.[30] I make absolutely no claims here about his personal values but in one sense his intent is irrelevant: the architecture regulated behaviour, whether he intended it to or not. Complex systems often have unintended emergent properties. Changing things in complex systems also results in unintended consequences, sometimes negative, sometimes positive. Irrespective of the intent of the architect, therefore, architecture can regulate behaviour in ways not originally envisaged.

Constraints of the context – the built environment or the architecture – change or regulate behaviour in all these cases. Architecture is also self-regulating – the steep steps get in the wheelchair user's way because they are steep and they are steps. Once the architecture is in place it does not need someone to enforce constraints on behaviour. It does so by default. Laws, norms and markets, on the other hand, can only punish or regulate behaviour deemed unacceptable when a 'gatekeeper' chooses to use the constraints they impose.

Law, norms, economics and architecture regulate behaviour

Lessig's four forces – law, norms, market forces and architecture or built environment – operate together to limit or enable what we can or cannot do. In this model these four devices determine how individuals, groups, organisations or states are regulated. The four interact and can compete, just like the components in any system. One can reinforce or undermine another. If the price of cigarettes dropped to 10 pence a packet tomorrow, then more children would get access to them, regardless of what the law says.

Lessig's is a relatively simple but fairly powerful model for looking at decision making situations.

Proxies in decision making

Because it is impossible for us to do everything or understand every complex situation we face, we often employ proxies to make decisions for us. A proxy is a person or an organisation or a machine that acts on our behalf in some way.

We vote for politicians who subsequently sit in parliament where our laws are passed. The English Football Association appoints the England manager to pick the team to play in the World Cup. Organisations have proxy computers that act as gatekeepers between the company network and external networks connected to the Internet. The chef at the restaurant sources the ingredients in the food customers are served. Law enforcement authorities and intelligence services are our proxies in fighting serious crime.

Proxy decision makers present us with a problem, however. Even though they are making decisions on our behalf, we may or may not trust them. If the Irish team manager fails to get the team through to the World Cup finals we may lose confidence in his ability to choose the right team and employ the right tactics. Governments are often reported as being untrustworthy in the eyes of the public, especially in the wake of political scandals, such as political favours granted in exchange for financial donations to parties in power. Proxies have to earn our trust through success, transparent decision making, third party audits, experience, know-how and recommendations of people we do trust. Trust in governments for example is fundamentally dependant on transparency and the more a particular government resorts to secrecy, as in the case of Bernstein's cryptography program, the more likely it is that the general public will not trust their actions.

Proxies will not necessarily make the decisions we ourselves would have made faced with the same circumstances, since they have their own complex agendas, motivations and constraints.

Social technologies

NASA's procedures allowing a shuttle launch to proceed in spite of clear safety concerns could be considered to be a subset of what my 'systems thinking' colleagues at the Open University think of as 'social technologies'. Social technologies involve people, organisations and practices and mental and administrative frameworks and models for understanding situations, including language and numbers. They are often invisible and followed without question or awareness of their origins, or the need for contextual understanding because they form the fabric of our daily routines. I spent a proportion of my early days in industry, as a graduate trainee, documenting production processes. I would regularly ask why some procedure was carried out in a particular way. By far and away the most common answer I got was: "Because we've always done it like that." NASA bypassed their safety procedures because it was routine, so routine in fact that they had established a formal process for doing it.

Social technologies include laws, organisational procedures and rules to regulate behaviour. They can structure how we think and act and therefore determine how decisions are made. A hugely widely deployed (used and abused) numeric social technology is cost benefit analysis which we will look at later in Chapter 9. In the context of language, control of the language used in a decision process can be the key to controlling the outcome of that process. Language is rarely neutral in complex decision making situations. 'Intellectual property',[31] which is at the heart of some of the most contentious decisions in this book, is something of a misnomer, which might be more accurately described as 'temporary and limited intellectual monopoly'. Describing someone as a 'citizen' or a 'consumer' subtly defines their role. Social technologies therefore include the mental structures through which we view the world and hence we come full circle again to the personal values that shape our thinking.[32]

The Rio and the copyright lawyers: a DDM situation

In the mid-1990s Karlheinz Brandenburg's team at the Frauenhofer Institute in Germany invented the MP3 digital audio standard.[33] Then in 1998 Diamond Multimedia launched a hand-held digital music player, about the size of a pack of playing cards, called the ‘Rio’. The Rio could be used to copy and subsequently play music (or other MP3 audio files) from the Internet. There wasn’t much high quality music available on the Net at the time but this state of affairs was just about to change dramatically with the arrival of Napster, the peer-to-peer file swapping software. The Rio could also be used to record sounds directly in budding rock stars’ bedrooms or from CDs. The Apple iPod music player is often referred to as the ‘modern Sony Walkman’ but the iPod’s true digital ancestor is the Rio and it seemed to be a fairly uncontroversial innovation in the consumer electronics market.

The Recording Industry Association of America (RIAA) and the Alliance of Artists and Recording Companies (AARC) thought differently. To them this little electronic gadget was a threat to the future of the music industry and so they immediately deployed their lawyers to get the device outlawed by the courts. The theory was that if something like the Rio became widely available, it would encourage people to engage in widespread illegal copying of songs over the Net. Thus it had to be outlawed or at least hamstrung and delayed by legal action until the industry could work out what to do about it. They were right to be worried. Some years on there is a massive amount of illegal swapping of copyrighted songs over peer-to-peer networks like Grokster or Morpheus or Bittorrent.[34]

The Rio case was brought under a rather obscure US law,[35] which stated that companies selling ‘digital audio recording devices’ needed to pay a levy on each unit sold which would be distributed to copyright owners by the appropriate collecting society. The law also required that these devices should be designed and manufactured in such a way as to inhibit multiple serial recordings of the same source – so the machine could not be used to copy a copy. Diamond Multimedia had not paid the levy and the Rio did not incorporate copy-of-copy prevention technology, so the industry lawyers felt they had a pretty strong case.

Surprisingly, however, they lost the case in the appeals court on a legal technicality. According to the letter of the law, neither the Rio nor a computer hard disk[36] qualified as a ‘digital audio recording device’ and hence the music player was perfectly legal.[37]

This furore over the Rio was what first drew my attention to an obscure, complex and increasingly important area of legal doctrine for the digital universe, with the eye-glazing title ‘intellectual property’.[38] Intellectual property covers things like copyrights, trademarks and patents. As we come to live in an information-dominated economy, the legal regulations governing the flows of information, like intellectual property laws, are becoming increasingly important. Yet these laws, despite their direct effect on increasing sections of the population, remain in the esoteric domain of influence of a small number of trained professionals, lobbyists and businesses dependent on intellectual property for their revenues. That story forms a large part of the subject matter of the next two chapters and Chapter 8.