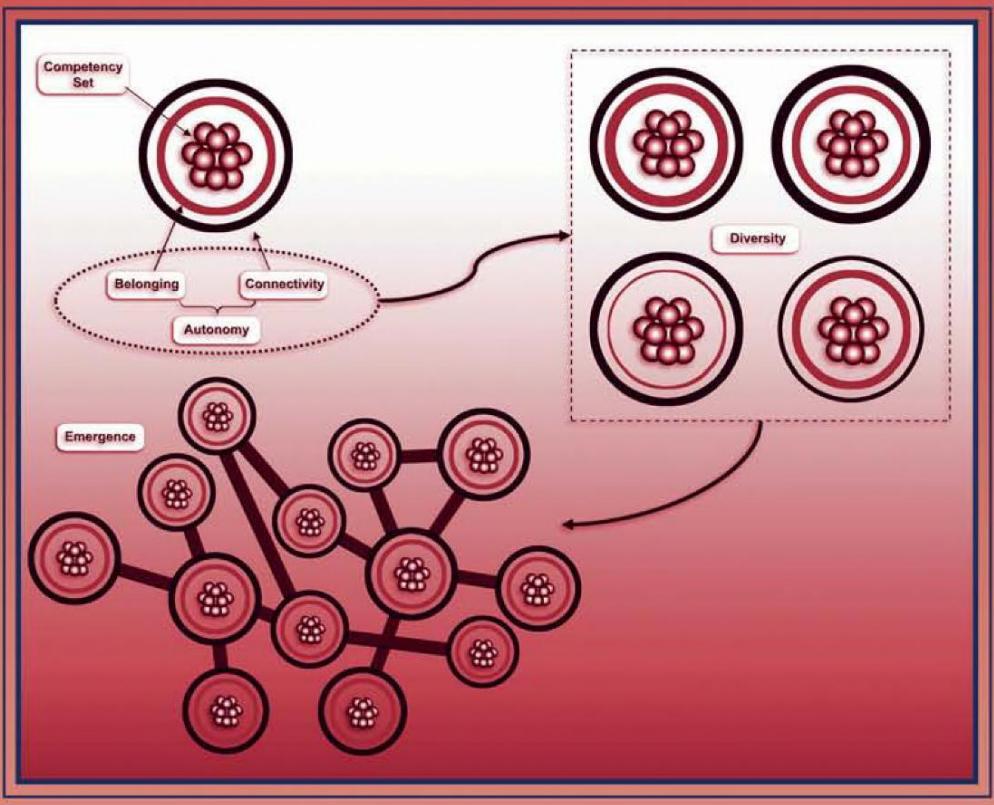
Systems Thinking

Coping with 21st Century Problems



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chapter one

Perspectives

1.1 If You Leave Me Now

Should the United States pull out of Iraq? Or should we stay? On April 9, 2003, Saddam Hussein's government lost control of Iraq as U.S. forces advanced into the center of its capital. In a symbolic moment, U.S. soldiers helped a cheering crowd of Iraqi citizens pull down a giant statue of the ousted president. After only a few weeks of fighting following the first missile attacks on the city it seemed as though the war was settled and over. On May 1, President Bush formally announced an end to the major combat operations, declaring that the United States had prevailed in Iraq. However, he warned that "difficult work" lay ahead.

Less than 3 months later the head of U.S. military operations acknowledged that attacks on the occupying U.S. troops bore the hallmarks of a classic guerrilla-type campaign. On August 19, a huge bomb demolished the United Nations headquarters in Baghdad, killing twenty people. It was a suicide attack, and a number of international agencies decided to pull their staff out of the capital. November 2 saw a Chinook helicopter shot down by insurgents, killing fifteen U.S. soldiers and wounding twenty-one more. On December 13, Saddam Hussein was found in a cellar of a farmhouse near his hometown of Tikrit by U.S. soldiers. It is an early Christmas present, bringing hope of a timely end to the insurgence, violence, and disruptions to a process of peaceful transition to Iraqi democracy. It is a false hope. In 2004, 849 U.S. soldiers are killed and a further 8,002 wounded. The year is long and bloody. The targets widen. On March 2, 180 Iraqi Shias are massacred in the cities of Karbala and Baghdad as they seek to celebrate the climax of a holy ritual.

The following year gets off to an ominous beginning. On January 20, an audiotape apparently made by one of the insurgency leaders, Abu Masab al-Zarqawi, warns the fight against U.S.-led forces could continue for years. The tape, posted on an Islamist Web site, denounces Shia Muslims for fighting alongside U.S. troops in Iraq. A report issued in July 2005 estimates more than twenty-five thousand Iraqi citizens have been killed since the start of the war in 2003. Based on media reports, the dossier attributes one-third of these deaths to U.S.-led forces. One month later, one thousand Shia pilgrims are killed in a stampede in northern Baghdad. Panic spreads alongside the rumors of suicide bombers in their midst. It is the largest loss of life in a single incident since the invasion. December 15 saw a huge turnout for voting

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in the elections across the country for full-term government. It is Christmastime and hope returns.

But on February 22, 2006, two men blow up the golden dome of the al-Askari shrine in Samarra, one of the holiest sites in Shia Islam. The year is marked by the execution by hanging of former president Saddam Hussein, found guilty of crimes against humanity. But the death toll for U.S. soldiers has passed three thousand and the Baker-Hamilton report is published recommending a change in policy.[1] The makeup of Congress has changed following elections in November. The Democrats control the Senate and the House and President Bush finds the war in Iraq is now being fought out on Capitol Hill. Those first shots fired in early 2003 are now ringing around the White House itself.

It is 2007 and the American people are war weary. They want their men and women in uniform to come home, their blood no longer to be shed, and American treasure to be directed to better ends. What is your perspective?

The question of Iraq is an emotive one. People feel strongly about it and differently as to what to do. When emotions run high, it is at the risk that intelligence will drain away. So much bloodshed, so little progress. Such a strategic location. Think of the oil, think of democracy, think of freedom. Think of lives lost, think of contracts gained. Think of the future of America and stability in the world. Think of war as the continuance of negotiation by other means. Think of the dead, think of sacrifice. Think of terror. Think.

Systems thinking is a deliberate attempt to think when thinking itself is put at risk by emotion, confusion, and confrontation. When the thinking process is being assailed and overwhelmed by debate, opinion, doctrine, and information, systems thinking stands in the breach and says, "I can help."

Systems thinking does not suppress or supplant perspectives; it adopts them and finds sense in their multiplicity and diversity, their surprise. It does not guarantee success, but it does make thinking possible when that seems impossible. Systems thinking asks, What systems are involved here? And when we find those answers to be unhelpful, it asks, What kinds of systems might be involved here that we have not thought about before? To answer that question, systems thinking has to come up with some new ideas, concepts, techniques, and tools. Our book presents the choicest of these and illustrates their application to problems as large as Iraq and as familiar as children's puzzles.

We begin with taking a closer look at perspectives, at what they mean and what they might mean. We look at four distinct but interrelated areas in which perspectives arise. First, we have the area of *choice*, where there is a decision to be made, a route to take, and of all those choices that compete for our favor, only one can be made. The choice may be clear or unclear, and multiple perspectives are offered to support one choice or another. Second, there is the area of *both*, in which every single perspective is valid and each must be treated with due respect (and diligence). It is not a case of which of these is correct, since quite conceivably the candidates may be opposed,

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but rather a question of "What is the correctness of the simultaneity of all these perspectives?" Third, we look at the odd case of the inverse whereby if one perspective is volunteered, an opposite immediately arises. This may be the case where people who are continually diametrically opposed will look for an opposite purely to continue their antithetical behavior. Or it may be an important dialectic to exercise whereby suspension of belief in our own correctness helps us remove any unseen or unfelt blinders and see things differently. Lastly, there is the area of paradox to which we later devote an entire chapter. In this case, perspectives both support and oppose one another, making it peculiarly difficult not to dismiss them out of hand for being deliberately frustrating and distracting. And yet, paradox holds an intrigue beyond which lies the hope of greater wisdom. It is helpful but increasingly rare when situations arise that fall neatly into one of these categories, except perhaps the paradoxical one. But the complex issues, and systems, we encounter today, and more so in the future, do not fall neatly into one category. They are an intricate interweaving of all of them, at many different levels and with multiple facets. But just as electronics engineers know how to build any digital logic circuit from a few simple gates—*or*, *and*, and *not*[2]—so we suggest that complex situations can be accessed by these areas of perspective.

1.2 Areas of Perspective

1.2.1 Or

The Mississippi River is one of the world's major river systems in size, habitat diversity, and biological productivity. It is the longest and largest river in North America, flowing 2,315 miles (3,705 kilometers) from its source at Lake Itasca in the Minnesota North Woods, through the mid-continental United States, the Gulf of Mexico Coastal Plain, and its subtropical Louisiana Delta. *Mississippi* is an Ojibwa (Chippewa) Indian word meaning "great river" or "gathering of waters"—an appropriate name because the river basin, or watershed, extends from the Allegheny Mountains in the eastern United States to the Rocky Mountains, including all or parts of thirty-one states and two Canadian provinces. The river basin measures 1.81 million square miles, covering about 40% of the United States and about one-eighth of North America. Of the world's rivers, the Mississippi ranks third in length, second in watershed area, and fifth in average discharge.

The Mississippi River and its adjacent forests and wetlands provide important habitat for fish and wildlife and include the largest continuous system of wetlands in North America. The river supports a diverse array of wetland, open-water, and floodplain habitats, including extensive habitats on national wildlife refuges. Yet human activities have greatly altered this river ecosystem. Most of the river and its floodplain (defined as the adjacent, generally flat surface that is periodically inundated by floodwaters overflowing

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a river's natural banks) have been extensively modified for commercial navigation and other human developments. Much of the watershed is intensively cultivated, and many tributaries deliver substantial amounts of sediment, nutrients, and pesticides into the river. Pollutants also enter the river from metropolitan and industrial areas. Some of the great U.S. cities that lie along the river are Minneapolis, Memphis, and New Orleans.

Now here is the point—how do two communities separated by such a river form a connection? This is a challenge, a puzzle really, typically thrown at a class of students to exercise their ingenuity while exhibiting a degree of realism bounded by their experience, expertise, and enthusiasm. Of course, it is that very experience that they call upon to nominate candidates, for example, a bridge or a tunnel. Others that we have heard in our time include ferries and hot air balloons. No one has seriously pursued the choice of human cannonballs. One surprising nomination was "divert the river." While this choice is not in the same league as the suggestion that it is better to lower the Atlantic than to raise the Titanic, it does betray a trait of passing the problem onto someone else as opposed to dealing with the one that you face. However, whatever candidate is chosen, the connection of the communities will produce new problems for both—that is the nature of systems. While many candidates can be identified, only one of them is to be pursued. The problem is deliberately framed as an *or* perspective even though in principle a multiplicity of connections can be supported and inevitably are, for example, the Ben Franklin and Walt Whitman bridges that span the Delaware joining Philadelphia with its New Jersey neighbors. Our focus is on what thinking is called for in addressing the *or* perspective.

One thing we have to think about is to be able to generate the choices or candidates. No one really knows where an idea comes from let alone what makes a good or original idea, but we do know that they appear. Some ideas come from past experience—it is just a matter of memory retrieval. But where do the new ideas come from? How can you think of things that you never thought of before? Clearly, a second thing to think about is how to select a candidate from the many that compete for our attention. Engineers love to talk about metrics and criteria and trade-off studies, and this is all very useful equipment that they bring to their domain and from which other disciplines, given some abstract thought, can possibly make good use of also. These two things—identification and selection—seem to be prime foci for whatever thinking we do. A third focus, sadly too often overlooked, is that of considering the need rather than merely accepting it as a given. In other words, what are the needs of these communities to be connected? What drives this? How persistent is it? Can it be expressed differently so that the overriding notion of physical movement between the two communities is not the only influence on the identification process? Also, what are the constraints these communities put on the satisfaction of that need? These are not only applicable to the selection from a list of candidates, but they are also influential on the generation of the candidates' list. So if someone can say

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"Let's divert the river," which effectively forms a single community since the interposing dry land can now become common ground, cannot another say "Move community B to the other side of the river and join community A in a new adventure"?

These then are three foci for our thought process: profiling the need, identifying the candidates, and adopting a selection mechanism. And for systems thinkers these thought foci *interact*. They are parts of a wider system. They have relationships, such that changes in any one can affect others, and in ways that might cause the relationships between them to change. And it is the whole of these foci, whatever that might be, that constitutes the system of thinking. And we are not speaking of only the instantiation of this system for a given example—the need for two communities separated by a river to have connectivity. We are interested also in the exploration of this system of thinking at an abstract level so that we might be better prepared for the particular problem itself when it comes along, sometimes in ways that are suggestive of past *or* perspectives and sometimes not. That is how the *or* perspective itself becomes better known or more accessible to refinement.

1.2.2 And

We both played sports as kids. Two different types of football at least. The real deal (soccer) and the American version of football. We also remember those coaches' talks at halftime when our teams were losing badly and something needed to be done. Great coaches diagnose the problem and know what the solution is—maybe a change in tactics, or a key substitution, or a change in roles for some players, or more aggression, or singling out one or two key players from the opposition and putting them out of the game (safely, that is). Whatever it is, you do not know if it works until the final whistle, and by then it is too late. But whatever our differing experiences we do agree on this point—great coaches listen to their players; they get them to talk and to say what they think is wrong, what changes need to be made and why, and how to put those changes into effect. All of this takes place in the heat of the all too brief interlude with passion, when people are frustrated and maybe hurting from bruises, and a sense that everything is at stake. The value of listening is that people give vent to their emotions, they are heard and respected, and they hear one another. Whatever comes out of that mix, there is buy-in and a renewed commitment to do things differently, to make change work, and to refocus on the one goal that all members of the team share: victory.

What is true for sports, including games of sheer inconsequence, is also true of government cabinets. Is it halftime in Iraq or are we close to the end? What does the cabinet think? More precisely, what does each member of the cabinet think? What are they telling the president? And what sense does the president make of this collective wisdom. What buck does he get?

From changing room to cabinet room to chamber room. Different venues, same situation. Four blindfolded men are led into a chamber room to sense

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one single object. They cannot see what the object is, but they can touch it, smell it, and hear it. They occupy different parts of the room and sense different parts of the same object. After a little while they try to make sense of what they discover. The first person concludes the object to be a spear—having felt something long, hard, and with a sharp point. A second person concludes differently. He senses a snake. True it is long, but it is not rigid; it is flexible and swishes around. He thinks the sound he hears is that of a hissing, but maybe it is the swift movement of the object itself. Not a spear, not at all. The third man differs, yet again. He believes the object to be a fan. Where he is stood there is an unmistakable draft and the drumbeat noise he hears is surely that of an oscillating mechanism, a fan. Lastly, the fourth companion makes his judgment known. It is none of the above. It is a pillar. It is tall, circular, and solid. A sturdy object, and maybe there are three more, one at each corner, the collection clearly capable of bearing a huge weight collectively. Four reports, zero eyewitnesses, but each given with accuracy and confidence with conclusions that could not match less. Who or what is in the chamber room?

Some readers may know the "answer" to this little puzzle. We congratulate them, but we further challenge them to change their mind, to come up with something new, to not be satisfied by simple memory retrievals but to learn what the puzzle is really all about. Others may not know. We want to help them find an answer. Equally, we would like to be able to help President Bush or the team losing at halftime to come through at the final whistle. The way we know to do this is to find the *thought foci* for the *and* perspective.

The prior existence of the thought foci for the *or* perspective is a help here. With these we settled on three entities: candidates, need or objective reality, and choice or discriminating mechanism. The candidates had to be generated or conceptualized. The need or objective had to be validated to ensure that the work in generating candidates did not prove nugatory. And the discriminating mechanism had to be developed, something by which the candidates could be prioritized or differentiated in order to select an optimum. These entities have reuse value in the *and* perspective. But the verbs that apply to them change.

There is no shortage of preexisting candidates. There are at least as many as there are sensors (in the case of the chamber room), advisors (in the case of the cabinet room), or players (in the case of the changing room). Sensors, advisors, or players—one might refer to these as types of stakeholder, an entity that has a valid role to play. So it is not a case of generating these but rather validating them. Does what the sensors conclude make sense? Is what an advisor has to offer, essentially a subjective assessment, of value in the mix? Can what a player brings to turning the game around work, given what others think? Our first thought focus for the *and* perspective then is the validation of subjective statements.

In the same way, the prior need or objective reality does not exist for the *and* perspective, whereas of course it did and was to the fore of thinking with

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the *or* perspective. This leads us to conclude that there is a thought focus to deal with the generation or synthesis of a need or objective reality based upon the validated subjective viewpoints or candidates available a priori.

Finally, there is a thought focus that provides an integrating mechanism whereby the validated candidates can be synthesized into a single objective reality or need that singularly makes sense of the variety of viewpoints available. By contrast, the *or* perspective required a differentiating mechanism to distinguish the candidates that allowed some prioritization or filtering of the less attractive from the optimum.

In summary, therefore, for the *or* perspective the foci are generate candidates, develop differentiation mechanism, and validate the need. For the *and* perspective the foci are validate candidates, generate the need, and develop an integration mechanism. If that helps, go ahead and motivate the football players, assist the embattled President Bush, and identify the mystery object in the chamber room. But if you need more guidance, and we suspect you will, this book is for you.

1.2.3 Not

We are all quite familiar with contrary behavior. Sheep that will not be herded, subordinates who will not conform, infants who refuse to eat their food. It is as if the very thing you want these miscreants to do they stubbornly refuse and do the exact opposite. Sometimes you have to offer them the opposite of what you want them to do in order to get them in line with your true goal. Lenz's law is a beautiful illustration of this perversity. Insert a bar magnet into a conducting cylinder wrapped in a coil of wire and this will induce an electric current in the wire that then produces an electromagnetic force that opposes the bar's insertion. On the other hand, withdraw the bar magnet and a second current is induced, flowing in the opposite direction, creating a second induced force that resists the bar's withdrawal. This laissez-faire attitude might work toward errant infants, but we do not find much evidence of cats that are left alone conveniently herding themselves into a paper bag! Not all *nots* are consistent!

The *not* perspective is a case where one point of view held by a stakeholder is inverted and a contrary point of view adopted by a second stakeholder. This can occur in a football team or president's cabinet, but it does seem to represent a sad loss of franchise, on both sides.

For example, on the issue of withdrawal of U.S. troops from Iraq, it is argued that to post a timetable is simply to invite the enemy to hunker down, bide their time, and, when the United States has gone, continue their aggression at even higher levels of atrocity, presumably until they have achieved their goal. So what our enemies want is for us to withdraw. Accordingly, that is precisely what we should not do. Does this constitute a loss of vote? We do what our enemy does not want and do not do what our enemy does want us to do? So our enemy does not want us to stay in Iraq? If this is true, he is

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certainly gaining much from what he does not want: the ability to increasingly improvise IED warfare; the ability to propagandize on the success of that; the ability to demonstrate to a watching world that guerrilla-type warfare is incessant, relentless, and tough to beat; the ability to expose the relative impotence of the world's sole surviving superpower in the face of what is mildly termed an *asymmetric threat*. None of the foregoing constitutes a sufficient argument for withdrawing, but it does show a complexity in contrast to what an elementary rendition of the *not* perspective would belie.

But this perspective is not without merit if one handles it correctly. For example, it can be exceedingly useful in the case of assumptions review. Consider the following account:

> Greg and Tracy lie dead on the floor. Eyes wide open. Near the lifeless bodies are small puddles of water and pieces of broken glass. But there is not a trace of blood to be found. Further chards of glass lie on a table that sits beside an open window. A casement swings to and fro as the breeze blows, fluttering the curtain. How did the poor couple meet their death?

In order to come up with a reasonable explanation for the demise of Greg and Tracy, we have to be able to piece together the evidence that is available and our own case experience of crime reports that bear similarity to the situation described. Inevitably we will make several assumptions and proceed further on the basis of these at risk. The question we now pose is: What assumptions do you make as you navigate this scene? Make a list, as tedious and pedantic as this may seem. Then use the *not* perspective on one or more of these assumptions. We are not going to give you our answer, but we will give you a clue.[3]

So what are the thought foci for the *not* perspective? Well, the entities we have worked with so far can serve us again—candidates, need, and mechanism. In this case our candidates need to be identified in terms of making explicit what assumptions we are relying upon to meet our need, or perhaps to counteract the opponent's need or goal. We may even have to make explicit what we believe our enemies' assumptions are. The mechanism we need for the *not* perspective is tantamount to inversion, though it is not clear what that might yield. Some *nots* are not so obvious. What this does is to produce a variety of different needs and perceived needs of the enemy. The entities interact, as should all elements of a system, and produce a different approach to the initial set of need, goals, and assumptions. None of this takes away the need for intelligence, experience, and common sense, but it does perhaps give those things a better chance of resolving the problem, solving the puzzle, or unraveling the situation.

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1.2.4 Paradox

We come to the final kind of perspective and by far the most intriguing. It is a case of *and* and *not*. Just to complicate matters, it is also a case of *not or*! This case makes us think more than any other. The risk is that the thinking will do us no good and so we reject it as pointless and unfruitful. The true test this perspective brings is whether we withdraw from it or find a way through it. Our development of foci for the previous three perspectives will hopefully find more useful service and so help us find a way through.

Here is something to think about. Consider a sheet of paper that has writing on both sides. On one side appears this statement: "The statement that appears on the other side of this sheet of paper is true." No ambiguity there. We turn over the piece of paper and find a second statement: "The statement that appears on the other side of this sheet of paper is false." Once again, a simple, clear statement. But wait. If that second statement is true, then the other statement, the first one, is false. Correct? In which case that first statement is saying that the second statement is false! But we just asserted it to be true.

Let us start again. Take the first statement to be true. If that is the case, then the second statement is true. But if the second statement is true, the first statement has to be false. But we just ... and so we get lost once again. How can such ambiguity arise when there is none in either statement? Is it possible to get something from nothing? Put another way, can the whole be greater than the sum of the parts? There is a whole here and it is not just the sheet of paper. The whole is identified by the fact that these statements relate to one another, they refer to one another. So there are parts (each statement), there are relationships (what each part says about the other), and there is now a whole. And that whole is (an example of) the *paradox* perspective.

Paradox is the subject of an entire chapter, so our purpose here is necessarily confined to its essence and to its representation in terms of perspective. Moreover, we pose the question: How often do we find among multiple perspectives the potential for paradox? That being the case, do we reject the "offending" viewpoints because we do not want to face this unnecessary mystery of paradox, or do we esteem these in particular and look for wisdom from above, deeper insights into the situation that gave rise to these viewpoints? Accordingly, we represent two examples of a paradox and attempt to get some better handle on the meaning of this perspective.

Our first example typifies the impossible versus the imperative. Engineers may be familiar with this in that they often do the impossible dictated by their superiors or customers. On a more conceptual level, take the case of a flea leaping across a table by making jumps that bifurcate the distance yet to be covered. After one leap the flea is halfway. After two leaps there is only a quarter of the table to go. Three, four, five leaps and the flea is considerably nearer. The situation seems to be that he must surely get there but equally he needs to take an infinite number of leaps. From an imperative standpoint the

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flea must surely get there—there is nothing to stop him. But can an infinity of steps really be taken, in time? This paradox is solved by a brilliant piece of mathematics, the concept of the limit, which gave birth to calculus in the late seventeenth century, and for which all high school math students remain eternally grateful. But that calculus has not always been available to us. It took a leap of imagination into hitherto uncharted territory. It was wisdom from above, rather like the proverbial apple that allegedly fell on the head of Sir Isaac Newton, whose genius is credited for the invention of calculus.

A second example brings two very powerful forces into conflict, which so often happens, judgment and mercy. In civilized society we go to great lengths to legislate and to make effective judgment in accordance with law. When we abandon law we risk our very selves. But as our minds struggle with the formulation of law, including the appropriate penalties commensurate with the guilt of an offense, we have a deep inclination toward mercy, which is the deliberate setting aside of judgment. It is not a case of either-or, though we may make that choice; it is a case of both, and yet the paradox is you cannot have both. They rule against one another. It takes great wisdom to wrestle with both and come through the other side, as opposed to making a choice and possibly missing this access to wisdom. A superb illustration of this wrestling comes from a person famed for his wisdom, King Solomon. When confronted with a case in which two women laid claim to a newborn babe his decision was to divide the child in two and give half to each claimant. This judgment evoked mercy. While one woman remained silent, accepting the king's decision, the real mother cried for mercy and gave her precious child over to the other woman. The king knew that only the real mother would be willing to sacrifice her child to the false claimant rather than to the sword. Accordingly, he gave the child to this woman. Mercy triumphed over judgment, but only because the dilemma was confronted and wisdom afforded an entrance. Thank God for paradox, calculus, and wisdom.

1.3 *Perspectives on Google*

We both know a lot about Ph.D. students. Among the many we have been privileged to mentor some have been quite outstanding. In one case two students, who had been close friends from early childhood, after graduating went on to form a software company specializing in statistical process control for manufacturing enterprises. Today they are millionaires though their company's technical expertise does not relate to their Ph.D. work.

The Ph.D. process is not about getting another degree. And it is not about doing research. It is not even about developing leading-edge expertise to make your fortune, although few would pass up this opportunity. For us, the process is really all about the development of character. Over 3 to 6 years, depending on the circumstances, the intellectual challenges hurled at a Ph.D. student ensure a person's character gets developed. Resilience gets built in so you learn to take the knocks and come back swinging. Maybe even an agility

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gets embedded so that you learn to avoid a lot of the knocks by anticipating what is to come and making whatever reconfigurations are needed to swing around the blows and move on to higher ground.

We would like to turn our attention to two former Ph.D. students in the Computer Science Department at Stanford University: Sergey Brin and Larry Page. Both young men came from academic parents. Stanford is world renowned for its scholarship and entrepreneurship. One of us once asked a Stanford professor, "Can you get tenure on arrival here?" He blinked wondering whether it was a serious question and then reposted, "Yes. If you can walk on water." Some Stanford faculty may not be able to do this literally but in many fields they do it equivalently, and they are a mighty role model for their Ph.D. students. Page and Brin may not be walkers on water, but they were pretty good surfers, and in their own way they got out of the boat like Peter did.[4]

For some time the two had collaborated on search techniques to help users locate information on the growing World Wide Web. They published a paper outlining their algorithmic designs called Page Rank (it had started out life as Backrub) and had the benefit of their own university preferring this search engine for its own needs. The Office of Technology Licensing (OTL) at Stanford is no slouch. It exists to promote good ideas, borne of the outstanding thinking from students and faculty, in the marketplace in order to make money and allow faculty and students to concentrate on scholarship. The boys approached Stanford's OTL with their designs, which then promptly set about a brokering project to sell the IP, make some money for Stanford and the boys, and then let them get on with their Ph.D. programs. Alta Vista was offered the search technology for $1 million but turned it down. The boys were disappointed. Not so much by the loss of potential income but because the world was being denied an opportunity to benefit from their endeavors. So committed were they that they took the monumental decision to suspend their studies and leave the program to set up in business for themselves. Today the company built on that technology is worth over $200 billion. It is Google, Inc.

The phenomenon that is Google is nothing short of miraculous. From nothing to bigger than GM in less than 5 years. That gets people's attention. The Google story is today well told by many, and David Vise[5] has been our preferred narrator. Tales of Stanford venture capitalists dropping in $100,000 checks to the boys when they had no business model, and not even a bank account into which to pay the money, charm the senses. Spice is added when you consider that person's investment today is worth perhaps $500 million. We'd all take out a second mortgage to make a bet like that, but how would we recognize what Andy Bechtolsheim saw? We may be taking liberties here, but we want to suggest that some systems thinking went on in the development of Google, and with that as a lens, we explore more closely those elements that seem to us to be crucial to that success, and how perspectives played a part in the creation of those elements.

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The first perspective concerns the structure of the Web. The prevailing notion was that it had no structure. How could it have? Anybody could join at any time in any way that worked for him or her. Standards and protocols applied for connection purposes, but as for central governance of the Web, its growth, the relative importance of Web sites, and so on, no structure was imposed and none could be said to exist. In such a case how could it be possible to be algorithmic about searching for information? The idea seems doomed at the outset. Along come Brin and Page. They believed there is a structure and their designs exploited this. That structure is similar to the citation of published work that is so familiar to academics and scholars. To show competence in a field you have to know what is being said, what papers are being published, and what the value of that work is. As part of any paper, references are made, intelligently in the body of the text, so that other people's work is cited. The good work is cited more often. So to demonstrate good work yourself, you are expected to cite the good work already out there. This, the boys believed, was the way the Web worked. Web sites cite other sites. The more the citations, the more important it can seem that cited site is. It becomes even more important if it is cited by the important sites. This became the basis of the search technology Page and Brin developed and remains that way today. This makes the Google site the one to use, the site to cite. And it comes down to being farsighted. It is about perspective, and the boys showed they had it more than most. They set out on their systems thinking course of assumptions busting and thought inverting, charting a way that millions follow today, and laying a foundation for a brilliant business model.

One of the premises that we believe Google assailed is that of ownership. Once again, the received wisdom was that this comes from a sale. For example, a person walks into a shop carrying a purse or wallet laden with credit cards and cash. She sees something she wants and buys it. You get her money, she gets the goods. You once owned the goods, but now you don't. She does, and you have her cash. That is how it works. That is how ownership is transferred. It is "How to Sell and Buy 101." Not for Google. It decided to sell nothing. Instead, it sought to serve for free. The customers pay Google nothing. Customers love that, and Google is rather happy too. It gives Google a warm feeling. It also makes the company a ton of money. How? That is the second example of Google's radical business model.

In the first example people left with their newly bought goods, some of the money no longer in their wallet and the rest still in there for the next shopkeeper. In the Google model, as people leave with no goods to speak of, they leave behind some of their money without even noticing it. It is the digital equivalent of the Artful Dodger,[6] who knew how to pick a pocket or two. Not all Google customers fall into this category. Only those who visit the discreetly located and subtly termed sponsored links located on the right-hand side of the search results page that Google provides in response to a user's queries. Every time someone clicks on one of these sponsored links

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