How Breakthroughs Happen

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Introduction

There are common misconceptions about technology. We tend to think about technologies as hardware or software, nuts and bolts, the purely physical objects that come to our mind easily. But these objects are themselves deeply enmeshed in particular networks of people, ideas, and other objects. It is these relationships among people, ideas, and objects that constitute technology. Technology can be defined as the arrangement of people, ideas, and objects for the accomplishment of a particular goal. These points are covered in Andrew Hargadon's fascinating book, "How Breakthroughs Happen."

The Business of Innovation

Existing technologies are unique combinations of three elements. The objects are hardware and software. The ideas are an understanding of how to interact with those objects. And the people are those who know the ideas and objects. Their experiences give them the tacit knowledge that makes the ideas and objects work effectively together.

Breakthrough innovations cause networks of people, ideas and objects to shift dramatically. People, ideas, and objects form new relationships seemingly overnight. New technologies make obsolete the complex organizations and markets that have grown up up around these combinations of ideas, objects and people.

Innovators are no smarter, no more courageous than the rest of us – they are simply better connected. They find ways to exploit the networked landscape. So they are able to innovate continuously by seeing and making connections between people, ideas, and objects from across the broader landscape.

By focusing on networks, rather than their solitary genius, we can learn a great deal about the innovation process. Hargadon introduces the term technology brokering in this context. Rather than producing fundamentally novel advances in any one technology or dominating any one industry, technology brokering involves combining existing objects, ideas, and people in new ways.

Technology brokering relies not on breaking from the past and inventing something new, but instead on leveraging the knowledge and efficiencies that reside in elements of existing technologies. Hargadon introduces another term to describe this practice - recombinant innovations. By working in a range of different industries or markets, firms can see when the people, ideas, and objects of one world can be combined in new ways to solve the problems of another. For these companies, innovation is not the process of thinking outside of the box so much as one of thinking in boxes that others haven't seen before.

Technology brokering also involves building new communities around those innovative recombinations. The pursuit of innovation changes dramatically when the goal shifts

from invention to inventive recombination, from pushing people to think outside of the box to helping them think in other boxes. But what makes recombinant innovation difficult, is that the elements that make up existing technologies do not come apart, nor come together again, very easily. As Albert Szent Gyorgyi, the Nobel Laureate once remarked, "Discovery is seeing what everybody else has seen, but thinking what nobody else has thought."

Another point which Hargadon emphasises is the crucial role of marketing in innovations. He argues that good ideas do not necessarily sell themselves. Here, he quotes Winston Churchill, "having a good idea is not the end; it's not the beginning of the end; it is the end of the beginning."

Hargadon also quotes Louis Pasteur, "In the field of observation, chance favors only the prepared mind." At first glance, Pasteur's dictum promises a means for harnessing chance events – the prepared mind. But this approach does not increase the likelihood that such an event will happen. Moreover, a prepared mind can sometimes be the last one to recognize the value of a novel recombination. Here, Hargadon quotes novelist Robertson Davies, "Knowledge makes you wise in some ways, but it can make you a blindfolded fool in others."

Bridging Small Worlds

The strategy of technology brokering can take many forms in practice. But two central activities remain the same: bridging distant worlds in order to see new ways of combining existing but previously distant people, ideas, and objects, and building new networks between and around these new combinations.

Bridging distant worlds brings organizations into contact with the wide variety of already well-developed technologies that exist in other worlds. Also, the act of bridging distant worlds actually changes the way people see and think about the worlds they inhabit. In this way, bridging activities overcomes the parochialism that hinders individuals, groups, organizations, and even industries from seeing the value of people, ideas, and objects that reside outside their traditional boundaries.

The skills required to bridge distant worlds and generate novel combinations are ill suited to the focused process of building new worlds around such innovations, while the skills required to build new worlds are ill suited to searching widely for alternatives. Firms in pursuit of innovation must learn to develop both types of skills.

People do not suddenly come up with new ideas. They piece them together from what they already know. People often fail to come up with a new understanding of what's happening, new ways of dealing with problems, when they lack the wide-ranging set of ideas from which to piece together alternatives.

The trick is to develop in-depth knowledge within a given field but, at the same time, develop the willingness to take that knowledge apart and combine it in new ways. This is difficult because, people are reluctant to abandon their old knowledge. Bridging distant

worlds provides a way to acquire knowledge without acquiring the ties that typically bind such knowledge to particular worlds.

On the one hand, knowledge represents the raw materials for recognizing and creating radical innovations. On the other hand, knowledge also represents the old ways of thinking that prevent people from seeing new opportunities.

The paradox inherent in the innovation process is that innovators need wide-ranging ties across distant worlds to generate the innovative ideas in the first place, yet they also need strong, focused ties to build communities around emerging innovations. Firms must commit resources to both. The answer is not to resolve the paradox, but rather to appreciate what each seemingly conflicting goal provides the organizations. Bridging brings the people, ideas, and objects of distant worlds into the organization and into new combinations. The next step is to build new worlds around these new combinations.

Building New Worlds

Construction of webs around emerging technologies is a central part of the innovation process. An innovation emerges when one or a few people recognize the potential in an idea or an object for uses beyond what's already been done. They share this vision with a few others. Those others collectively contribute their own ideas and their own skills, and by doing so push the idea along and encourage each other to push even further. They pitch the idea – maybe to a manager or potential investors, who add yet more resources, and to other interested colleagues, potential suppliers, or retailers. Over time, a community begins to take shape which is connected around the emerging technology. The efforts of this growing community accelerate the evolution of the new idea, and their diverse perspectives push it in new directions.

In the beginning, these webs create collectives – usually small groups of people working closely together, sometimes in collaboration and sometimes in competition. Over time, these same webs turn into larger communities whose tight-knit interactions propel the new technology forward.

Most of the actual improvements in the productivity and performance of a new technology take place in use – and long after "individual investors" have lost control of their ideas to the commitments that are forming around them. As communities grow around new technologies, they create the necessary feedback loops that sustain them.

Building new worlds from the pieces of old ones means creating meaningful and valuable links between previously unconnected people, ideas, and objects. Technology brokering relies on building these new networks to both generate and build on innovations, first in creating collective ventures and then in establishing self-sustaining communities. These links must be meaningful and valuable to the others who might enlist in the cause.

The risk in building these new networks lies in losing ownership of the very innovations at their core. Some of this risk is simply a vestige of the cult of the inventor. It's hard for

individuals to seek out and build collectives when they think the path to greatness requires going it alone.

Organizations in pursuit of innovations must learn to build new networks around their emerging ideas without losing control of them. Like the activities of bridging, there are no certain recipes for success. There are no clear rules for how much is enough and how much is too much. Every situation is different, but a clear appreciation for the role of collectives and communities is the right place to start. Collectives build a common belief around a new venture that is necessary to overcome the resistance of tradition. But that common belief becomes a closed mind over time. Teams first become more productive as they find out about each other's skill and the right ways to put those skills together, and then become less productive as they become fixed in their ways and begin to think that they know all there is to know about their field.

Skunkworks are a means to circumvent the bureaucracy, the politics, and the short-term goals of the larger organization in order to build a collective that works closely together. But, skunkworks also severe the team's connections to the rest of the organization. Ultimately, skunkworks need the rest of the organization to embrace their innovations. With few links between the development group and the rest of the organization they face a different challenge: getting their ideas heard at all. Thus, part and parcel of building collectives and communities is knowing their limits: when they can become too insulated and when they should be dismantled.

What sets apart, the great innovators, is the realisation that innovation requires not just a new idea but also the collective effort necessary to make that new idea work against the doubt and uncertainty of the process. The world will not beat a path to your door. Instead, innovation requires building a community of like-minded and wholly committed individuals who see their shared future in the success of the emerging technologies and industries.

As Hargadon puts it, "So to succeed, the technology brokers actually must walk a delicate line between establishing the broad-ranging networks required to see and recombine valuable new ideas across a range of industries and, once new innovations are constructed, building the necessary collective action and community around those innovations. Technology brokers must pursue strategies that put them on the periphery of existing worlds, yet retain their ability to become the core of new ones."

Technology Brokering in Practice

By working across many different worlds and building network connections, firms increase the chances that they will see solutions in one world that solve the needs of another. By remaining on the periphery of these different worlds, rather than committing to any one, they avoid the need to limit themselves to working with only one or a few problems or technologies. Consequently, they retain the flexibility to mix and match the many problems and solutions they come across.

Such strategies ultimately boil down to a few key decisions that managers must make about their firm and their markets: whether to (1) commit themselves to a full-time strategy of technology broking, (2) remain focused on the markets and customers they serve but create groups within their bounds that are focused on bridging worlds and building recombinant innovations, or (3) develop the ability to recognize and seize one-time opportunities for brokering.

The entire firm can dedicate itself to the pursuit of innovation through technology brokering, and seek a position in the larger network that allows it to move among worlds. Firms can also pursue technology brokering strategies by constructing smaller groups internally that are dedicated to bridging different worlds and building recombinant innovations. This is often a very effective strategy because large organizations tend to already span multiple small worlds in their environment, but do so by divisions that rarely interact. The potential exists in many of these firms to recombine the people, ideas, and objects of the different worlds they move through, but it requires cooperation and communication among divisions. Another way to pursue technology brokering is to build dedicated groups within these larger organizations that can move among the different divisions and their different worlds. These groups act as consultants to the different divisions. They are freed from the operating responsibilities within any one market.

Technology Brokering as a Firm

Here, the firm itself acts as a technology broker. The links between a firm's network position and its organizational structure, work practices, and culture emerge as interdependent features of the strategy. It results in an internal marketplace of ideas and objects which can move around freely. Each person's contributions can quickly take on new value for each new problem the organization faces.

Technology brokers benefit from having worked in a wide range of different industries. They not only see radically different sets of technologies, but also see radically different uses for the same underlying technology. They can move and recombine the ideas, objects, and people they find in one that might be valuable in another.

Technology brokers have a fluid structure. For each project at IDEO, the famous California based design firm, for example, there is a clear project manager, a clear boss (the client), and a clear role for everyone on the team. But on the next project, the old manager might now be working for someone she managed the last time. And depending on the nature of the problem, the client, and the industry, different engineers or designers become the experts.

Within technology brokers, individuals work on a range of problems in a range of different industries, often moving to another industry after only a single project. Teams form and disband round individual projects. Additional members are invited for brainstorming sessions. The teams are often small, averaging from two to seven people and changing in size over time depending on the demands of the project. This movement of people on and off teams benefits projects because it allows teams to draw on the

unique experiences and knowledge of members of the firm as they are needed, without drawing them away from other projects.

The constant flow of people and new projects also builds dense networks among people across the company and helps them to learn about each other's distinct knowledge and skills. These contacts become part of each employee's personal network that others can turn to when they face a problem in the future.

Technology brokers develop four intertwined work practices that help them to do their job: capturing good ideas, keeping ideas alive, imagining new uses for old ideas, and putting promising concepts to the test.

Capturing Good Ideas Technology brokers span multiple markets, industries, and geographic locations, they keep seeing proven technologies, products, business practices, and business models to bring in promising ideas. Brokers recognize that these old ideas are their main source of raw material for new ideas, even when they are not sure how an old idea might help in the future. When brokers come across a promising idea, they experiment with it to figure out how and why it works, to learn what is good and bad about it, and to start thinking about new ways to use it.

Keeping Ideas Alive Ideas can't be used if they are forgotten. The biggest hurdle to solving problems is that people can't access the necessary information at the right time even if they've already learned it. Spreading information about who knows what is important if ideas have to be kept alive.

Imagining New Uses for Old Ideas New uses must be identified for the ideas captured and kept alive. Often those applications are blindingly simple. When Edison's inventors were developing the lightbulb, bulbs kept falling out of their fixtures. One day, a technician wondered whether the threaded cap that could be screwed down so tightly on a kerosene bottle would hold lightbulbs in their sockets. It worked, and the design hasn't changed since.

Putting Promising Concepts to the Test A good idea for a new product or business practice needs to be turned into something that can be tested and, if successful, integrated into the rest of what a company does, makes, or sells. Quickly turning an imaginative idea into a real service, product, process, or business model is the final step in the brokering cycle. Real means concrete enough to be tested. Quickly means the testing can be done early enough in the process that mistakes can be identified and the necessary improvement made.

Brokers must be good at testing ideas. If an idea seems to solve a current problem, they must build on it. If an idea does not work out, they must look for another. They must judge ideas on their merit without letting politics or precedent get in the way.

Putting a concept to the test not only helps determine if it has commercial value, but also teaches brokers lessons they might be able to use later, even when an idea is a failure.

Brokers benefit from failures, because in learning about why an idea failed, they get hints about other problems the idea might solve some day.

In technology brokering firms, sharing problems and admitting failures is not just accepted, it's expected. Within technology brokers, everyone feels the pressure to conform, but it's a conformity to disconformity. Everyone is valuable to the firm to the extent that he or she brings in new ideas from the outside. And everyone is valuable to the extent that he or she can draw on these diverse ideas to build new combinations of objects, ideas, and people into successful ventures.

A dedicated technology brokering strategy bridges small worlds, exploiting a position between worlds to combine existing objects, ideas, and people in new ways that promise new ventures. This strategy also builds the necessary communities around these new ventures that will ensure their success. Such a strategy works because these firms are continuously moving into new worlds. They create an internal marketplace of ideas and a culture of wisdom where new ideas and artifacts can move around freely and each person's contributions can quickly take on new value for each new problem the organization faces.

Technology Brokering within the Firm

Organizations are their own fragmented landscapes, broken into the many small worlds of their division, groups, and teams. In modern organizations, no amount of memos, speeches, and seminars on the virtues of knowledge sharing is likely to overcome the values of individuality and independence that pit one person against the other and one department against the other.

Hargadon emphasises that these differences must be taken advantage of. The focus that each manager, each division, each group brings to their unique situation is what powers the short-term growth of the company. Their focus creates the kinds of small worlds in which valuable new technologies emerge and develop. The fragmented groups within large companies become the source of new ideas in other groups. While the problem remains getting potentially valuable ideas out of their different small worlds and across the organization, it's important not to lose sight of the sources of those ideas.

People need to focus on their work, and for most of the firm, that work entails building and maintaining strong ties within its market – staying close to a few key suppliers, customers, regulators, and competitors. This expertise and understanding of a particular technology or particular market is the raw material of new innovations, and needs to be supported. Effective innovation strategies that attempt to recombine the organization's existing technologies in new ways need to exploit those differences without undermining them.

For the most part, organizations discover the innovative potential that comes from recombinations of their existing resources through size and serendipity. Serendipity is the gift of making useful discoveries by accident. Size brings more ideas, objects, and

people into the organizational mix, increasing the odds that accidental combinations will happen. But serendipity and size should not be the only factors on which one must rely.

Technology brokers are comfortable with idea of sharing best practices within the organization. Divisions often evolve different ways to organize factories, optimize supply chains, or manage people. When one division, or even one factory, develops a novel way to accomplish a business process, chances are that other divisions are facing the same problems, but may not be knowing about the novel solution.

One of the central tensions in managing innovations is striking a balance between short- and long-run performance. Short-run performance means being good at what we are already doing; long-run performance means being good at adapting to changes in the environment. It's never clear, though, how much time and resources must be devoted to exploiting existing competencies and how much to focus on developing new ones. To make matters worse, it's practically impossible to ask people to do both at the same time – to be good at what they do and to continually experiment with changing what they do. This is where internal technology brokers come. They can focus on bridging and building innovation networks. The rest of the organization can focus on improving what they already do well.

The key to success is the realization that technology brokering happens on the ground, where people are most familiar with the capabilities of existing technologies and the problems of their markets and their work.

Creating internal technology brokers requires posting these groups outside the individual division, where they might be subject to the distractions and resource constraints that follow profit and loss within a single market. It means creating the conditions in which they're rewarded for introducing existing technologies into the different small worlds of the organization. It involves building a structure and culture within these groups that rewards the group for bridging different worlds; recognizing valuable new ways to combine the organization's existing ideas, objects, and people; and building new networks around those recombinations.

Not all firms are large enough, diversified enough externally, or fragmented enough internally to benefit from developing internal technology brokers around particular problems or technologies.

Exploiting Emergent Opportunities for Technology Brokering
For many companies, opportunities for technology brokering result from accidental connections between people moving on the periphery of the organization and the technologies they might run across in their travels in other markets or organizations.

These opportunities can also happen in established organizations, often by accident, as people moving on the periphery of an organization recognize how technologies in previously unrelated worlds fit the organization's existing needs. Opportunities also arise when synergies within the organization are noticed and pursued – sometimes through

chance meetings between engineers or managers, where discussions turn to problems one or the other is facing. Such conversations often bring out the recognition that technologies in one corner of the organization could be useful in another, or that breakthrough products might come from combining the existing technologies of different divisions.

Innovation requires building new networks around these emerging combinations in order to ensure their success. This needs power. The problem is that people on the periphery have little incentive to risk it by introducing innovations. Technology brokering, by taking advantage of one-time opportunities, requires unique collaborations between the periphery and the core, between those with potentially valuable ideas and those with power.

Looking Back, Moving Forward

Breakthrough innovations come by recombining the people, ideas, and objects of past technologies. Technology brokering provides organizations with the means to exploit the opportunities for recombinant innovation. The challenge for managers is to put in place the organizational capabilities to bridge distant worlds, in which lie potentially valuable resources, and to build the new worlds in which new combinations will thrive.

The difficulty lies in balancing the activities that bridge many small worlds and those that build new ones. Bridging activities pursue breadth over depth. Bridging involves gaining broad access to and experience with the people, ideas, and objects of many different worlds rather than a deep expertise in any one set. Bridging involves loosening the ties that normally bind people, ideas, and objects into existing technologies and blind them to alternatives. Building activities, on the other hand, involve actively pursuing those ties. Building involves encouraging commitment around a single set of people, ideas, and objects – the kind of commitment that sticks doggedly to an emerging technology in the face of more established alternatives.

The challenge for managers is to simultaneously encourage doubt and dedication, doubt in the small worlds of today, and dedication to building new ones in their place. The past provides the raw materials for building the future. But the past also perpetuates old and obsolete ways of doing things.

When should a company adopt an innovation strategy of technology brokering? When should it bridge small worlds, recognizing and recombining ideas? And when should it build new ventures around those ideas?

If a company's strengths lie in the close relationships it has developed with end users, competitors, retailers, regulators, and other key players in a particular market, it must leverage the dense network it has already built within a single world. Such a position provides a deep understanding of the existing problems and opportunities, as well as of the movements and thinking of the other players in that world. Abandoning this network in search of new markets is not advisable. It makes sense to look for new technologies,

that would become innovative again in the current market when combined with existing capabilities.

On the other hand, a firm's close relationships might revolve around a particular set of product or process technologies, and the suppliers, scientists, and engineers who are part of this community. This is often the case in emerging markets. These firms can seek market opportunities in other industries – where their expertise and connection surrounding a potentially valuable technology overcome their lack of ties within the new market.

In rapidly changing markets, firms must devote more resources to building coalitions around their particular innovations than to bridging distant worlds in search of the next breakthrough idea. The need to keep up will always be present, but often, what the next-generation technologies will be is already clear to all involved. The deciding factor will be how they are implemented. On the other hand, firms competing in stable markets will find few advantages in creating denser ties than they already have though they can't ignore them. The pursuit of innovation will have to focus on bridging distant worlds, on finding the already well developed people, ideas, and objects that would provide distinctive advantages.

Multiple products and multiple production sites create small worlds within organizations. These are worlds in which potentially valuable ideas can emerge and develop. Firms with such internal complexity will find it valuable to build technology brokering groups that bridge internal divisions, exploiting much of what the organization already knows. On the other hand, firms that have relatively few products or process technologies or that have few internal divisions may find it useful to seek out and draw upon the broad-ranging experiences of external technology brokers rather than attempting to create their own.

Concluding Notes
Hargadon lists eight rules for the organized pursuit of innovation through technology brokering.

The future is already here: Nothing is more powerful than the recognition that our future already surrounds us. Instead of trying to create something new, we must realise that other people know something we do not, and we know something they do not.

Analogy is better than Invention: The raw materials for the next breakthrough technology may already be here, but they are certainly not categorized and available neatly in one place. Untangling them from their current context and putting them together in new ways requires thinking by analogy. It means constantly asking how things are the same. Hargadon emphasises that genius lies in the ability to see how two things that nobody else sees as related are related. This ability to make distant analogies unlocks a world of potential.

Create Discomfort: Sitting between two worlds, means not being inside any one and hence not being fully accepted by any one. The benefit of this discomfort lies in freedom from the binding (and blinding) ties of any one small world. Technology brokering entails finding one's discomfort zone. One reality check is whether adequate discomfort exists. If our colleagues agree with the decisions we make, the budgets we sign, and the projects we initiate – then chances are we are thinking within the same boxes they are. If, however, we find that our closest allies reside outside our traditional circles, chances are we are on to something good.

Take advantage of diversity: The primary role of most organizations, is not to develop breakthrough innovations but to focus on making the most of their existing technologies and markets. The more ties we build among different project teams, different manufacturing plants, and different divisions, the more time it takes to maintain these ties, and the more risk there is that a common set of people, ideas, and objects will come to dominate the larger community. It is better to embrace the boundaries in organizations. Those boundaries ensure both focus and variety. Then we must find and support the few people who will thrive by moving among these different worlds.

Bridge to your strengths: Technology brokering is not about moving into unknown worlds. It is about finding worlds we know little about but where our own knowledge looks valuable. One must move into those worlds where past experiences will be valuable contributions. Without the ability to contribute in a new place, technology brokers will find it difficult, if not impossible, to work with the best people and the latest thinking.

Build to your Weaknesses: We must not underestimate the power of a group in turning emerging ideas, especially deviant ones, into new realities. The notion of the lone genius is misconceived. We must find persons who complement our abilities. The more ties we can build around us, the bigger the collective becomes and the more others become willing to join.

As go the individuals, so goes the organization: It's one thing to establish strategies that move a firm among worlds or that build new project teams from across disparate divisions. It is another for the individuals involved to not only commit but also thrive in the new settings. An individual's value must come not from any fixed position or authority, but rather from the ability to see connections between what they have seen before and the problems others are facing now. Power must come not from controlling a fixed resource but from making new resources out of old experiences.

Rip, Mix, Burn: Much of innovation is about taking apart old ideas, mixing them together and repackaging them.

Just as genius turns to common sense, commonsense turns to prejudice. The same people, ideas, and objects that spawned a generation of revolutions become the ones to suppress the next. Starting a new innovation cycle requires building new combinations of people, ideas, and objects. And building those new combinations requires bridging distant worlds in order to find and exploit the existing resources within them. It may take genius to see

the potential for breakthrough innovations across a fragmented landscape. As Hargadon puts it, that genius depends more on the network of past wanderings that allows one to see across worlds than on any inherent talents.