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Google. Wikipedia. Threadless. All are well-known examples of large, loosely organized groups of people working together electronically in surprisingly effective ways. These new modes of organizing work have been described with a variety of terms—radical decentralization, crowd-sourcing, wisdom of crowds, peer production, and wikinomics.[i] The phrase we find most useful is *collective intelligence*, defined very broadly as *groups of individuals doing things collectively that seem intelligent*.

By this definition, collective intelligence has existed for a very long time. Families, companies, countries, and armies are all groups of individuals doing things collectively that, at least sometimes, seem intelligent.

But over the past decade, the rise of the Internet has enabled the emergence of surprising new forms of collective intelligence. Google, for instance, takes the judgments made by millions of people as they create links to Web pages and harnesses that collective knowledge of the entire Internet to produce amazingly intelligent answers to the questions we type into the Google search bar.

In Wikipedia, thousands of contributors from across the world have collectively created the world's largest encyclopedia, with articles of remarkably high quality. Wikipedia has been developed with almost no centralized control. Anyone who wants to can change almost anything, and decisions about what changes to keep are made by a loose consensus of those who care. What's more, the people who do all this work don't even get paid; they're volunteers.

In Threadless, anyone who wants to can design a T-shirt, submit that design to a weekly contest, and vote for their favorite designs. From the entries receiving the most votes, the company selects winning designs, puts them into production, and gives prizes and royalties to the winning designers. In this way, the company harnesses the collective intelligence of a community of over 500,000 people to design and select T-shirts.

These examples of Web enabled collective intelligence are inspiring to read about. But to take advantage of the new possibilities they represent, it's necessary to go beyond just seeing the examples as a fuzzy collection of "cool" ideas. To unlock the potential of collective intelligence, managers instead need a deeper understanding of how these systems work.

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In this article we offer a new framework to help provide that understanding. It identifies the underlying building blocks—to use a biological metaphor, the "genes"—that are at the heart of collective intelligence systems, the conditions under which each gene is useful, and the possibilities for combining and re-combining these genes to harness crowds effectively.

Organizational genes: The building blocks of collective intelligence

In our work at MIT's Center for Collective Intelligence, we have gathered nearly 250 examples of Web enabled collective intelligence (for more, see "About the Research"). At first glance, what strikes one most about this collection of examples is its diversity, with the systems exhibiting a wildly varying array of purposes and methods.

But after examining these examples in depth, we identified a relatively small set of building blocks that are combined and recombined in various ways in different collective intelligence systems. To classify these building blocks, we use two pairs of related questions (see Figure 1):

- *Who* is performing the task? *Why* are they doing it?
- *What* is being accomplished? *How* is it being done?

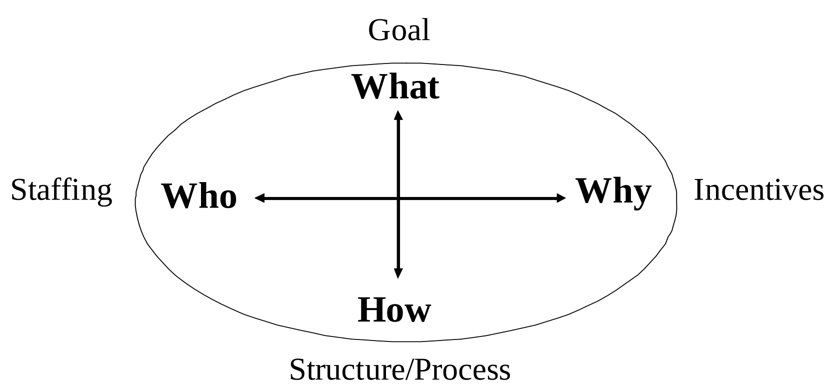

Figure 1: Elements of collective intelligence building blocks or "genes"

This framework is similar to ones that have been developed in the field of organizational design.[ii] The dimensions it describes are important in designing any system for collective action, be it a traditional organization or a new kind of electronically connected group.

Employing an analogy from biology, we call these building blocks the "genes" of collective intelligence systems. We define a gene as a particular answer to one of the key questions (Who, Why, What, or How) associated with a single task in a collective intelligence system. Like the genes from which individual organisms develop, these organizational genes are the core elements from which collective intelligence systems are built. The full combination of genes associated with a specific example of collective intelligence can be viewed as the "genome" of that system.

The genes of collective intelligence

To use this approach systematically requires a comprehensive classification of the different types of genes. That is, it requires identifying the potential answers to each of the four key questions.

Who? and Why?

The first question to be answered is, Who undertakes the activity? Here there are two basic genes.

***Hierarchy*.** In traditional hierarchical organizations, this question is typically answered when *someone in authority assigns a particular person or group of people to perform the task*. The task may be assigned to personnel inside the firm or to people outside it, through the hiring of a subcontractor. For instance, even though the Linux community is not a traditional business firm, Linus Torvalds and his lieutenants use the Hierarchy gene when they decide which of the many modules that people have submitted will actually be included in the next release of the software.

***Crowd*.** In the Crowd gene, activities can be undertaken by *anyone in a large group who chooses to do so*, without being assigned by someone in a position of authority. For example, anyone who wants to can submit a module for possible inclusion in Linux.

While crowds have done certain things, like voting in elections, for a long time, low cost electronic communication enabled by the Internet now makes it feasible for crowds to do many more things than ever before.

For instance, *anyone* can create a link to a Web page, and each new link becomes part of the database Google uses to serve up answers to searches. *Anyone* can propose a new article or edit an existing article in Wikipedia. And *anyone* can submit a T-shirt design to Threadless or vote on the designs that are submitted.

Reliance on the crowd gene is a central feature of Web enabled collective intelligence systems. In fact, all of the examples we studied include at least one instance of the crowd gene—at least one task where anyone who chooses can participate.

Closely related to the Who question is Why? Why do people take part in the activity? What motivates them to participate? What incentives are at work?

Questions about human motivation have been central in philosophy, literature, economics, and psychology for centuries. It is impossible to do justice in a brief summary to all that is known about this important subject. As a simplified overview of the possibilities, however, three basic Why genes can cover the high level motivations that lead people to participate in collective intelligence systems.

Money. The promise of financial gain is an important motivator for most actors in markets and traditional organizations. Sometimes people receive direct payments, like a salary, and sometimes they hope that participating in an activity will increase the likelihood of their earning future payments, as in cases where people perform a task to enhance their professional reputation or improve their skills.

Love. Love is also an important motivator in many situations, even when there is no prospect of monetary gain. The Love gene can take several forms: people can be motivated by their intrinsic *enjoyment* of an activity, by the opportunities it provides to *socialize with others*, or because it makes them feel they are *contributing to a cause* larger than themselves. Studies of Wikipedia have shown that its participants are motivated by all three of these variants of the Love gene.

Glory. Glory or recognition is another important motivator. The programmers in many open source software communities, for example, are motivated by the desire to be recognized by peers for their contributions.

What is novel about many of the collective intelligence systems that have emerged in recent years is their reliance on the Love and Glory genes, in contrast to traditional organizations, which have relied more heavily on Money as a motivating force. For instance, collective intelligence systems often explicitly engineer opportunities for recognition by compiling and publishing “top contributor” lists or by institutionalizing performance-based classes of membership that confer various degrees of status, such as “power seller” on eBay and “top reviewer” on Amazon.

What? and How?

The third question to be answered for any activity is: What is being done? In traditional organizations, the answer to this question is often spoken of as the mission or goal.

For What, the many organizational goals encountered in collective intelligence systems can be boiled down into two basic genes.

Create. In this gene, the actors in the system generate something new—a piece of software code, a blog entry, a T-shirt design.

Decide. In this gene, the actors evaluate and select alternatives—deciding whether a new module should be included in the next release of Linux, selecting which T-shirt design to manufacture, deciding whether to delete a Wikipedia article.

Threadless shows both the Create and Decide gene at work. Each week, Threadless relies on the crowd to *create* a group of new T-shirt designs, and then *decides* which ones to produce through a combination of voting (by anyone who is interested) and a hierarchical decision (by Threadless management).

The final question to be answered concerning an activity is, How is it being done? In traditional organizations, the How question is typically answered by describing the organizational structures and processes.

Many collective intelligence systems still use hierarchies for some of their tasks, but what is novel is how they use crowds. So we focus here on instances of the How gene where the crowd does the Create or Decide task.

A key determinant of the answer to this question is whether the different members of the crowd make their contributions and decisions *independently* of each other or whether there are strong *dependencies* between their contributions. This insight gives rise to four primary How genes for Crowds (see Table 1).

	Independent	**Dependent**
Create	Collection	Collaboration
Decide	Individual Decisions	Group Decision

Table 1: Variations of the How gene for Crowds

The two How genes associated with the Create task are *Collection* and *Collaboration*.

Collection. This gene occurs when the items contributed by members of the crowd are created independently of each other. For example, *YouTub*e videos are created mostly independently of each other, and this makes YouTube a collection. Other examples of this common gene include *Digg*, a collection of news stories, and *Flickr*, a collection of photographs.

An important subtype of the Collection gene is the ***Contest*** gene. In contests, like Threadless, one or several items in the collection are designated as the best entries and receive a prize or other form of recognition.

In another example of contests, *InnoCentive,* companies offer cash rewards, typically totaling in the five or even six figures, to researchers anywhere in the world who can solve challenging scientific problems such as how to synthesize a particular chemical compound.

In the *Netflix Prize*, a $1 million award is being offered for the first algorithm that is at least 10 percent better than the one currently used by Netflix for suggesting to customers which DVDs they will like.

In *IBM's Innovation Jams*[iii], IBM employees, as well as customers and vendors, participate in on-line brainstorming sessions to develop ideas for new products and services. Participants and managers then rate the ideas that emerge, and a total of $100 million in seed funding is divided up each year among the top ten concepts.

In *TopCoder*, independent computer programmers compete to provide the best solutions to customers' problems.

Collaboration The Collaboration gene occurs when members of a Crowd work together to create something and important dependencies exist between their contributions. For example, even though there is extensive hyper-linking between them, articles in Wikipedia are meant to stand on their own as independent entities. This means Wikipedia as a whole is a Collection of articles. But the additions and editorial changes that different contributors make within a single Wikipedia article are strongly interdependent. So each individual Wikipedia article is a *Collaboration*, comprised of contributions submitted by a number of users.

Another important example of the Collaboration gene is *Linux*, and any other open source software project, where there are strong interdependencies among the modules submitted by different contributors.

For Decide tasks, there are two possible genes: *Group Decision* and *Individual Decisions*.

Group Decision. The Group Decision gene occurs when inputs from members of the crowd are assembled to generate a decision that holds for the group as a whole. In some instances, such as Threadless, this decision determines the subset of contributed items that will be included into the final output. In other instances, such as Digg, the decision relates to generating a common rank-ordering of the contributed items. In yet other instances, such as prediction markets, the decision relates to aggregating individual inputs to form a publicly visible estimate of a quantity.

Important variants of the Group Evaluation gene are *Voting*, *Consensus, Averaging*, and *Prediction Markets*.

Voting. New technologies make the Voting gene feasible in many situations where it would not otherwise have been practical. For example:

- *Digg* users vote on which news stories are most interesting, and the winning stories are displayed prominently on the website.

- *Ebbsfleet United*, a U.K. soccer team, is owned by 30,000 members who vote over the Internet on issues that are usually decided by team management, such as which players should be traded and which should play.

- *Kasparov v. the World* was a chess match held in 1999, when world champion Gary Kasparov played against “the World,” with the World’s moves determined by majority vote over the Internet of anyone who wanted to participate. Kasparov eventually won, but he said it was the hardest game he ever played.

An important sub-variation of voting is *implicit voting*, where actions like buying or viewing items are counted as implicit “votes.” For instance, *iStockPhoto* displays photos in order of the number of times each photo has been downloaded, and *YouTube* ranks videos by the number of times they have been viewed.

Another important sub-variation involves *weighted voting*. For example, *Google* ranks search results, in part, on the basis of how many other sites link to the sites in the list. But Google’s algorithm gives more weight to links from sites that are, themselves, more popular.

Consensus. Consensus means that all, or essentially all, group members agree on the final decision. For example in *Wikipedia*, the articles that remain unchanged are those for which everyone who cares is satisfied with the current version. Thus *Wikipedia* uses a kind of consensus to make editing decisions on individual articles.

Consensus is also used in an interesting way in *reCAPTCHA*, a Web security utility. Two words are displayed on the screen, with users required to type both to gain access to a Web page. One of the words is a security key and the other a word previously scanned as part of a project to digitize old books. Words the optical character recognition software finds difficult to read are served up to multiple users as one half of each reCAPTCHA. Only after the transcriptions provided by multiple users reach a level of consensus, as determined by a statistical algorithm, is that word deemed to have been correctly transcribed.

Averaging. In cases where decisions involve picking a number, another common practices is to average the numbers contributed by the members of the Crowd. In some cases, such as guessing the weight of an ox[iv], simple averaging works surprisingly well.

Averaging is commonly used in systems that rely on a point scale for quality rating. For example, users of *Amazon* can rate books or CDs on a five star scale, and these ratings are averaged to provide an overall score for each item. Similar systems allow users of *Expedia* to rate hotels and users of *Internet Movie Database* to rate movies.

Other examples of averaging include:

- *NASA Clickworkers*. In 2001-02, NASA let anyone look at photos of the surface of Mars on the Internet and identify features they thought were craters. Crater locations were designated by sets of coordinates in two dimensional space. When the coordinates contributed by amateurs were averaged, they were found to be just as accurate as the classifications made by expert scientists.

- *Marketocracy* runs an investment portfolio that is selected by averaging the stocks and bonds chosen by the 100 most successful investors from over 55,000 who participate on the website.

Prediction markets. A useful way of letting crowds estimate the probability of future events is with prediction markets. In prediction markets, people buy and sell "shares" of predictions about future events. If their predictions are correct, they are rewarded, either with real money or with points that can be redeemed for cash or prizes. Google, Microsoft, and Best Buy have all used prediction markets to tap the collective intelligence of people within their organizations.

Microsoft used its prediction market to estimate completion dates for projects. When one of the first of these markets opened, the share prices for a project declined within minutes to a price indicating a 1 percent probability of on time completion. The managers in charge had thought everything was on schedule, but the prediction market's results led them to investigate further, and they found problems. The project was eventually completed three months late. Awareness of the problem was available in the organization, but the prediction market was required to bring this decentralized knowledge to the attention of people who could act on it.

Individual Decisions.

The Individual Decision gene occurs when members of a Crowd make decisions that, though informed by crowd input, do not need to be identical for all. For instance, individual YouTube users decide for themselves which videos to watch. They may be influenced by recommendations or rankings from others, but they are not required to watch the same videos as others.

Two important variations of the Individual Decisions gene are: *Markets* and *Social Networks*.

Markets. In Markets, there is some kind of formal exchange (like money) involved in the decisions. Each member of the crowd makes an individual decision about what products to buy or sell. Purchasing decisions by buyers in the crowd determine collective demand, which, for its part affects the availability of products and their prices. And in turn, the quantities and prices of the goods put up for sale by sellers in the crowd influence, but do not bind, purchasing decisions.

Markets for many kinds of goods and services have existed for millennia, but new technologies will enable new electronic forms of markets. For example:

- In *iStockPhot*o, photographers post their photos for sale on a website, and editors and others buy the rights to use photos they want.

- In *eBay*, sellers post items they want to sell, and buyers bid for them.

Social Networks. In Social Networks, members of a crowd form a network of relationships that, depending on the context, might translate into levels of trust, similarity of taste and viewpoints, or other common characteristics that might cause individuals to feel an affinity for one another. Crowd members assign different weights to individual inputs on the basis of their relationship with the people who provided them and then make individual decisions. For example:

- In the *blogosphere*, authors have the habit of placing links to content they like, including entries by other bloggers, notable news articles, or interesting videos. Readers, in turn, have favorite blogs that act as personalized entry points to the blogosphere. By reading these blogs and their links every reader makes an individual decision about what content to consume. But these individual decisions are shaped by the structure of the social network of the crowd. For example, bloggers often cluster in cliques that link frequently to one another. Clicking on a blog entry by one member of such a clique can quickly give a reader access to an interlinked web of related content.

- In *YouTube*, every user is associated with a "channel." On these channels, users can upload their own videos and/or link to selections of other users' videos, via a favorites option. Users can subscribe to other users' channels and receive notifications when their favorite channels have been updated. Users thus form social networks that affect their choices of what videos to watch.

- In *Epinions.com*, a product review site, users form trust networks with other reviewers. Empirical evidence suggests that users weigh reviews written by members of their trust network more heavily than other reviews, leading to personalized assessments of individual product quality.

- *Amazon.com* provides personalized recommendations to users. Amazon does this by automatically constructing an implied social network that relates each user to other users who have purchased or rated similar products in the past. The system then recommends products that many "similar" users have liked but which the target user has not yet purchased. This is an example of the broader class of systems that are referred to by the term *collaborative filtering*. While in the previous examples listed, users form explicit social networks with each other, collaborative filtering systems infer such social networks computationally from people's past actions and use them to derive personalized recommendations.

From genes to genomes

Using the individual genes, let's now consider how sequences of these genes can be combined into genomes of complete collective intelligence systems.

Linux

As described above and summarized in Table 2, the Linux community performs two key tasks. First, anyone who wants to can Create new software modules. Then a miniature Hierarchy, consisting of Linus Torvalds and a small group of colleagues, Decides which of the submitted modules to include in the next release. Most who contribute do so for enjoyment or peer recognition, though some are also paid to contribute by companies like IBM.

Example	What		Who	Why	How
Linux	Create	New software modules	Crowd	Money Love Glory	Collaboration
	Decide	Which modules warrant inclusion in next release	Torvalds and lieutenants	Love Glory	Hierarchy

Table 2: Mapping the collective intelligence genome for Linux

Wikipedia

As described above and summarized in Table 3 (top), editing individual Wikipedia articles is a form of Collaboration in which decisions are made by a rough consensus: anyone who wants to can make a change in almost any article, and articles remain unchanged only if everyone who cares is satisfied with the current version.

A different set of mechanisms is used to decide which articles should be included at all (see Table 3, bottom). Anyone who wants to can create a new article. For instance, no one would stop someone from creating an article about his or her own cat (What = Create article; Who = Crowd). But if someone else thinks the article isn't important enough, they can nominate it for deletion. Then anyone can give comments about why the article should or should not be deleted and cast a vote (What = Decide whether to delete article; Who = Crowd; How = Voting). Eventually, a Wikipedia administrator looks at the votes, reads the comments, and makes a final decision about whether to delete the article (What = Decide whether to delete article; Who = Wikipedia administrator; How = Hierarchy).

Example	**What**		**Who**	**Why**	**How**
Edit existing Wikipedia articles	Create	New version of article	Crowd	Love, Glory	Collaboration
	Decide	Whether to keep current version	Crowd	Love, Glory	Consensus
Decide what Wikipedia articles to include	Create	New article	Crowd	Love, Glory	Collection
	Decide	Whether to delete (preliminary)	Crowd	Love, Glory	Voting
	Decide	Whether to delete (final)	Wikipedia administrator	Love, Glory	Hierarchy

Table 3: Mapping the collective intelligence genome for Wikipedia

While some of these details are unique to Wikipedia, anyone designing a system for a crowd to create intellectual products—such as product designs or how-to advice—might find it useful to consider using this combination of genes.

Comparing the InnoCentive and Threadless genomes

This way of analyzing genomes can also highlight important similarities and differences between related examples. For instance, consider two examples of contests: InnoCentive and Threadless. As shown in Table 4, these two genomes are nearly identical. The only difference is the addition of the intermediate Decide by the Crowd in Threadless.

Example	What		Who	Why	How
InnoCentive	Create	Scientific solutions	Crowd	Money	Contest
	Decide	Who gets rewards	Management	Money	Hierarchy
Threadless	Create	T-shirt designs	Crowd	Money Love	Contest
	Decide	Which designs are best	Crowd	Love	Averaging
	Decide	Which designs to use	Management	Money	Hierarchy

Table 4. Comparing the genomes of Innocentive and Threadless

For InnoCentive, such a step probably would not make sense, because the company with the problem that needs solving typically would not want the crowd to see all the entries. In addition, the company's management is usually able to assess the fit of the proposed solutions within the context of the firm's unique needs. On the other hand the objective of Threadless is to produce T-shirts that will fare well in the market, that is, will be liked by the crowd. Asking the crowd's opinion on submitted T-shirt design, then, makes a lot of sense. Other organizations considering the use of collective intelligence approaches to designing new products may want to consider inclusion of the intermediate gene included by Threadless (What = Decide; Who = Crowd; How = Averaging).

Which gene in which situation?

Through genome mapping, we can see underlying structure and think about ways of combining and recombining genes to form new systems. But one remaining thing is needed to enable the development of new collective intelligence systems through a process akin to genetic engineering: an understanding of which genes are effective in which situations (see Table 5).

Question	*Gene*	*When useful*
Who	**Crowd**	• Resources useful in doing activities are distributed widely or in places not known in advance • Activities can be divided into pieces satisfactorily (necessary information can be shared; gaming and sabotage can be managed)
	Hierarchy	• Conditions for crowd aren't met
Why	**Money** **Love** **Glory**	• Many factors, too complex to list here, are relevant, with two rules of thumb – Appealing to Love and Glory, rather than Money, can often (but not always) reduce costs – Providing Money and Glory can often (but not always) influence a group's direction and speed.
How—Create	**Collection**	Conditions for Crowd, *plus*… • Activity can be divided into small pieces that can be done (mostly) independently of each other.
	Contest	Conditions for Collection, *plus*… • Only one (or a few) good solutions are needed.
	Collaboration	• Activity *cannot* be divided into small independent pieces (otherwise Collection would be better) • There are satisfactory ways of managing the dependencies among the pieces
How—Decide	**Group Decision**	Conditions for Crowd, *plus* . . . • Everyone in the group needs to abide by the same decision, *plus* …
	Voting	• It is important for the Crowd to be committed to the decision
	Averaging	Conditions for Voting, *plus*… • Decision consists of estimating a number • Crowd has no systematic bias about estimating the number
	Consensus	Conditions for Voting, *plus*… • Achieving consensus in reasonable time is feasible (group is small enough or has similar enough views)
	Prediction market	• Decision consists of estimating a number • Crowd has some information about estimating the number (biases and non-independent information are okay) • Some people may have (or obtain) much better information than others • Continuously updated estimates are useful
	Individual Decisions	Conditions for Crowd, *plus*... • Different people can make their own decision, *plus* …
	Market	• Money is needed to motivate people to provide the necessary effort or other resources
	Social network	• Non-monetary motivations are sufficient for people to provide the necessary effort or other resources • Individuals find information about other's opinions useful in making their own choices.

Table 5. Conditions for when collective intelligence genes are useful

When the Crowd gene is useful

The Crowd gene is most useful in situations where *the resources and skills needed to perform an activity are distributed widely or reside in places that are not known in advance*.

In prior decades, for instance, when video recording and editing equipment was so expensive that only a few large corporations could afford it, it made sense for the creation of movies and television shows to be managed hierarchically by film studios and TV networks. But creative ideas have always been widely distributed in the population, and now that many people can afford their own video cameras and use personal computers for editing, sites like YouTube allow anyone to create and share their own videos.

For the Crowd gene to work for a given activity, it must also be possible to divide the activity into pieces that can be performed satisfactorily by different members of the crowd.

There must be also mechanisms in place to protect against people gaming or sabotaging the system. The Schaumburg Flyers, a minor league baseball team near Chicago, showed what can happen when this condition is not met. The Flyers management experimented with a system like that used by Ebbsfleet United, the English soccer team, with fans voting to make decisions usually made by the front office and on-field coaching staff. But while Ebbsfleet restricted voting to fans who owned shares of their team, the Flyers let anyone vote. This led to a very disappointing season. Many people suspected that fans of opposing teams were purposely voting for moves that undermined the Flyers.

Such examples show that relying on the crowd is not always the right thing to do, at least not for all tasks. Many collective intelligence systems use the crowd for creation and some intermediate decisions, but leave the final decision to a small group assigned to the task.

Which motivational levers?

Two rules of thumb are especially important for motivating groups to participate in systems for collective intelligence:

Appealing to Love and Glory may reduce costs. Amazon doesn't pay for the book reviews it runs; users write them to gain recognition or because they simply enjoy doing so.

Reliance on Love and Glory, however, doesn't always work. When Heinz Ketchup invited the public to help it create a new commercial, it still faced significant expenses for promoting the contest and reviewing the flood of submissions. And Heinz ended up alienating some customers, who "badmouthed [the company] on its website forums for being lazy and just angling for cheap labor."[v]

Money and Glory can help the Crowd to move faster. It is often difficult to control how fast or in what direction a crowd works. But if there are specific goals in mind, the crowd can sometimes be influenced to achieve them faster by providing Money or Glory to the members of the Crowd who go in the desired direction. As noted before, an example of this approach is IBM, which assigns many of its paid employees to work on Linux features that are particularly important to the company.

Although the selection and combination of motivational genes is a very complex matter, it is also an extremely important one. While we don’t know of any systematic studies on this issue, we suspect that getting the motivational factors wrong is the single greatest factor behind failed efforts to launch new collective intelligence systems.

Collection, Contest, or Collaboration?

In addition to the conditions for Crowds, in general, the most important condition for the Collection gene to be useful is that it be possible to divide the overall activity into small pieces that can be done independently by different members of the crowd. If this condition is not in place, then the Collaboration gene is likely required.

The Contest gene is useful when all the conditions for a Collection hold and only one or a few good solutions are needed. InnoCentive’s customers, for example, don’t need a large number of alternative solutions to their problems. They only need one, or at most, a few. Also, for a contest to work, the Why genes, such as Money or Glory, must be powerful enough to motivate contestants to enter with no guarantee of reward. This effectively offloads risk from the contest sponsor to the contestants; the companies that post problems on InnoCentive do not have to pay an award unless someone actually solves the problem.

The Collaboration gene is useful when two conditions are met. First, a Collection is impossible because there are no satisfactory ways of dividing the large activity into independent pieces. Second, there must be satisfactory ways of managing the dependencies between the individual pieces contributed by members of the crowd. In practice, managing dependencies among the pieces usually involves some combination of Decide genes.

Group vs. Individual Decisions

Group and Individual Decisions are useful when the conditions of a Crowd are met, such as the knowledge needed to make the decisions being widely distributed. Group Decisions are useful when everyone in the group has to be bound by the same decision. For instance, everyone in a product development team should be working from the same specifications for the product. When widespread agreement is *not* needed or when a population’s tastes and viewpoints are highly heterogeneous, for instance in deciding which YouTube videos individuals will watch, individuals can often make their own decisions more effectively.

Which kind of Group Decision? If the group is small enough and like-minded enough to reach consensus in a reasonable amount of time, then consensus may be the most desirable method. But reaching complete consensus in a large or diverse group is often impossible, so *voting* is usually better in these cases. *Voting* is also useful when it is important to have everyone committed to the outcome.

Averaging can be used to enable a crowd to estimate numbers under conditions of uncertainty or when qualitative characteristics can be translated effectively into numbers. When the members of a crowd provide such an estimate, the numbers they submit include some relevant information (signal) and also some random errors (noise). When the errors are truly random and not systematically biased in either direction, the average works well because the errors cancel each other out. But averaging may result in poor estimates if the errors are systematically biased in some way. Bias may arise in situations where early participants influence later ones or where the group of participants is not sufficiently diverse to include all relevant perspectives.

Running successful *prediction markets* usually requires more resources than simple averaging. But prediction markets have several important potential advantages. They may be less subject to bias, because unbiased participants can profit handsomely by exploiting others' biases, thereby making the overall market more accurate. Prediction markets can also function effectively even when most market participants have little relevant information, because only the well-informed participants are motivated to trade heavily. And prediction markets can provide continuously updated estimates without requiring repeated polling of the entire crowd.

Which kind of Individual Decisions? When Individual Decisions are needed, *markets* are especially useful when money (or similar incentives) are needed to motivate people to provide the necessary effort or other resources. *Social networks* are especially useful when individuals don't need to be paid, and they find information about the opinions of others useful in making their own choices.

Conclusion

The early examples of Web enabled collective intelligence are not the end of the story, but just the beginning. As computing and communication capabilities continue to improve, there will be a myriad of other examples like these in coming decades.

There is still much work to be done to identify all the different genes for collective intelligence, the conditions under which these genes are useful, and the constraints governing how they can be combined. But we believe the genetic framework described here provides a useful start.

With this framework, managers can do more just look at examples and hope for inspiration. Instead, for each key activity to be performed, they can systematically consider many possible combinations of answers to questions about Who, Why, What, and How.

This approach does not guarantee the development of brilliant new ideas. But it increases the chances that others can begin to take advantage of the amazing possibilities already demonstrated by systems like Google, Wikipedia, and Threadless.

Appendix: About the Research

In 2006, drawing on over 15 years of experience mapping knowledge about business processes[vi], our research team collected more than 100 examples of collective intelligence in an on-line wiki called the Handbook of Collective Intelligence[vii]. The descriptions were based primarily on published reports and studies of the examples' websites. Over time, we added more examples from a variety of sources, including a task posted on Amazon Mechanical Turk asking people to provide examples of collective intelligence for as little as 3 cents per example! There are now 249 examples in the team's database.

In parallel, we also began developing a series of classification frameworks. The goal was to make important (even if non-obvious) distinctions and to classify examples in categories that were mutually exclusive, collectively exhaustive, and as easy and intuitive as possible to understand and use.

To test informally the degree to which the frameworks possessed these properties, we presented them to students in MIT classes, to managers and researchers in professional meetings, and to research assistants who used them to classify examples.

The framework presented here is the fourth major generation we developed, with several iterations in each generation. A key feature of the fourth generation is the emphasis on analyzing each example as a combination of building blocks and the introduction of the genetic analogy.

One of the important lessons learned in this work is that there are *many* ways to classify examples of collective intelligence. The framework presented here is certainly not the only one that could be useful. Other frameworks that emphasize different factors could be useful for different purposes. The primary claim made about this framework is that it is useful for understanding the relationships between different kinds of collective intelligence and for generating ideas about new possibilities.

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[i] T. W. Malone, "The Future of Work" (Boston: Harvard Business School Press, 2004); J. Howe, "Crowdsourcing" (New York: Crown Business, 2008); J. Surowiecki, "The Wisdom of Crowds" (New York: Doubleday, 2004); Y. Benkler, "The Wealth of Networks" (New Haven: Yale University Press, 2006); D. Tapscott and A. D. Williams, "Wikinomics" (New York: Penguin, 2006).

[ii] A. Kates and J. R. Galbraith, "Designing Your Organization" (San Francisco: Jossey-Bass, 2007).

[iii] O. M. Bjelland and R. C. Wood, "An Inside View of IBM's 'Innovation Jam,'" Sloan Management Review 50, no. 1 (fall 2008): 32-40.

[iv] Surowiecki, "Wisdom," xi – xiii.

[v] Howe, "Crowdsourcing," 283.

[vi] T. W. Malone, K. G. Crowston and G. Herman, G., eds., “Organizing Business Knowledge: The MIT Process Handbook” (Cambridge, MA: MIT Press, 2003).

[vii] This initial collection was done by Richard Lai, then a doctoral student at Harvard Business School, now a professor at The Wharton School, University of Pennsylvania.