Mobilization Systems: technologies for motivating and coordinating human action

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to appear in: Routledge Handbook on Knowledge Economy, Education and Digital Futures, eds: Peters M. A., Besley T. and Araya D., (Routledge, 2012 or 2013)

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technologies for motivating and coordinating human action

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Abstract: Recently a number of techniques have been developed that stimulate people to act towards specific objectives. These include persuasive technologies, gamification, user experiences, and various methods and tools used in open-source and other communities to encourage and organize participation. After surveying various examples of such applications, we generalize these approaches by proposing a new theoretical framework. The basic concept is a *mobilization system*, defined as an ICT environment that motivates and coordinates the actions of people, so as to increase their focus and commitment, while minimizing distraction, hesitation and procrastination. We then analyze the fundamental mechanisms of (individual) motivation and (collective) coordination, starting from Csikszentmihalyi's concept of *flow* and the mechanism of *stigmergy*. The basic requirements are clear goals in line with real needs, immediate and rich feedback, challenges in balance with the user's skill levels, and a shared workspace in which all tasks and results are registered for every contributor to see. We conclude our review of mobilization systems by pointing out their potential dangers, such as addiction and political or commercial exploitation, as well as their potential benefits, in domains such as work, health, education and research.

Introduction

The ubiquitous presence of ICT has spectacularly facilitated all activities that center on the storage, communication and retrieval of information. If you want to investigate a particular domain, you no longer need to travel to specialized libraries, spend hours combing through their card catalogs and book racks, borrow the most relevant documents, and finally carry all these pounds of paper home with you to read. Similarly, if you want to widely disseminate your ideas, you no longer need to painstakingly type a manuscript on your typewriter, make photocopies of it, send them by post to various publishers, and hope that you can convince one to invest a lot of money into editing, typesetting, printing and eventually, a year or two later, distributing it to potential readers.

The physical effort needed to retrieve or publish information had one advantage, though: it motivated people to be selective in what they read or communicate. As these obstacles have disappeared, information is now being disseminated virtually without restrictions. The most obvious effect is *information overload*, a form of mental bombardment that (Shenk, 1998) aptly characterized as "data smog", since it obscures rather than enlightens, while damaging health by increasing stress levels. It is typically accompanied by a barrage of interruptions or distractions caused by incoming emails, phone calls, text messages, tweets or "status updates".

A less obvious effect is the accompanying *choice overload* (Schwartz, 2005): as the number of available options for documents to read, products to buy, services to use, people to connect to, or destinations to visit increases, people need to invest ever more effort in deciding which option they should choose. Even when a decision is finally made, the decider is typically left with the gnawing feeling that perhaps there was an even better option, thus feeling less satisfied with the choice. The result is continuing anxiety, and a tendency to avoid or postpone such stressful decisions. This phenomenon can be illustrated by a classic experiment in which prospective buyers are offered to taste either half a dozen or several dozen types of fruit jam. Paradoxically, given the larger choice, people are less likely to buy a pot of jam than given the smaller choice! (Schwartz, 2005) A final effect is growing *transience*: nowadays people are both quicker to adopt and to abandon new technologies, services, jobs, and even relationships, presumably because: (1) it has become much easier to change such commitments; (2) there are so many more options to be explored; (3) new, and potentially better, options appear at an ever faster rate.

The overall result is that it has become much more difficult for people to commit to any particular choice, and much easier for them to get distracted and abandon whatever they are busy with. The combination of distractability, lack of commitment, and procrastination (J. Heath & Anderson, 2010) results in poorly focused, inefficient, unreliable, and stressful work. These individual effects are magnified at the social level: when several people suffering from such lack of dedication collaborate on a common project, the result can only be poorly coordination, since no one knows exactly what to expect from the others. Thus, we come to the conclusion that while ICT undoubtedly has increased the mechanical productivity of work, it may well have decreased our psychological and social productivity, together with our overall level of involvement, satisfaction and well-being.

The question then is whether information technology is able to compensate for these unexpectedly vicious side effects. The thesis we wish to defend in this paper is that it can: there exist a range of behavioral methods to effectively combat distraction, procrastination and lack of commitment, while increasing focus, motivation and coordination (e.g. C. Heath & Heath, 2010; Thaler & Sunstein, 2008). When these techniques are implemented in ICT, the result may be called a *mobilization system.* According to the Oxford dictionary, to *mobilize* means to "organize and encourage (people) to act in a concerted way in order to bring about a particular political objective". Given that any valuable objective deserves concerted action, the only generalization we need to make is to leave out the adjective "political". A mobilization system can then be defined as: *a socio-technological system that motivates and coordinates people to work towards a given objective*—thus efficiently rallying their efforts.

While the term "mobilization system" is new, the underlying ICT techniques have been explored for at least a decade or two, under labels such as "persuasive technology", "collaborative technology", "user experience", and "gamification". This paper will first review a number of such existing approaches and then try to distill their common core in the form of a list of mobilization principles. Finally, we will sketch both potential benefits and dangers of a more systematic and widespread application of mobilization systems.

A brief survey of mobilization systems

Internet communities and collective action

The last decade has seen an explosion of spontaneous—yet surprisingly effective—collaborative communities on the web. Perhaps the best-known examples are the different communities that develop *open source software*, i.e. programs that not only can be freely used, but freely modified, by anyone. These include some of the most commonly used programs on the Internet, such as the Apache web server, the Linux operating system, or the Drupal content management system (Kiemen, 2011). Similar communities are developing *open access documents*, i.e. texts that can be freely consulted—and often edited—by anyone. The most impressive example is *Wikipedia*, the global encyclopedia to which everybody can contribute, and which is by far the largest and most complete encyclopedia that has ever existed (Arazy, Morgan, & Patterson, 2006; Kittur & Kraut, 2008). More traditional communities gather around a domain of interest, such as fans of a particular musician, football supporters, bird watchers, users of a software application, or researchers working on a particular subject. These communities typically organize by means of discussion forums where a variety of questions are raised and if possible answered, after which the most important results are aggregated in the form of a wiki website or a FAQ (Frequently Asked Questions with their answers) document.

What these communities have in common is that they collectively produce very useful—and typically high-quality—applications and information, but this without any financial compensation or legal organization. In other words, these communities consist purely of volunteers contributing on an informal basis to a common project. From the perspective of traditional economics and organizational theory, this is paradoxical (Heylighen, 2007): why would anyone provide such valuable services to others without being either paid or ordered to do so? Several authors have investigated the motives that incite people to contribute to such communities (Ghosh, 2005; Lerner & Tirole, 2002; Weber, 2004). These include curiosity, altruism, free expression, need for belonging, desire for status and recognition, and the hope for future financial rewards for private consultancy after being publicly recognized for one's expertise. More interesting for our purpose than these individual motivations, though, are the structures and processes that encourage individuals to take part in such a collective enterprise, i.e. the underlying mobilization system.

A first analysis (Heylighen, 2007) points at two fundamental mechanisms: *feedback* and *stigmergy*. By contributing a question, comment, answer, program, photo or any other input, participants hope to get a reaction from the other community members, because that would give them an indication of whether they are on the right path, or need to make some correction. Such feedback provides valuable information that allows participants to get better in whatever they are interested in. For example, a programmer who contributed a piece of code will benefit if a user points out a bug in that code, suggests a way to extend it, or simply confirms that the job was well done.

Stigmergy is a mechanism of spontaneous coordination between actions, where the result of an individual's work stimulates a next individual to continue that work (Parunak, 2006; Bolici, Howison, & Crowston, 2009; Heylighen, 2011a). For example, a paragraph contributed to a Wikipedia article may incite a later reader of that paragraph to add a reference or further detail, which in turn may elicit further contributions from others. Stigmergic coordination does not require any direct communication between the agents: the different contributors to a Wikipedia article generally do not know each other, and do not discuss who should contribute what. It also does not require any planning or supervision: each individual contributes whenever or whatever s/he deems fit. The only thing needed is a shared *medium* or *workspace* in which clear *traces* of the work are registered (Heylighen, 2011a; Parunak, 2006). The aggregated trace functions as a collective memory that keeps track of the different contributions and indicates where further work may be needed. This function is typically performed by the community website, such as the Wikipedia site.

A more advanced example of this functionality can be found in the *issue queue* used by Drupal developers (Kiemen, 2011; Zilouchian Moghaddam, Twidale, & Bongen, 2011). This is a community-maintained, ordered list of feature requests or problems that need to be addressed, together with the status of the work being done on each. The issue queue makes it easy for contributors to see where their contribution would be most helpful, and to keep track of the advances made by others. It can be seen as a more spontaneous, self-organizing version of the job ticketing systems that are commonly used in technical support centers, where each incoming problem is assigned a “job ticket”, after which the ticket is assigned to one or more employees, and monitored so as to make sure it is adequately dealt with (Heylighen & Vidal, 2008; Orrick, Bauer, & McDuffie, 2000).

Web communities benefit from another ICT mechanism: the nearly effortless publishing of information. This means that it does not cost anything for a person to make the results of her personal activity available to others. Moreover, information is what economists call “non-rival” (Heylighen, 2007; Martens, 2004): the fact that someone else uses it does not prevent you from using it at the same time. This removes the main impediment against sharing: you do not lose anything by offering the fruit of your labor to others; you merely gain an opportunity to get something (feedback, a further improvement, recognition, a similar contribution…) in return. But the “no cost” assumption should extend to the mental and physical effort you invest: contributing should be so easy and transparent that you can do it without having to think about *how* to do it.

An example of a community that uses this principle to get people to act is *Avaaz.org* (Kavada, 2009). At present, Avaaz appears to be the largest organization to mobilize people globally for political action—with 14 million members in April 2012. Becoming a member is very easy: you just submit your name, email address and country on the website. Members can vote on which issues they consider to be most important. These include causes such as combating corruption, preventing global warming, helping democratic movements, protecting Internet freedom, or saving rainforests. For the issues elected as priorities, the organization then selects the actions that are likely to produce the most effect for the least effort. These are typically sending letters to members of congress about to vote on the issue, or submitting petitions to government representatives. All members receive the text of the letter or petition together with background information by email. They are then invited to support the action by signing this appeal. They can do this simply by clicking a link. This automatically appends their name and coordinates to the list of signatories. In this way, an appeal to amend a law about to be voted can gather millions of signatories in a few hours time, thus inciting the lawmakers to take into account the opinion of this worldwide community. This nearly effortless style of collective action has been called rather disparagingly *clicktivism* (Karpf, 2010). Yet, up to now it appears to be quite effective, while providing an interesting model of electronically supported democracy.

Another example of electronically supported political mobilization is the spontaneous coordination of activities that led to the downfall of authoritarian regimes in Tunisia and Egypt during the so-called Arab Spring (Sabadello, 2011). Here, Internet-based social media, such as Twitter, Facebook, and YouTube, allowed protesters to widely disseminate news while bypassing official censorship, thus drumming up support for collective actions. This made it possible, for example, to very quickly organize mass rallies, simply by announcing time and place, and propagating this announcement to friends and acquaintances in nearly real time. A more playful use of the same functionality can be found in so-called "flash mobbing" (Molnár, 2010), where a crowd of people suddenly gather at a specific time and place to perform some synchronized action (like dancing or playing music), just to impress the public.

More generally, platforms are being developed that allow citizens anywhere to report events they witnessed to a central database, if possible uploading photos, movies or other evidence via their mobile phones. A widely used example of such a platform is *Ushahidi*, originally created in Kenya to trace cases of violence and intimidation during the elections there (Gao, Barbier, & Goolsby, 2011). Such applications make it possible to document, analyze and map out instances of e.g. traffic jams, crimes, infectious diseases, or earthquake damage, thus revealing the precise degree and distribution of any such socially distributed problems. This in turns facilitates rapid mobilization, targeting and coordination of remedial actions, an advantage particularly important in situations of disaster relief (Gao et al., 2011).

Games and gamification

While Internet communities typically emphasize collaboration and sharing, there is another type of mobilization system that emphasizes competition and rivalry: *gaming environments*. The games available on the web are nearly infinite in their variety, but they all share the objective of scoring points or winning, i.e. doing better than the others. This too is a powerful motivator, which enhances focus, commitment and persistence. But games exhibit a variety of other motivators, given that by definition they have been designed for enjoyment, i.e. for providing stimuli that people find intrinsically pleasurable, so that they seek to collect as many as possible. Since the early days of personal computers, gaming has become an increasingly popular pastime. This has led programmers to create an ever-greater variety of ever more sophisticated games.

Up until recently, game design was largely intuitive: designers would create the kind of games that they themselves would like to play, or produce variations on popular examples. Out of the thousands of different games and their variants, the most enjoyable would typically spread widely, and be regularly updated and expanded, while the less successful would eventually disappear. This process of variation and natural selection produced an evolution towards ever "fitter", i.e. more enjoyable, games. The result is that the best games tend to be addictive, as players are so strongly motivated to continue the play that they find it difficult to get back to their normal activities (Grüsser, Thalemann, & Griffiths, 2006; Kim, Namkoong, Ku, & Kim, 2008).

With the variety of successful games available for examination, a number of observers have started to make abstraction of the specific features of any particular game, so as to find common patterns (e.g. Koster, 2005; Salen & Zimmerman, 2004). These have been called "game mechanics" or "game design fundamentals". While these principles help designers to produce more pleasurable games, the more interesting use is to apply them in domains other than entertainment. For example, given their ability to entice children and adolescents to focus on sometimes complex problems, gaming techniques are being used in education to make learning more effective and enjoyable (e.g. Dickey, 2006; Michael & Chen, 2005). An outstanding application is the *Khan Academy* (Thompson, 2011), an educational website that combines video lectures on a variety of topics starting from elementary mathematics, with game-like, computer-generated tests, in which learners can assess their progress by scoring points, and getting bonuses that allow them to move to a higher level.

But educational applications are merely the beginning: the recent development of *gamification* applies the mechanisms of game design to enhance focus and motivation for nearly any kind of activity (Deterding, Dixon, Khaled, & Nacke, 2011; Zichermann & Cunningham, 2011). It is used in particular by businesses and organizations to goad people into performing tasks that are useful for the organization—but not intrinsically rewarding for the individual. Examples are participating in surveys, filling in forms, or joining customer loyalty programs. While performing these activities, respondents are given the kinds of points, "badges", or bonuses that are used as symbolic rewards in games. This constant feedback motivates them to contribute additionally, so as to attain ever-higher total scores. Moreover, the more points they have gathered already, the less they are inclined to lose these points by prematurely stopping the activity—a psychological bias for continuity known as "sunk costs" (Garland & Newport, 1991).

Communities too sometimes use gamification techniques to boost participation. The Avaaz website, for example, exhibits a continually updated ticker listing the latest people to sign a petition, together with the total number of signatories, so that contributors feel they participate in an efficient, globally advancing movement. A more sophisticated example is *Stack Overflow*, a collaboratively edited question and answer site—initially about programming problems, but later extended via *Stack Exchange* to a network of sister sites covering such diverse topics as cooking, physics, photography and language (Mamykina, Manoim, Mittal, Hripcsak, & Hartmann, 2011). Participants in these communities can ask questions, propose answers, and vote on the questions and answers from other participants. As members contribute more good questions and answers and receive more positive votes, their status as recognized "experts" increases via a point system. This allows them to reach increasingly advanced levels of privileges, so that the more active and constructive contributors can make changes in the site organization that are impossible for newcomers. Thus, every member has a continuing incentive to provide high-quality contributions, making the community remarkably fast and effective in dealing with its problems (Mamykina et al., 2011).

More generally, gamification applies a variety of *game mechanics*, i.e. techniques that help to produce a compelling, engaging experience for the user or game player. They include:

- challenges or quests, in which the player is incited to achieve some difficult objective, which the player has not reached before (i.e. novelty),
- scores or points, to quantify all the small, step-by-step advances accumulated by the player, so that players get a continuous feedback about how well they are doing
- levels, which represent larger, discontinuous transitions to a higher degree of game difficulty or status

- competitions or leaderboards, where players can compare their achievements with those of other players, so that they are incited to do better than they did up to now
- narratives, in which the challenges are situated within a concrete context or storyline, so that individual actions become part of an extended course of action within a meaningful environment (Dickey, 2006; Heylighen, 2012a)
- epic meaning, in which the impression is created that the player is working to achieve a goal that is particularly important or awe-inspiring (McGonigal, 2011)
- trophies or virtual goods, in which players receive virtual presents as a reward for their achievement
- gifting, in which players get the opportunity to give virtual presents to other players, thus tightening links of friendship or cooperation.

Persuasive technology and the user experience

To be fully effective, the mostly social dynamics within communities and games needs to be supported by a good individual interface: users of a computer application should feel an intuitive understanding and control of what is happening, and be stimulated to explore and extend their mastery of the system. In other words, a good application should feel like a favorite tool or toy: easy and fun to manipulate. This essentially subjective appraisal is what is usually denoted by the rather ambiguous phrase of *user experience* (Garrett, 2002; Hassenzahl & Tractinsky, 2006). A compelling user experience is what makes a person want to use the application again and again. It is usually the result of smart design combined with extensive testing of the way users tend to interact with the system. Classic examples of good design can be found in Apple products such as the iPhone or the Mac operating system, and in Google web services such as Google Search or Google Maps, explaining the popularity of these tools.

Some of the elements of well-designed user experiences are:

- simplicity: the number of components or options on a given screen are limited, and common actions can be performed with a minimum number of steps
- esthetics: color schemes and designs are calm, elegant and pleasant; images, sounds and movements are not coarse, grainy or jerky
- interactivity: the tool responds clearly, distinctly and immediately to different user actions
- intuitiveness: user actions have as much as possible the effects that a naïve user would expect them to have (Spool, 2005)
- transparency: functions are self-explanatory, or can be understood after a minimal investigation
- consistency: the same actions or interface elements always produce the same effects
- richness: the tool offers an unlimited variety of content or applications to explore

A good user interface will compel the user to extensively use the technology. The next step is a technology that compels the user to do something beyond the technology itself. Fogg (2003, 2009) has defined *persuasive technology* as “any interactive computing system designed to change people's attitudes or behaviors”. Persuasive tools have been investigated especially with respect to their ability to improve health and well-being, e.g. by motivating people to exercise regularly, quit smoking, or stick to a more healthy diet (IJsselsteijn, de Kort, Midden, Eggen, & van den Hoven, 2006; Intille, 2004).

More generally, a persuasive system can be seen as an implementation of what has been called the *extended will* (J. Heath & Anderson, 2010). This is a generalization of the idea that we use various information technologies as external memories, so as to "extend our mind" into the environment (Clark & Chalmers, 1998; Heylighen & Vidal, 2008). But mind encompasses more than memory and information processing capability: it also includes the motivation, concentration and determination needed to act effectively—i.e. what is conventionally called "will". In our present environment full of distractions and temptations, our willpower is heavily taxed. Therefore, in general we need external support if we want to make sure that we stick to our intentions (Allen, 2001; J. Heath & Anderson, 2010).

A good support will not only keep reminders of what needs to be done, but provide the right stimuli at the right moments to incite us to act in the right manner. For example, if you try to lose weight, you will be helped by a tool that calculates the calorie content of your meals, suggests low calorie alternatives, provides a variety of tasty recipes, keeps track of your weight, extrapolates how much weight you would lose if you stick to the plan, and reminds you how much better you would look and feel without that extra weight. While there does not as yet seem to be a general methodology on how to design such tools, most of the used techniques are similar to the ones we have surveyed earlier. Persuasive technologies will be more effective if they:

- tap into real needs (e.g. combating the dangers of obesity)
- present clear goals (e.g. realistic weight targets)
- make it easy to do what is needed (e.g. prepare healthy meals)
- give feedback about the progress made so far (e.g. compare your present weight with your initial and ideal weights)
- provide clear visualizations of potential means or ends, so that users can easily imagine the effect of their future actions (e.g. a computer-generated photo of how you would look after losing all that weight)
- make use of social pressure (e.g. by pointing out the achievements of others)
- provide timely triggers to stimulate their users to do something (e.g. alarms to remind you to exercise)

Principles of Mobilization

Now that we have reviewed a variety of specific technologies, it is worth trying to extract the general principles behind the mobilization of action. A first step is to split the problem into its two aspects: *individual* and *collective*. Individuals first of all need to be stimulated or *motivated* to act effectively. Then, their actions need to be *coordinated* so that they help rather than hinder each other, and collectively achieve an optimal result. Let us discuss these aspects in turn.

Individual motivation

Possibly the most useful paradigm to understand individual drive is the psychological concept of *flow*, which was derived from numerous observations of how people feel while performing different types of activity (Csikszentmihalyi, 1990; Nakamura & Csikszentmihalyi, 2002). “Flow” refers to the pleasurable state experienced when the activity, while intensely focused, proceeds in a seemingly effortless, flowing manner—because every action immediately elicits the next action, without any hesitation, worry or self-consciousness. In such a state, continuing the activity becomes the only real concern, while everything else is pushed to the back of the mind. That is exactly the kind of focus and commitment that we expect from a good mobilization system. The gratifying, addictive quality of computer games is commonly explained by their capacity to produce flow (Cowley, Charles, Black, & Hickey, 2008).

The basic conditions needed to generate flow are:

- the activity has clear *goals*;
- every action produces an immediate *feedback*.
- the degree of difficulty or *challenge* of the task remains in balance with the level of *skill*.

The formulation of goals seems the most obvious requirement for focus and commitment: the goal functions like a target or “attractor” for the course of action, determining the direction for all future activity (Heylighen, 2012a). It is this directing influence that precludes the hesitation that would otherwise be elicited by an overload of choices. For example, for a rock climber trying to reach the top, the direction is clear: up! On the other hand, for a tourist sauntering through a strange city without specific destination, every crossroads presents a dilemma: left, right, or straight on?

An important aspect missing in typical flow models is that in order to produce enduring commitment a goal should correspond to something truly valuable. For example, while the goal of shooting a maximum number of spaceships in your game of Space Invaders may be clear, it does not satisfy any real needs. Therefore, playing games, however enjoyable at the time, if continued long enough will eventually leave you with the feeling of having wasted your time. One way game designers try to overcome this limitation is by creating a sense of “epic meaning” (McGonigal, 2011), i.e. situating the game action in a narrative context which implies that something truly great or valuable is being achieved (like saving the world from alien invaders).

But what then are these values that are able to motivate action? To understand values or needs at the individual level, we can investigate the (extensive) psychological literature on motivation, but there is no space here to go into any details. A commonly applied model is Maslow’s hierarchy of needs (Heylighen, 1992; Maslow, 1970), which assumes that needs or motives can be ordered from the most urgent or basic “deficiency needs” (hunger, thirst, security…) to the more long-term “growth needs” (status, self-actualization, …). A more pragmatic list of motives relevant for mobilization systems could be the following:

- (material) reward (e.g. receiving money or presents)
- learning (acquiring new knowledge and experience)
- belonging (being accepted as member of a community)
- altruism (helping others)
- status (being esteemed at least as high as others)
- achievement (being able to look back with pride on what you did)

Goals that contribute to satisfying one or more of these needs will obviously be more attractive or compelling, and therefore more effective in mobilizing action.

The second component of the flow model is feedback. Knowing the general direction in which your actions should lead is not sufficient to effectively get there: you should make sure that every action has the intended effect. If the effect is not exactly what you expected, you will deviate from the planned course of action. Even tiny deviations will gradually accumulate into a large deviation, so that you may completely miss the target. The only thing that allows you to correct such deviations is *feedback*: a response signal that informs you to what degree and in what direction you have deviated from the intended path. For example, if you start walking towards a faraway target, e.g. a tree in the middle of a plain, you will keep an eye on the target, and correct your course as soon as you notice that you have deviated either to the left or to the right from the proper direction. However, if a dense fog would arise so that you can no longer see the target, this visual feedback signal would be lost, and you may continue to wander through the mist without ever reaching your destination.

The flow paradigm emphasizes the *immediacy* of such feedback. Indeed, if a feedback signal would only arrive after a finite interval, deviations could grow during that interval. Even when the actual deviation would remain small, the absence of feedback would create a growing sense of uncertainty about whether you are following the right course of action. And this uncertainty is precisely what feeds the anxiety, hesitation and procrastination that we would like to avoid. Vice-versa, each feedback signal is either a confirmation that you are on the right track, or an indication of how you can get back on the right track. Therefore, any feedback signal, even if negative, boosts your effectiveness, and therefore self-confidence, in continuing your activity, adding to the sense of flow. (It must be noted, though, that the maximum interval between action and feedback depends on the speed with which deviations are likely to grow: if the course of action is sufficiently clear or its progression sufficiently slow so that there is no immediate danger of getting lost, you can afford to wait before you get any feedback. This happens for example during activities that you have mastered to such a degree that you feel very confident about being on the right track.)

Not just the immediacy, but the *richness* of the feedback helps to maximize flow. Minimal feedback might tell you merely: “yes, you are on course” or “no, you have deviated”. (This would be the equivalent of a game where you earn one point if you get it right and no point otherwise). But the latter information would not be enough to steer an efficient course. Complex activities can go wrong in many different aspects. Each aspect defines a dimension or degree of freedom in which the course of action can vary. Effective feedback would inform you about the precise degree and direction of the deviation in each of these dimensions, so that you know what correction to make. Therefore, as we noted, a good user interface must be fine-grained and multidimensional, offering if possible images, sounds, colors, and animations that react in tune with your actions. Ideally, the channel of communication between user and system should have a high bandwidth, so that a lot of information can be transmitted swiftly in both directions, from the user to the system (action), and from the system to the user (stimulus, feedback). This maximizes the control the user can attain over the system.

The final requirement for flow is the balance between challenges and skills. This means that the task should not be too difficult for the level of skills available, but not too easy either. According to the basic flow model (Nakamura & Csikszentmihalyi, 2002), a too easy task produces

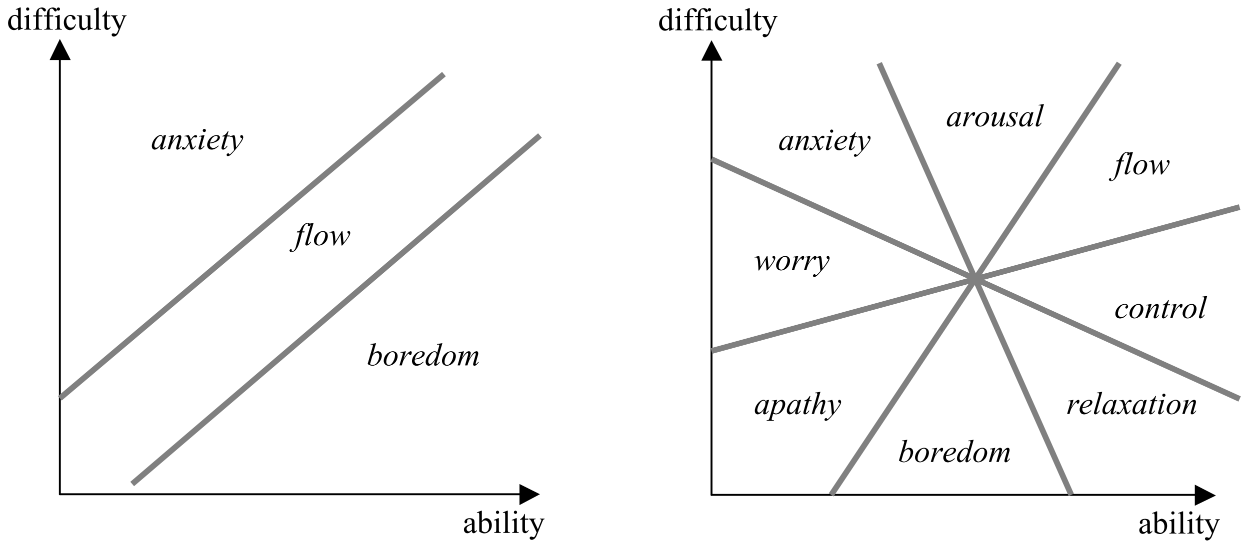

Figure 1: two models of flow as arising out of the balance between challenge (difficulty) and skill (ability). In the simple model (left), the "flow channel" is defined by the near equality of difficulty and ability; in the more complex model (right), flow only arises if both difficulty and ability are higher than average.

boredom, as it does not fully engage the attention, while a too difficult one produces anxiety, as the person becomes afraid to fail. Only a task that is challenging enough will engender the level of intense, but tranquil, concentration that characterizes flow. There are two ways to control the balance between challenges and skills: changing the intrinsic difficulty of the task, and changing the person's ability to cope with the task. At first sight, balance could be achieved by proposing a relatively easy task at which the person is not particularly skilled. But a more advanced model sees flow as emerging from high skills applied to difficult challenges (Fig. 1). In this more complex model (Nakamura & Csikszentmihalyi, 2002), limited skills applied to limited challenges merely produce apathy, as there is not much to create interest.

This means that a good mobilization system not only should present goals that are difficult to reach, but provide the additional abilities necessary to handle that difficulty. This is the "new skills" feature that characterizes a truly compelling technology: you will feel most stimulated to use a tool if it allows you to tackle challenges that you could not tackle without it—albeit in such a way that its use is fully intuitive and transparent. Eventually, a good tool should start to feel like an augmentation or extension of yourself—the way a stick extends the reach of your arm, a telescope extends your vision, and a notebook extends your memory.

A final addition to the flow paradigm is the observation that in "natural" environments challenge levels vary. A mechanical application of the flow prescription would try to maintain the challenge level within close boundaries around the skill level. But such a constant level of challenge tends to become tiresome (Sorenson & Pasquier, 2010), as a person's attention levels naturally fluctuate. One solution is to let the degree of difficulty increase and decrease rhythmically, so as to build in regular periods of relaxation—but this too seems somewhat artificial. Natural fluctuations rather seem to be characterized by an irregular distribution governed by a *power law*: many small ones, some medium ones, and few large ones. This means that the challenge level, while variable, would mostly remain near to the one matching the skill level, but that from time to time a particularly easy or difficult challenge would arise. During the easy challenges, the mind can relax and recover, during the difficult ones it is stimulated to surpass itself. This is likely to keep the attention ready for "surprises", thus avoiding a sense of monotony setting in.

More generally, the flow paradigm lacks the notion of *adventure* (Dickey, 2006; Heylighen, 2012a), which can be characterized by a sequence of unforeseen challenges (dangers, opportunities, surprises…)—as contrasted with the foreseen challenges that we call 'goals'. It is the unpredictability or unexpectedness of these challenges that creates the excitement that we typically associate with an adventure, and that forms the basis of full emotional involvement. Adventure is associated with the notions of *exploration*, *curiosity* and *mystery*: mystery can be defined as a lack of prospect that incites the emotion of curiosity, which in turns incites exploratory action (Heylighen, 2012a). Mystery and adventure are common features of game design (Dickey, 2006). However, their role will need further analysis if we want to apply them systematically to mobilization, given that they imply a level of uncertainty that—if experienced too intensely—may produce the anxiety that mobilization systems are trying to avoid. On the other hand, the uncertainty about what you will encounter next is of a different nature than the uncertainty about what you should do next. The typical surprises experienced during an adventure (attack by a killer, discovery of a treasure, spotting of a mysterious person…) do not leave much doubt about how to react (run away, collect the riches, try to find out more…). Thus, they incite action rather than procrastination, while contributing to a more intense mobilization of mental and physical resources.

Coordination

When several people work together, their actions need to be coordinated. This means, minimally, that the actions do not obstruct or oppose each other (conflict, friction); ideally, that the actions complement each other in such a way that together they achieve more than separately (cooperation, synergy). In other words, *coordination* can be defined as the arrangement of actions across people, places and times so as maximize synergy and minimize friction. In earlier work (Heylighen, 2012b), we have analyzed coordination into four components: *alignment*, *division of labor*, *workflow* and *aggregation*.

Alignment is the most obvious requirement for synergetic action: the different actions and agents should point towards the same target(s). This means that the overall goals or values of the participants should be consensual rather than conflicting. Consensus can be achieved explicitly or implicitly. The simplest explicit method is *voting*: of the different objectives proposed, the ones that gather most votes within the community are chosen as priorities. This is easily automated in a mobilization system, e.g. by adding "like" buttons next to the different options, and counting which ones are most popular. A better method lets dissenters propose arguments for why they like or dislike certain options, so as to allow a more reasoned (and in general more broadly supported) consensus to emerge. That is what happens in typical discussion forums, albeit in a rather anarchic fashion.

This too can be further automated, so as to come to better conclusions more efficiently. The *Delphi technique*, which uses several rounds of structured, anonymous, and moderated discussion, is a classic method that has proven its value in a variety of settings (Keeney, Hasson, & McKenna, 2006; Linstone & Turoff, 1975). Some newer techniques extend this approach so as to be applicable to larger groups while requiring less moderation: 1) the *synthetron* method lets the ideas that collect most votes in a small group propagate across ever wider groups, while allowing people to improve on the ideas they encounter, so that the best formulations eventually garner the widest acclaim (Faieta, Huberman, & Verhaeghe, 2006); 2) *argumentation mapping* allows large on-line groups to investigate very complex issues, such as climate change, by linking issues with arguments and counterarguments in a growing public network (Iandoli, Klein, & Zollo, 2009; Klein, 2011).

Alignment can also happen implicitly or spontaneously, like in a conversation where people mutually adjust their way of communicating without being aware of it. Such self-organization is typically driven by a positive feedback, where the more alignment there already is, the more the remaining people are incited to align to that emerging standard (Heylighen, 2012b). An example is a call to hold a demonstration on a certain place at a certain time: the more people think that this is a good idea, the more they will try to persuade their friends and acquaintances to join that meeting, the more these friends will persuade their friends, the more people will agree to go to the meeting, the more attractive it will seem to others to join that growing group, and so on, until a large crowd gathers at the target event. This process too can be facilitated by using the right technological medium, such as Twitter or text messaging.

When the target is not as simple as a time and place for meeting, alignment on a common outcome tends to be a slower and more complex process. Here too, technology can facilitate what is in essence a self-organizing process. An example is Wikipedia, where different contributors with different opinions correct each other's contributions, until a consensus—or at least a balanced survey of pro and con views—emerges (Kittur, Suh, Pendleton, & Chi, 2007). The underlying coordination mechanism here is *stigmergy*: contributors are in general not arguing with each other, but with the aggregated "trace" of all previous contributions, by making what they consider improvements here or there. If someone else considers the latest addition to be biased or inaccurate, that person will make a further edit. Except for the most controversial issues, this back-and-forth editing tends to converge to a version that is acceptable to all.

Stigmergy is also an excellent mechanism for achieving a division of labor: different people normally have different abilities. Therefore, the most efficient organization of a collaborative work is to let every person do that part of the work that s/he is best able to do. In a stigmergic medium, like Wikipedia or a community-maintained list of feature requests, the work is laid out for every one to see. Thus, every prospective contributor can choose the task that offers the best balance of skills and challenges for that person. This basic form of self-organization can be enhanced with various tools.

One technique is to characterize tasks (and potentially also people) with keywords or tags. Such tags can be used to suggest a task to the people in the best position to deal with it. These are not necessarily the most skilled people. For example, the profusion of development tasks has led the Drupal community to introduce a "novice" tag (Byron, 2009), indicating that a task is easy enough for an inexperienced person to handle. This reduces the workload on the experts, stimulates the novices to acquire the necessary experience to contribute more efficiently, while offering a better skill/challenge balance, thus stimulating flow. In Wikipedia too, there exist a variety of tags that attract the attention of specific people to specific problems that an article being worked on may have—such as lack of references, poor grammar, or need of expert review.

Tasks can also be directly suggested to specific individuals, by adding their names to a "to the attention of" list for each task. These people will then be informed by the system about the task, but maintain the freedom to ignore it, or to pass it on to someone else who is more fit. The system should also keep track of which person has committed to perform which task. In that way, others will know that their efforts are no longer needed for this particular job. Additionally, if the work does not to seem to progress, they can remind the people assigned to it of their commitments. The latter function could also be automated, letting the system send reminders at regular or predetermined intervals, until the task is listed as "done" or "closed".

Workflow is the *serial* complement to the *parallel* division of labor: a complex activity must in general be decomposed not only in tasks done simultaneously by different people, but in tasks that have to be done in a particular order or sequence. The "flow" in this case denotes the smooth transmission of a partially finished work from person to person along the sequence. Workflow too can be implemented in a simple manner using stigmergy: as soon as someone has finished part of the work, s/he leaves the result in the shared medium, ready to be picked up and continued by the next person capable and willing to work on it. Again, Wikipedia is a prime example of this functionality.

Like in the case of the division of labor, this minimal support can be enhanced by letting people add keywords, states or names that help to attract the right person to the task at each stage. Issue queues (like the one used in Drupal) generally have a state function that directs the workflow, e.g. from the state "new" (issue formulated but not yet addressed) to "active" (someone is working on it), to "needs review" (work had been done, but must be checked by someone else), to "closed" (the result has been approved). Other examples of states are "won't fix" or "needs documentation". These would attract different users, specialized e.g. in difficult problems or writing documentation. Contributors can also more actively send invitations to action to people they know, who may pass it on to their connections. This process may be called *challenge propagation,* as challenges (incitements to act) are transmitted from person to person along a technologically supported network (e.g. using social media), until the challenge is completely dealt with (Heylighen, 2012c).

The final requirement for effective coordination is *aggregation*: the assembly of all the different contributions into a coherent end product. Aggregation of results in a communal memory is the essence of collective intelligence, as it synthesizes the diverse points of view, experiences and knowledge of a group of individuals into a "wisdom of the crowd" (Heylighen, 2012b; Surowiecki, 2005). Again, stigmergy provides a robust default mechanism: people add their contributions to a shared, structured workspace (e.g. a Wikipedia page, an argumentation map, or an Ushahidi database of witness reports), thus ensuring that they become part of an articulated whole. In the case of voting or other quantifiable actions, averages or distributions can be calculated automatically by the system so as to reflect the collective wisdom of the community (Heylighen, 2012b). Aggregation can also be performed by a moderator or editor, who gathers the most important contributions, lays them out in a clear format, and possibly synthesizes them (like in the Delphi or Synthetron techniques).

Synergy between individual and collective mobilization

At first sight, (individual) motivation and (collective) coordination may appear like independent functions that are better implemented in separate systems. However, some further thought makes it clear that the one directly reinforces the other. Committed and focused individuals are more dependable. Therefore, it will be easier for them to collaborate in an efficient, coordinated manner (Allen, 2001). Moreover, committed individuals will be more enthusiastic and persuasive in getting others to join the cause, thus extending the group of "aligned" people.

Vice versa, when individuals feel aligned in their goals with others, they become more motivated to work towards these goals. This can be explained by the universal motives of belonging and altruism. When others want the same as you, you will feel a sense of group solidarity or kinship with them, so that you become more committed to work for that community. Furthermore, the more people around you are already aligned in their goals, the more you will be inclined to adjust your own goals and values to theirs and thus join the group. Indeed, one of the most effective ways to motivate people to do something is to point out that others already do it (Thaler & Sunstein, 2008). This can be understood from the universal drive to imitate others and to conform to group norms.

In conclusion, motivation boosts alignment, while alignment boosts motivation. Additionally, coordination boosts the sense of achievement: the more efficiently you collaborate with others (e.g. because of good workflow, division of labor and aggregation), the more difficult the challenges you will be able to tackle, and therefore the more flow you will experience. This mutual reinforcement between individual and social stimulation explains why the most effective mobilization tends to be found in communities—although we must not forget that mobilization systems are also very effective for encouraging purely individual activities.

Finally, it is worth noting that the basic mechanisms for motivation and coordination, respectively *flow* and *stigmergy*, are in essence two sides of the same coin. Both describe the close interaction between an agent (the user) and a medium (the system or technology), so that an action by the one incites an immediate response by the other. In the case of flow, the focus is on the feelings of the user, with the medium merely providing the targets and feedbacks needed to keep the user fully engaged. In the case of stigmergy, the focus is on the state ("trace") of the medium, which develops through the subsequent user actions it incites, up to the point where it offers an aggregate solution to whatever challenges it started out with. The coordination between different user actions is merely the byproduct of the fact that all users share this stimulation by the medium, and thus effectively act in the same workspace on the same overall task.

The upshot of this symmetry between flow and stigmergy is that a technology good for the one will in general also be good for the other: both require a medium that is very responsive, high-bandwidth, and multidimensional, so that it can aggregate plenty of fine-grained data while presenting clearly articulated challenges and feedbacks to its users. That is why the most effective mobilization systems will both *incite individuals* and *coordinate communities*.

Applications and implications

We have reviewed a variety of examples as well as general principles for the technology-mediated mobilization of action. Both practical experience and scientific theory suggest that such mobilization systems can be very effective in getting people to act in a focused and coordinated manner, towards either individual or collective goals.

Like with all technologies, this power can be used for good or for bad. Mobilization systems can help people to work for their own well-being or for the benefit of society (Heylighen, 2009;

Thaler & Sunstein, 2008). Yet, they can also be used to exploit inherent human drives for selfish purposes. Thus, mobilization systems create a variety of social, political and ethical issues (Verbeek, 2006) that will need to be investigated in depth as the technology matures. While there is no space here to go into detail, let us point out some of the more obvious risks of abuse as well as potential benefits.

Potential dangers

We have already alluded to the common problem of game *addiction* (Grüsser et al., 2006). Similar types of addiction are emerging with respect to various forms of social media that people use to stay in touch with their community (such as Facebook or Twitter), and with technologies offering a particularly compelling user experience (such as virtual reality). The underlying mechanism extends to any kind of mobilizing technology: the feeling of flow produced by a well-designed system is intrinsically pleasurable and stimulating, while making the user forget all concerns except the here-and-now of the system. While the system may have been designed with the best intentions (e.g. make the user study mathematics), such objectives should never override all other objectives (e.g. the user needs to rest, eat, go to work, care for children, etc.). Yet, the nature of flow is to keep the attention focused on a single task. If the mobilization system would moreover be designed so as to minimize the natural reactions of monotony, fatigue or boredom that would normally set in after a prolonged period of focused activity, the danger is real that the user would start neglecting real needs. There is plenty of anecdotal evidence about players who become so immersed in their gaming environment that they forget to eat and sleep, and go on for stretches of 36 hours or more until complete exhaustion.

A possible remedy is to have built-in usage limits, so that the system would switch itself off if it is used for more than a preset duration. Better even is that the user would be able to specify a usage regime, so that the system would only be available for a certain number of hours per day, week or month. This is already possible in some games. For example Blizzard, the company behind some well-known online games like *World of Warcraft*, *Starcraft* and *Diablo*, offers a "parent control" mode allowing parents to regulate the playtime of their children.

In order not to brutally interrupt the flow state, the "switching off" at the end of the preset period may happen in a gentle way, with the system providing a warning as the end of the period comes nearer, and then becoming increasingly unresponsive until it stops functioning completely. Some of the more challenging activities in *World of Warcraft* have a "cooldown" mechanism illustrating this gentle decline of gaming abilities. Another useful feature illustrated by this game is the difference between "fatigued" and "rested" states. Players adventuring too far may accumulate fatigue. If their fatigue level increases too much, their game character sustains damage and eventually dies. Resting happens while the user is logged out of the game. Its effect is to increase the player's gaming abilities. The fatigue/rest dynamic can motivate players not to spend too much time in the game. But to effectively prevent addiction, such features would need more general and explicit controls, e.g. specifying the maximum play and minimum rest periods under different conditions.

Another major danger is that mobilization systems would be abused by commercial or political organizations to influence and exploit unsuspecting users. Political mobilization is likely to attract most controversy. However, the example of Avaaz (Kavada, 2009) shows that technology-supported activism can be perfectly free and democratic, by making it equally easy for users to opt out or to opt in to specific actions. More generally, advocacy groups throughout the world are successfully using social media to stimulate democratic engagement (Obar, Zube, & Lampe, 2011), by making it easier for members of the public to express their opinion and participate in collective projects. Ideally, community members should not only be able to collectively choose objectives, but abstain from participating in objectives for which they did not vote without feeling excluded.

Such democratically supported collective action is not necessarily positive or negative, but its amplification by social media can produce a potentially dangerous acceleration of events. This can be illustrated by the 2011 riots in London, which were initiated and coordinated with the help of new media such as Twitter and Facebook (Baker, 2012; Bohannon, 2012). They resulted in a lot of chaos and destruction throughout the city. Yet, in the following days the same social media were used to organize a clean up, bringing the city in a very short time back to business as usual.

An even greater danger is the use of mobilization systems for propaganda by totalitarian regimes or extremist factions that lack any kinds of democratic checks. Here, a mobilization system could be used to stir up religious or ethnic hatred and orchestrate mass killings, as happened e.g. in the 1994 Rwandan genocide. But that can be achieved as well with more traditional means of mobilization, such as the RTLM radio station used in Rwanda for propaganda (Yanagizawa-Drott, 2010). We can only hope that in such situations the opponents of extremist actions would have access to equally powerful mobilization systems, so as to be able to mitigate any incitements to hate and violence. Still, considering the example of the London riots, we should be aware of the potential for escalation, and the danger that the situation would accelerate out of control before any countermeasures can be taken. In London, the damage was mostly material, but the propagation of extremist messages and the ensuing alignment on coordinated aggression could well result in irreversible human casualties.

Commercial exploitation of mobilization technology may be less spectacular, but more insidious. All commercial organizations have the incentive to maximally extract profit from their clients. If this cannot be achieved simply by offering the best products, the preferred strategy up to now was advertising, i.e. trying to persuade potential customers to buy their products rather than those of the competitors. The incessant stream of publicity undoubtedly contributes to the overload of stimuli and choices that we discussed in the introduction. As people learn to turn away from such unwanted distractions—e.g. by using technologies such as spam filters or ad blockers—corporations seek more effective means of attracting and engaging customers. Viral marketing, which uses the power of social media, and gamification are among the newer, more powerfully mobilizing techniques.

While such technologies may benefit individual companies, competition between equally valuable products is essentially a zero-sum game, meaning that gains for some will be counterbalanced by equal losses for others. However, it is the public that will accumulate net losses: mobilization systems by definition demand a lot of concentrated attention from their users, but this energy will be lost in "games" that merely benefit one company at the expense of another, without overall benefit for the public itself. The more effective the mobilization, the more mental energy will be spent in going along with various marketing campaigns, and the less will remain for more productive activities. The best way to minimize such "mental parasitism" may be to educate the public about the powers and dangers of mobilization systems, emphasizing the differences between frivolous and constructive uses, so that people can consciously decide to ignore a mobilization system offered to them if it does not satisfy any real needs.

Potential benefits

Let us move on to the positive applications of mobilizing technologies. It seems that their power of motivation and coordination is such that, if used for truly valuable activities, it could potentially revolutionize society.

Perhaps the most obvious application is to make traditional work more productive and less stressful (Allen, 2001; Heylighen & Vidal, 2008). Ideally, a good mobilization system should produce a flow state for the employees, while efficiently coordinating their activities, so that their work would achieve its objectives with much less waste of mental and physical resources, while maintaining the sense of flexibility and serendipity needed to deal with a constantly changing environment full of new challenges. Our institute has begun to implement such a system for managing our own work, starting from the Drupal "issue queue", but adding a number of more advanced workflow and prioritization features. Similar systems can be (and are being) used for volunteer work in communities, such as open-source development (Heylighen, 2007). This can greatly enhance the effectiveness of non-profit organizations, e.g. in supporting sustainable development in poor countries, or providing disaster relief (Gao et al., 2011). In business environments, such systems are likely to boost productivity, flexibility and morale, while minimizing distraction, burnout, and employee turnover.

At the government level, mobilization systems can be a powerful aid for implementing a policy of *libertarian paternalism* (Heylighen, 2009; Thaler & Sunstein, 2008), i.e. inciting people to do what is good for themselves and for society, but without legal enforcement. Rather than prohibiting "bad behavior", such an approach would organize the environment (i.e. create a mobilization system) in such a way that people would feel motivated to spontaneously behave in the right way. For example, instead of outlawing tobacco use, the government could provide mobilization systems that would stimulate people to stop smoking. Such mobilization systems may eventually become seamlessly integrated into the physical environment, as envisaged in the scenario of *ambient intelligence* (Verbeek, 2009), i.e. an intelligent environment that automatically responds to the needs and desires of the people present. As we saw, persuasive technologies may be especially effective in encouraging a healthy lifestyle, and more generally in promoting overall well-being and happiness (Heylighen, 2009; Thaler & Sunstein, 2008).

A particularly important application domain is *education*: in principle, mobilization technologies should be able to substitute the traditional following of courses in a school or university with a universal system of computer-guided learning supported via the Internet (Heylighen, 2007; Thompson, 2011). Such automated teaching and testing of students would save an enormous amount of money—a benefit crucial for boosting education in the poorest countries and communities. Moreover, it would allow an education tailored to the specific needs of each individual, as the system would be available at any time and place, and provide challenges carefully tuned to the skills and needs of the learner, thus progressing at the fastest rate possible for that person. Developing all the needed educational materials will still be a tall order, but this is already being addressed by a variety of committed volunteers, communities, NGOs and governments. These merely need better coordination—something that existing mobilization technologies (such as wikis) already offer, as illustrated by wikiversity.org, an educational sister project of Wikipedia.

Educational applications are readily extended to scientific applications: the best teachers of advanced knowledge are the researchers who participated in developing that knowledge. A good system should help them to further develop that knowledge by keeping track of unsolved issues, registering and linking together all ideas and data that seem relevant to solving that issue, coordinating researchers working on related topics, eliciting feedback on new ideas, and analyzing the resulting knowledge network to find the places where progress may be made most swiftly, so that researchers can be directed to the for them most interesting challenges. We envisage that the combination of these teaching and research applications would result in a mobilization system that we have called the *stigmergic university* (Heylighen, 2011b), as it largely automates the functions of a real university, while using stigmergy as a basic mechanism for developing, organizing and disseminating knowledge.

Such a system would moreover facilitate the assessment of progress that is crucial for education, as it provides the learners with the necessary feedback, while challenging them to attain ever-higher scores. This is particularly difficult in the higher stages of education where studying given material is gradually replaced by autonomous research and development. As a first example of such an application, we have recently performed an experiment using an extended issue queue to mobilize a large group of students to develop their own projects (Kiemen, 2012). Moreover, the project of one student had to be formally evaluated by at least two other students via the same issue queue. This made it possible to distribute the labor-intensive task of assessing original work, thus reducing the workload on the teacher, while promoting the autonomy of the students.

This list of potential applications is by necessity incomplete: mobilization systems can be used to stimulate any type of activity deemed valuable by some person or group. At the most general level, mobilization technology is likely to become a crucial component of the planet-wide collective intelligence that is emerging from the interconnection of all people via the Internet and associated information technologies (Heylighen, 2008). Such a distributed intelligence, which is perhaps best described by the metaphor of the *Global Brain*, may be able to tackle problems that are as yet too complex for individuals or traditional organizations. Usually, studies of distributed intelligence and of human-machine symbiosis focus on the acquisition, storage, retrieval and processing of information, i.e. the *cognitive* dimensions of mental functioning. However, as we noted earlier, a true mind or brain also has an intentional or motivational dimension, i.e. a *will*. This *conative* function (Huitt & Cain, 2005; Poulsen, 1991) just as much needs technological support in order to deal with the growing number and complexity of available options for action (J. Heath & Anderson, 2010). Mobilization technology may help us to align the scattered wishes, desires and intentions of millions of people, thus gathering the momentum, engagement and "political will" necessary to tackle truly global problems, such as climate change (Iandoli et al., 2009; Klein, 2011). This is probably the greatest prize of all. But whether mobilization technology would be sufficient to achieve it remains of course very speculative at this stage…

Conclusion

We have defined a mobilization system as an ICT-supported form of organization that stimulates or motivates people to work towards some goal(s), while efficiently coordinating their actions. The need for such systems follows from the overload of information, distractions and choices that we are confronted with. This bombardment with scattered stimuli produces anxiety, hesitation, and procrastination, while making it difficult to remain focused and committed. Collaboration between uncommitted, distractible and stressed individuals without clear objectives is highly inefficient. Working at cross-purposes in such an erratic, fragmented manner can only waste resources.

We have argued that the first requirement for effective mobilization is the creation of a state of flow. Such a mental state is characterized by an intense but relaxed focus, a disregard for any worries or distractions, and a seemingly effortless progression towards a challenging target. Flow can be produced by formulating clear goals, preferably in line with real needs, providing immediate and detailed feedback, while maintaining the level of challenge or difficulty of the task essentially in balance with the person's level of abilities.

The individual motivation produced by flow is readily extended to the collective coordination supported by stigmergy. Stigmergy, like flow, rests on clearly perceivable challenges, and multidimensional feedback on actions. To this, stigmergy adds a shared workspace, or "medium", in which all the work that is already done or still needs to be done is clearly laid out for everyone to see. This makes it easy for each contributor to pick the remaining task that best fits her level of ability. The fact that different contributions are presented and articulated in the same workspace automatically promotes coordination, in the form of alignment on coherent objectives, efficient division of labor, smooth workflow, and automatic aggregation of the results.

The real-life existence and effectiveness of flow (Csikszentmihalyi, 1990; Nakamura & Csikszentmihalyi, 2002) and stigmergy (Elliott, 2007; Heylighen, 2007; Parunak, 2006) have been extensively documented. While their mechanisms are rich and subtle enough to deserve further investigation, we already understand them well enough to apply them here and now. What remains to be done is implementing the abstract principles into concrete systems. Practical guidance here may be found by examining technologies that have proven their effectiveness in mobilizing action. That is why we have surveyed a broad variety of such existing applications and their underlying mechanisms.

The principles of flow are most readily recognized in computer games and the derived "gamification" techniques, and in interfaces characterized by a compelling user experience. All these technologies make use of salient, clearly formulated challenges and rich, immediate feedback, while transparently extending the user's abilities to achieve these challenges. The result is that people feel stimulated to such a degree that they often find it difficult to stop using the system.

The principles of stigmergy are at the base of various "social technologies", where people can post an idea, photo or other contribution in a forum where others are enticed to react to it (Elliott, 2007; Heylighen, 2007). In this way one contribution tends to build further on another one, producing a virtuous cycle of advances eliciting further advances. This spontaneous coordination mechanism is exploited by a variety of Internet-based communities, including open-source software developers, question & answer sites, political activists trying to get people involved in democratic movements, and even disaster relief organizations. The example of Wikipedia in particular illustrates the tremendous power of stigmergic organization (Heylighen, 2007): in a mere few years time a worldwide group of volunteers, who do not even know each other, have collectively produced the largest encyclopedia that has ever existed—an achievement of a magnitude and complexity difficult to imagine before the advent of the web.

The unsuspected effectiveness of mobilization systems based on flow and stigmergy signals both great promises and great dangers. Work, democracy, education, research, health and well-being are likely to be the first to benefit from a judicious application of these technologies, through a generalized increase in engagement and productivity, and a decrease in stress and confusion. On the other hand, cases of game addiction illustrate how some people would rather forego food than be separated from their flow-producing computer systems, while mass mobilization technologies have been used to produce riots and revolutions. Mobilization technologies can be exploited by companies, groups or governments to manipulate people into doing things that are detrimental to the common good.

The most critical question for the future, therefore, may be not so much how to create efficient mobilization systems, but how to control them and for what purposes to use them. Here too, stigmergy may come to our rescue, by supporting large-scale discussion of the issues (Iandoli et al., 2009) and facilitating alignment on broadly supported goals, guidelines and regulations. A worldwide alignment on the most important values, targets, and strategies may even create the equivalent of a *will* for the emerging "global brain"—the collective intelligence formed by humanity supported by its information and communication technologies. Such a broad consensus on what to do next may well be the ultimate reward, as it would enable a coordinated attack on the most pressing problems of our age: climate change, war, poverty, disease...

In conclusion, while much further work needs to be done in elaborating, implementing and testing the mechanisms that we have surveyed in this paper, the intrinsic power of such technologies appears immense. Whether that power would be used mostly for good or for bad, it will be crucial to further study the features and implications of mobilization systems, so as to become fully aware of the dangers as well as the promises, and to formulate appropriate strategies to deal with these challenges.

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