TECHNO-SOCIAL CONVERGENCE ENABLING PRACTICAL GENERAL-PURPOSE COLLABORATIVE DECISION-MAKING

8, January 2011

By Jeffrey Miller

PO Box 2060
Los Gatos, California USA 95031
+1 408 483 1697

EXECUTIVE SUMMARY

Cultures and nations compete on an economic stage built by many of individuals each drawing upon distributed societal wisdom. Common belief holds that the more people involved in a decision, the better the result. Unfortunately, this belief proves false as the number of participants grows beyond an optimal group size and demonstrates that traditional collaborative processes don't scale well.

Compromises to collaborative processes have been necessary to increase the capacity of those processes, but compromises tend to compound existing problems and create further constraints which limit the ability to produce quality decisions.

Information processing has been the greatest single factor constraining societal decision making. Social networking is built upon communications and information processing capability which both rest on other technology advancements. Advancement distributed processing and database design, voting algorithms, and other technology for massive data management have together achieved the technical prerequisites for an expansion of large scale societal decision making.

Each adoption of a technology has changed how people behave. A majority of internet users are a generation of collaborationists who have never known a world without mobile phone, personal computer or internet, and who collaborate to a much higher extent that preceding generations. Society's adoption of social networking, the proliferation of personal digital appliances, and the collaborative attributes of Web 2.0, are the result of changing behaviors, and will precipitate future behavioral change. Together, these technological and social changes have created a techno-social convergence which makes possible the creation of truly general-purpose collaborative decision-making processes which can be applied in social and political contexts.

A practical large-scale collaborative decision-making process provides not only the interactive capabilities offered by social networks today, but the additional element of facilitative leadership to focus the evolving, chaotic, Brownian motion of social interaction, towards a particular goal. Such a process must ultimately be a product of the interaction which it facilitates, and must evolve with changing uses, behaviors and technologies.

Wide use of a general-purpose collaborative decision-making process will cause the restructuring of existing markets and the creation of new markets. Three in particular which will change the face of economies are; knowledge markets, cognitive labor markets, and decision markets.

These markets will not only provide expanded opportunities for individual income, but revenue for those facilitating the process and providing infrastructure, through: 1) advanced demographic-specific based advertising, 2) brokering trade in knowledge, cognitive labor, and decision-making, and 3) data mining and sentiment polling.

This paper describes the present techno-social convergence, the concept of a general-purpose collaborative decision-making process, and the opportunities it offers those who possess foresight and the courage to act.

TABLE OF CONTENTS

BACKGROUND

SURVIVAL OF CULTURES AND NATIONS

Individual decision-making

Each individual's decisions are made freely, as each person economizes use of their limited resources for maximal satisfaction. The aggregate of these individual decisions insures that the finite resources of society are used optimally to satisfy the greatest number of needs. While individually made, these decisions are not made in isolation. To the extent that technology and social behavior allows, each individual's decisions are made by applying personal experience as well as the collective historical knowledge accumulated by the group.

Survival is social

Innate intelligence and the experience of a single individual cannot provide sufficient knowledge for that individual's survival in isolation. Survival depend on successful integration into, and function within social groups which use communication, specialization, and collaborative decision-making to solve problems. Charles Ellwood comments; "Man's social instincts,… have been perhaps even more important for his survival than his intelligence." (Ellwood, 2006)Page 33, KL337. This is consistent with Thomas Sowell's model of constrained vision in which the wisdom and knowledge of society is distributed across the population rather than concentrated in a small set of superior individuals. Social structures and behavioral interaction hold the processes by which societal knowledge is disseminated. Without successful participation in society, even the most intelligent individual will perish. Ellwood also reflects on the natural selection between competing cultures; "In the competition between … groups, only a few that have had efficient organization and government, loyal membership and high standards of conduct within the group, have survived.", (Ellwood, 2006)Page 42.KL461, which relates directly to the development and efficient use of knowledge.

Cultures and nations

How groups of humans make decisions has evolved through time, and has resulted in a set of skills which are the most effective of past alternatives. Thomas Sowell touches upon this idea when he said: "… the Darwinian "natural selection" principal may mean a natural selection of the "fittest" situation or process…" (Sowell, 1980) Page 104. He goes on to explain that the evolution of social process, especially communal dialog leading to collaborative decisions, is the product of natural selection.

Similarly, natural selection has dominated competition between cultures because success depended, in part, on a collective ability to make decisions and take the fullest advantage of accumulated knowledge. These same dynamics hold true in the modern global economy and dominate the fundamental calculus of cultural and national competition.

A nation's effectiveness in protecting its interests depends on a well functioning society, unencumbered economy, and efficient use of available resources. International competition, armed or otherwise, ultimately

takes place in an economic context. The sustained success of completing ideologies, societies, cultural practices and nations is predicated on economic success. Effective protection of national interest requires optimizing societal and governmental processes by which choices are made. In short, the ultimate success of a culture or nation, and all that it embodies, depends on the effectiveness of its decision-making.

COLLABORATION MAKES BETTER DECISIONS

Practical limitation of time and space, availability of knowledge, and the non-inclusion of potentially affected parties, has historically hindered collaborative decision-making.

Presumption of collective intelligence

Creation of any collaborative decision-making apparatus presumes the power of collective intelligence. Per Daniel Steinbock et al. "Collective intelligence is the ability of a group to exhibit greater intelligence and produce better solutions to a problem, than its individual members could produce working individually.", (Steinbock, et al., 2002) Page 1. Marko Rodriguez writes; "Social-structures are the means by which humans are able to synergistically combine their efforts to provide high quality solutions to the problems facing the group." (Rodriguez, 2004)Page 4.

Rodriguez comments on what amounts to the central tenant of Thomas Sowell's constrained vision (Sowell, 2007); "For difficult problems, it is naive to think that a single individual has the requisite knowledge to yield an optimal decision; much like it is naive to think a single merchant will offer the optimal price". (Rodriguez, et al., 2009) Page 5.

The larger the participating population, the better the decision

Collaborative decision-making works because the larger the number of participants the greater the chance of creating the optimal solution. An optimal solution is that one which meets the solution criteria in the shortest time and at the lowest cost of resources. Watkins writes; "The Condorcet Jury Theorem (Condorcet, 1785) from probability theory, states that if each individual in a collective is more likely than not to be correct, then as the size of the group scales, the probability of the collective decision being correct moves toward certainty (Watkins, et al., 2007) Page 3.

In collaborative decision-making each user has a different set of needs and other assets (skills, knowledge, and experience) which make a particular type of decision-making task or innovation low-cost for that user. The more participants, the better the chance that the assets of one or more users will be found to be a just-right fit, and the combined set of assets provides that which is needed to fully support the needs of the decision-making task. Adapting Linus' law (Linus Torvalds, inventor of Linux); Given sufficiently large population of decision-making participants, every decision case will receive sufficient knowledge, expertise, and cognitive rationality to render an optimally efficient tradeoff of cost and utility, maximizing satisfaction of the greatest number of individuals at the lowest social cost.

DECISION-MAKING TRADEOFFS

Compromises of Democracy

Methods of group decision-making are built upon the foundation of individual choice. Classic Greek democratic process based upon individual choice, has lead to representative government as practiced in the United States and much of the world. The application of classic democracy is bound by a society's ability to devise a practical implementation. While human intellect has advanced both theory and practice of decision-making, the chief gating factor retarding practical advancement is information processing technology. The two basic problems of a democratic process due to inadequate information processing have been described as 'an overload problem' and 'the expert problem'.

Overload problem

The ability of any group to function together effectively declines as the number of participants grows. Structures are created to accommodate more participants, but declining effectiveness persists. Rodriguez explains this as; "An overload problem occurs when … infrastructure is insufficient to support the level of active participation." (Rodriguez, et al., 2004) Page 2.

Expert problem

Among those who are able to participate, there are differing levels of ability to contribute to a decision-making process. This is expressed as the expert problem. "The expert problem [is] that in a heterogeneous population, not all members of the institution are capable of providing useful contributions [expertise] to the problem-solving effort in all domains." (Rodriguez, 2004) Page 13.

The expert problem afflicts not only direct participants of a decision-making process, but representative participation as well. To paraphrase Thomas Sowell's model of constrained vision (Sowell, 2007) Page 31.; Elected representatives, like everyone else, are competent in particular domains [expertise] but cannot be assumed to be competent in a broader range of skills, breadth of knowledge and wisdom. Perhaps expressed as an 'unjustified assumption of expertise', the expert problem afflicting representatives is that they cannot possibly possess the cumulative knowledge and wisdom of those they represent.

Growing demands on government

Expectations for performance and accountability of government decision-making and politics are increasing demands upon elected representatives and governmental process. Perceived inadequacy of governance has also spawned a growing number of non-governmental organizations which have been created by individuals with common interests to address specific problems. The comparatively slow rate of technology adoption by government creates a growing inability to satisfying increasing expectations of the populace. Ironically, the ability of more individuals to more closely monitor current governmental processes has been enabled by technology advancement.

Lasker and Elisa comment on the symptoms of dissatisfaction with governmental and representative processes; "Confrontational politics and the growing diversity of the American population have both

been cited as contributing to the polarization of people and organizations." (Lasker, et al., March 2003) Page 20.

Compromise doesn't scale

Historic compromises of the democratic process to counter the overload and expert problems were made in the context of available technology (the printed word, sailing ship and hoofed transport). As populations grew across wider geographies, new technologies like steam, rail and telegraph enabled the fixed structures of representative democracy to continue to function adequately, however continued growth in the number of social and economic transactions ostensibly within the purview of governance, and exceeded even those expanded capabilities of technology.

As populations and the tasks of governance grew, the limitations of technology and representative government required compromises which were made at the expense of decision quality (i.e. fairness). The result is that today's government's ability to make decisions is increasingly insufficient, and the quality of those decisions, continue to be sacrificed for expediency.

Information technology limits representational effectiveness, access to knowledge, as well as practical feedback and process improvement. These compromises manifest themselves in the reduced opportunities, and increased cost of individual participation in democratic processes.

GOVERNING TRADEOFFS AS SOCIETIES GROW

Growing burden of governance

As touched on above, the technology of information processing is the primary factor hindering maximally efficient societal decision-making. The information processing capabilities of a society are the bounding conditions within which all tradeoffs between decision capacity and quality are made. Growing populations and technology-use each contribute to the increasing load on governing processes by compounding the number of transactions (economic and social) in which government attempts to be involved.

Cumulative compromise

Decision-making by elected representatives embodies an incremental tradeoff of the individual's right to decide, in exchange for the ability of society to accommodate the increasing number of decisions required by the size of the populace, and to economize on the acquisition of knowledge needed to make adequate decisions. These compromises themselves create further problems. Today's representative government carries with it a growing burden of simplifying assumptions and compromises accumulated over time, which create greater inefficiencies, in response to which additional compromises are attempted.

As societies and individuals make greater use of technology, the per capita rate of economic and human interaction grows. This trend approximates an extra linear rate when combined with to population growth.

Population growth and these accelerating rates of interaction make greater demands on governance, thus requiring more compromise to governing processes. The secondary effects of technology are just one cause of the decay in political process effectiveness, but technology can also provide solutions to the problems created by the compounding effects of past compromises.

TECHNOLOGICAL CONSTRAINTS

The 4th information age

"The single most important characteristic of the Internet is its capacity to allow for a worldwide community and it's endlessly myriad subsets to exchange ideas, to learn from one another in a way not previously available". (Davidson, et al.) KL49. Robert Darnton, director of Harvard University's Libraries has suggested that we live in the fourth great information age. The previous ones being: 1) the invention of writing, 2) the turn from the scroll to the codex, 3) the invention of the printing press, and now 4) the invention of the Internet. "Of all of these, Darnton argues, the Internet has had the fastest and the most geographically extensive effect on every aspect of knowledge-making and all of the arrangements of life around how we make, exchange, share, correct, and publish our ideas. " (Davidson, et al.) KL190.

Large-scale decision-support system

Technology enabled decision-making is not new. RAND Corporation's development of Delphi techniques in the 1960s was an early attempt at technology mediated decision-making. William Dutton writes; "The potential for computer-based communication networks to enable the sharing of expertise accelerated the drive towards distributed collaboration in the 1970s, using systems like computer conferencing, group decision-support systems and later initiatives around computer-supported cooperative work." (Dutton, 2008) Page 6. The ubiquity of personal computers and internet connections has also led to 'groupware' and other applications to connect individuals within and between organizations.

The progression of semiconductor and information technology (networking, cloud computing, Teraflop multi-processors, etc.) and the application of advanced concepts of computer science (election and search algorithms for example) have created the capability to provide large-scale support structures needed to implement new technology mediated decision processes.

Technology advancement

Technology use for society's betterment has historical been through reduction of physical labor; however, modern advances of technology have included support for, or assumption, of cognitive tasks as well. The human brain's limitation is not adaptability, but bandwidth. Once offloaded of bulk demands, the minds cognition and plasticity can be applied to issues of greater complexity and abstraction. The benefits to society can be profound, just as improvement in farming methods and crop yield allowed more leisure time for advancement of art and science and other effects which propagated throughout human populations.

As new technologies are tried, their adoption depends on the benefits they bring over existing methods. At any given time there exists dissatisfaction born of an irresolvable compromise between desires and practicality. This is the context in which any technology which improves communication or facilitates social interaction providing greater satisfaction will command valuation commensurate with its effect rather than its cost.

To quote the National Academy of Sciences; “IT [information technology] has now reached a stage of maturity, cost-effectiveness, and diffusion that enables its effective engagement with many areas of the arts and design — not just to enhance productivity or to allow more efficient distribution, but to open up new creative possibilities” (National Academy of Sciences, 2003) Page 2. The intervening years have only served to emphasize this trend, to bear witness to the fulfillment of many new possibilities, and to envision more to come.

NO LARGE-SCALE GENERALIZED DECISION SUPPORT

Group ware, social software, business-to-business, and virtual design environments are applications of technology assisted collaborative activities which have traditionally been successful in single domain or well bounded circumstance. However, they do not lend themselves to wider multi-domain general purpose decision-making. “Despite the recent surge of innovation in social software engineering, there are no systems that are designed to support generalized distributed decision-making on a large-scale.” (Rodriguez, et al., 2006)Page 3.

TECHNO-SOCIAL CONVERGENCE

Technology advances and behavioral evolution have converged upon a point at which the prerequisites are present for a dramatic expansion in the potential to change foundational elements of human interaction and society. The first of these elements is how collaborative decisions are made. This convergence enables the creation of a practical general-purpose collaborative decision-making process.

TECHNOLOGY IN SOCIETY

Technology does not replace social interaction; however its capabilities do define the practical limits to which social processes which depend on it may expand and evolve. These limits of information processing, the restriction of choice and associated compromises, are a contributing cause of an expanding set of social, political and economic inefficiencies (i.e. Problems).

As new technology is adopted, how individuals and society interact, transact, and make decisions evolves. The integration with and use of new technology, while often adopted in support of existing social behaviors, becomes the catalyst for new behaviors which emerge and evolve as the full potential of technical capabilities are explored. One such evolving behavior is the expansion of participatory culture. James Carrie credits a colleague with as saying; “a participatory culture is a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and

sharing one's creations, and also an environment encouraging informal mentorship whereby what is known by the most experienced is passed along to novices." (Carrie)KL110. The advancement of technological, enabled by and built upon prior technology, has established both the technological and behavioral prerequisites for a convergence which makes possible new and disruptive collaborative methods of decision-making.

Web 2.0 refers to the second-generation of internet technologies characterized by bidirectional interaction and user contribution. These technologies by their very construct, encourage people to create, share, and modify on-line content. Web 2.0 internet sites and social software mediate and extend social processes. Many are built around collaborative contributions where knowledge is created and freely offered for use through the many-to-many connection architectures of these social sites. William Dutton said; "…the Internet has greatly expanded the opportunities for distributed work and the sharing of information and expertise. Increasing confidence in collaborative networking has been growing. For instance, so-called 'Web 2.0' applications have generated a wide range of proposals for employing 'user-generated content' and greater collaboration in a number of sectors, from social networking to corporate communication and scientific research." (Dutton, 2008) Page 7.

ADVANCED SOCIETAL DECISION-MAKING

The success of advanced decision-making depends on the extent to which those in society participate and the use of available technology to overcome barriers and take advantage of new opportunities which present themselves.

Successful participation in a social decision process depends on compliance with standards of 'normal' behavior, personal economic costs of involvement, and motivation of the individual. Once involved, continued participation depends on fulfillment of each individual's expectations and the degree to which they were met. There are also global barriers and enablers which directly affect the creation and degree of success of large-scale collaborative decision-making. All of these must be considered in architecting large-scale collaborative decision-making processes.

Reduced barriers to entry

Technology has enabled on-line social interaction which otherwise would not be possible. James Gee reflects; "Today, with web sites like Flicker, MySpace, and Face-book, and digital devices like mobile phones, it is easier than ever to form and join groups, even for quite short-term purposes. Often no formal institution is required and groups can organize themselves bottom-up through constant communication and feedback. These quickly formed groups can engage in social, cultural, and political action in a fast, pervasive, and efficient manner. Such groups can readily form and re-form, transforming themselves as circumstances change." (Gee, 2008) KL315.

The removal of distance as a factor in collaboration overcomes the problem of gaining a local critical mass of interested participants needed to create and sustain a group. Gerhard Fischer identifies a core limitation to collaboration as; "low local density of people sharing interests" He elaborates; "Bringing spatially distributed people together by supporting net-based communication allows the shift that

shared concerns rather than shared location becomes the prominent defining feature of a group of people interacting with each other. These opportunities have been successfully employed by the open source communities. Transcending the barrier of spatial distribution is of particular importance in locally sparse populations." (Fischer, 2004) Page 2. The ability of collaborative network communication to remove distance as a dominant formative influence enables use of widely dispersed knowledge which is local to each participant as if it was local to all participants, and which would not otherwise be practical for a collaborative group to acquire.

A generation of collaborationists

Collaborative learning, creation, problem solving, and decision-making, are tightly interrelated. Participatory learning is not simply about interaction, but about how any participant can learn by co-creating with myriad of others and thus benefit by accessing the experience and knowledge that others can offer**.** As the demographic of internet and technology users evolves, those born after 1983 (the introduction of the personal computer) and 1991 (wide use of the internet), are followed by individuals who have grown in a society much richer in technology enabled collaboration. They are a generation of collaborators who have learned through peer-to-peer knowledge creation, collaborative networks, and an aggregate of private and open source social spaces and shared preference sites like as MySpace, Facebook and Delicious.com.

Bottom-up creation

Systemic success of participation in collaborative decision-making is based upon attracting self selecting participants who together undertake effective bottom-up decision processes. In this context there is no a priori leadership. Different people with different motivations, skills, and knowledge make up the strength of diversity on which effective collective decision-making is built. The voluntary nature of collaborative interaction is one that eschews top-down authoritative management, so co-creations are inherently bottom-up.

Dynamic forms of representation

Dynamic representation is a form of representative democracy which does not suffer the ill effects of fixed representative structures. Static or fixed forms of representation do not adapt to growing population. They become increasingly ineffective as populations grow and as participation levels becomes more dynamic (i.e. fluctuating and transient). Dynamic representation can enable societal-scale decision-making systems as the methods of trust-based propagation of proxy become widely used.

Blurring professional distinctions

Gee observed that "We live in the age of pro-ams: amateurs who have become experts at whatever they have developed a passion for. Many … who use the Internet, communication media, digital tools, and membership in often virtual, and sometimes real communities of [interest and] practice to develop technical expertise in a plethora of different areas." He goes on to say; "These pro-ams have passion and go deep rather than wide. At the same time, pro-ams are often adept at pooling their skills and knowledge with other pro-ams to bring off bigger tasks or to solve larger problems. These are people

who do not necessarily know what everyone else knows, but do know how to collaborate with other pro-ams to put knowledge to work to fulfill their intellectual and social passions". (Gee, 2008)KL318,230.

Wisdom of leadership

Questioning of the underlying causes of group effectiveness has been a barrier to the advancement of technology enabled collaborative methods. Some of the most interesting findings in research question the notion that collaborative networks tap into a 'wisdom-of-the-crowds' effect. Instead, it is believed that the wisdom of these networks lies in the intelligence behind their management, by which the contributions of individuals and expertise is channeled by process and facilitated choices towards specific goals. Dutton elaborates; "The rhetoric of the 'wisdom of crowds' can deflect attention from the degree to which successful CNOs [collaborative network organizations] are best viewed as managed networks of individuals who choose whether and when to enter or exit a network. While crowds are more often unmanaged and accidental, leadership and management structures play a key role in recruiting active decision-making participants, maintaining their involvement, and managing their contributions." (Dutton, 2008) Page 36.

DECISION-SUPPORT NEEDS

As social and behavioral norms change in response to technology use, the tools and evolving methods of leadership and facilitation are also enabled by technology use to impart the 'wisdom of leadership' to organically forming virtual communities. In the case of collaborative decision-making, the term 'Decision support systems' encompass the technical, behavioral, and leadership support needed for effective group decision processes.

Technology makes possible the support systems and resources for human activities which provide access to tools, information, and knowledge. Information technology, the internet, and specifically social networks, have dramatically expanded the potential numbers and types of decision support systems possible. Rodriguez reflects; "Large-scale decision-support system development has advanced to successfully accommodate fluctuating group participation, problem modeling, natural-language problems, and general computer-mediated collaboration techniques." (Rodriguez, October 2004) Page 1.

Knowledge access

Knowledge access and management — categorization, sorting, storage, and retrieval methods for existing knowledge — are key elements needed to support collaborative decision-making.

Artificial intelligence

While the successful use of artificial intelligence remains confined to specific bounded applications, one promising use is in decision support systems for improved access to and use of, widely distributed heterogeneous knowledge.

Search technology

Increasingly sophisticated search algorithms, along with cloud computing, software-as-service, redundant storage and data center technology, have all contributed to search technology and the

accessibility of existing knowledge. One example of technology impact on existing knowledge access is the widespread use of natural language search query widely offered on smart phones and other platforms.

Knowledge commons

Wiki-type web based encyclopedic collaborations are centralized knowledge resources which have been referred to as 'knowledge commons'.

Local knowledge

Kaza-like file-sharing is one example of distributed knowledge represented as 'local' to all participants. A search for particular knowledge within a community initiates an automated query of all participant stores of 'local knowledge' and establishes a direct link to any successful finds.

Shared knowledge

Different from file sharing are 'shared files'. Dropbox.com is one such shared file service offering centralized storage space along with the automation to manage synchronous document use. The result is to provide each participant with the appearance of a vast specialized local knowledge resource.

Knowledge creation

If knowledge does not exist, exists but is not accessible, or for which the cost of acquisition is prohibitively high, alternative knowledge for a specific need must be created. Creating knowledge is the gathering, aggregation and integration of component knowledge, or the conducting of primary research. What differentiates component knowledge from 'Knowledge' depends on the context of the intended use. An ad hoc group of individuals, joining together, pooling their specialized knowledge and skill to authenticate "Ideas" and repackage it for a particular use, is the collaborative creation of knowledge which can then be made available for other.

Communications

Communication is fundamental for collaborative decision-making. E-mail, tweeting, multi-medium inboxes such as Facebook's social-inbox, Microsoft Outlook's integrated messaging, as well as other systems of technology integrating communication, have overcome separation of space and time that were formerly barriers to collaboration. Carrie comments; "Blogs allow people to speak out about issues they care about, and massive multiplayer online games invite players to form strategic collaboration and even modify the games as they play." (Carrie) KL115. A pilot study by Bradley Goodman et al. demonstrated [what may seems an obvious] intuitive correlation between the underlying communicative acts of collaborative learning dialogues as a predictor of the effectiveness of a collaborative learning session. (Goodman, et al., 2001) Page 11. This correlation is directly applicable to collaborative decision-making processes.

Behavior

Social networks

Built upon the underlying infrastructure of communication, social networks can propagate a wide array of information about relationships, preferences and interests. Rodriguez reflects; "Without an

environment in which to share realization of a particular abstraction of ideas, the notion of a problem [or issue on which to decide] would only be an internal concept represented within an individual's cognitive faculties." (Rodriguez, October 2004) Page 1. The use of social networks has allowed the rapid adoption of 'new social behaviors', language use, methods of relating and interacting with others which have established the behavioral basis for advancing social decision-making processes. Carrie states; "Social networking sites permit participants to forge new connections with people beyond their real-world cliques, schools" (Carrie) KL116, as well as within shared vocational and avocational communities of interest or expertise.

Propagate of trust

Facebook and Myspace are two of the best known social networks; however they are far from unique in their use of the internet to enable and support relationships between individuals with common interests. It is the potential of social networks to propagate conditional trust metrics which provide the greatest promise for enabling advanced collaborative decision-making. Trust metrics allow the preference of individuals to be influential, not just upon those people they interact with (one degree of separation), but beyond and through n degrees of separation.

Facilitation

Key to effective decision-support is the adoption of time-tested as well as and new behavioral and leadership practices which are compatible with participant's habits and preference. Leadership tools implemented within a virtual collaborative environment represent the key social enablers of effective virtual collaborative process implementation. Leadership in voluntarily populated collaborative groups is not a fixed role. The changing demands upon leadership throughout a collaborative process will be best served by a shared, rotational, or other group method of adaptive sharing of leadership.

A PRACTICAL LARGE-SCALE DECISION-MAKING PROCESS

With the emergence and adoption of social networks, the internet, the behavioral elements permitting use of advanced voting methods, and finally the methods of facilitation and leadership (aka 'management'), a practical basis for general-purpose collaborative decision-making has been established.

Assembling and applying technical, social and process elements to create a facilitated structure for large scale collaborative decision-making is done as a dynamic work flow process comprised of a framework supporting modular elements.

PROCESS STRUCTURE

The process is a progressive flow through a structured set of facilitated virtual environments. The 'system' is a framework on which hangs a descending hierarchy of structures. Each structure provides a standardized interconnect to those of greater specificity beneath is. This framework of structures holds replicable function modules which make up the stages of the process flow, callable decision support

resources and process memorialization. Together the elements of this structure enable an evolutionary capability to both system structure and process flow, and upon which new or experimental elements may be substituted and tried in place of 'proven' functions.

Global process space

At the highest level of construct is a global space which contains process sub-spaces. This global space is a universe composed of members (people), each of whom is a potential participant in some future project. Member groupings are vaguely defined as overlapping interconnected communities of interest. Those interests are any topics or issues shared between members, which have at least some aspect of their interest not entirely fixed in the past, and on which future action is possible. Global space holds not only the decision-making flow but related participant flow, support networks, and decision-making resources.

Process flow

Decision space is the first of three primary sub-spaces in which process flow takes place. The second is solution space which is followed by action space. A project is created and progresses to completion through these the spaces. Each project is initiated in global space by a few self-selecting participants who collectively define a project and invite or recruit other participants. Once created, the project is then moved into decision space where participants collaborate to produce a single decision model. From decision space the project proceeds to solution space where the group produces a pool of potential solutions from which a single solution is selected and implemented in the action space.

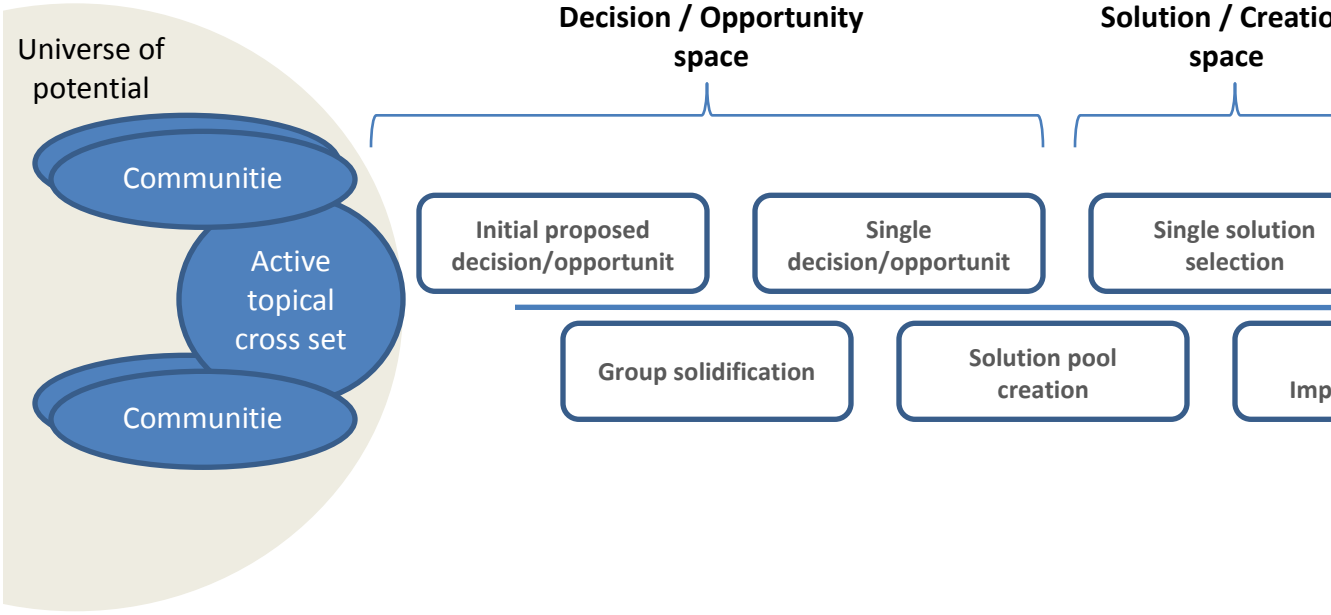

Figure 1: **Collaborative decision space model.**

Participant flow

Participant flow is a progression of facilitated participant interaction, group culturalization, team building and shared experience which establish and draw together the collaborative group as a unit, building and sharing a culture that is unique to the group. Distinct from process flow, it encompasses many of the human interactions of collaboration. It is through participant flow that social networks and their capacity to support the decision-making process are maintained.

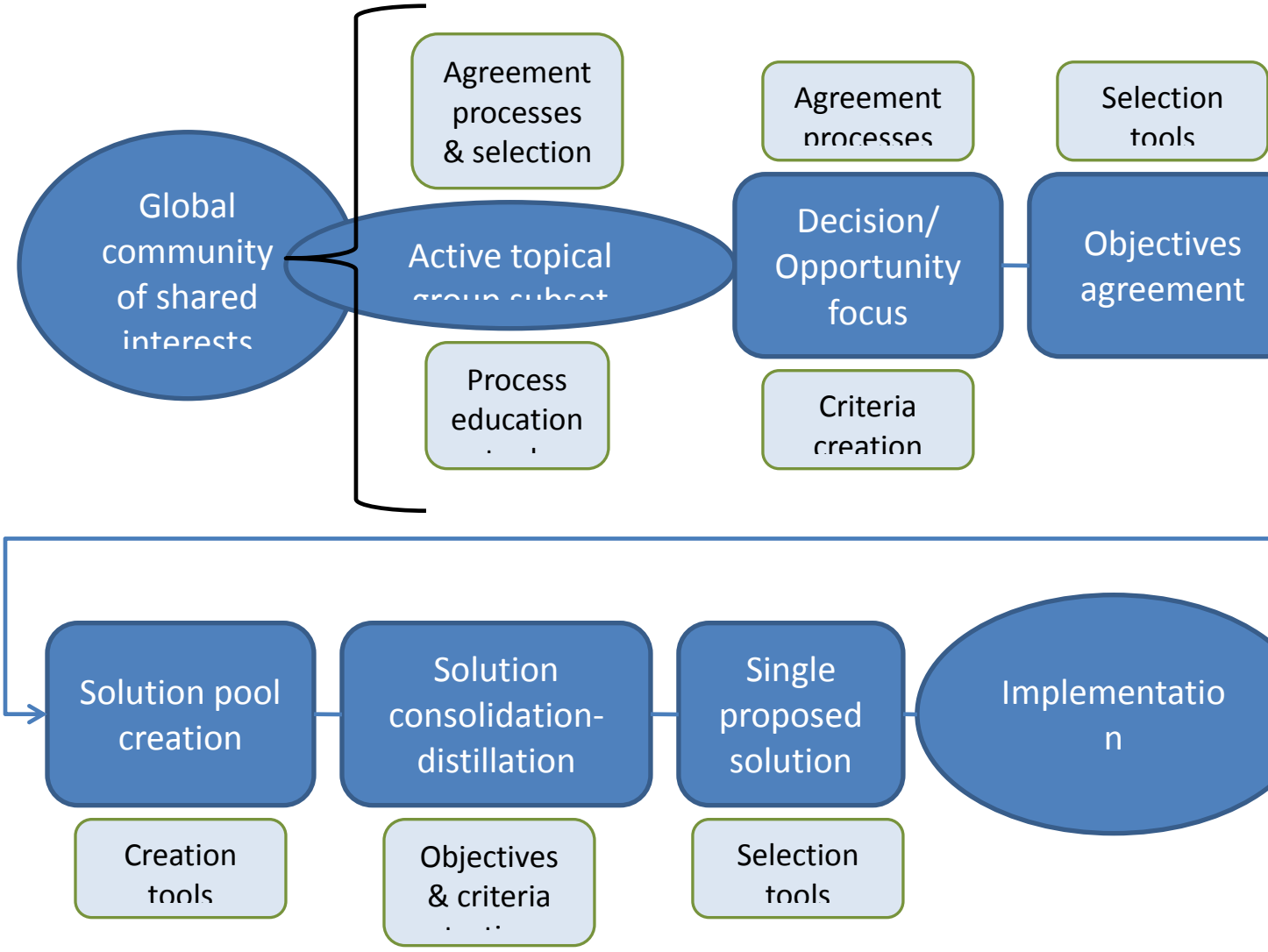

Figure 2: **Collaborative decision/solution – opportunity/creation process flow**

Memorialization

Alongside of process flow is a memorialization flow which captures and records a representation of the elective and variable elements of a particular decision process. Somewhat analogous to a flight data recorder, the record is available at any time in the collaboration process to replay preceding events and allow 'what-if' scenarios through substitution of alternative modules, application of different election weighting methods, or other process variables.

Until technology advancement allowed, collaborative processes were rarely asynchronous. Modern communications makes practical, asynchronous interactions as well as the ability to capture, store and replay those interactions. Per Goodman; "… combined synchronous and asynchronous interactive learning environments utilizing an asynchronous replay function can add benefit to collaborative learning sessions." (Goodman, et al., 2001) Page 11. These same asynchronous replay capabilities directly apply to enhance collaborative decision-making.

Memorialization permits 'do-overs' of any particular collaborative processes. In doing so, it essentially incorporates informal, internal corrective iterative loops in a single process flow. It also allows post process study of group interaction, tool effectiveness, election processes chosen and participant ranking of both process and peers. The memorialization flow is the basis for creating a process template creation, which is then available for modification and use in other decision-making projects.

DECISION SUPPORT

As described earlier, support for decision-making processes are foundational to advanced collaborative decision-making. The following describes the support methods and resources employed in conjunction with this collaborative decision-making process.

William Dutton categorized management of virtual collaborative decision-making as' "… fall[ing] into three broad categories: managerial, social and technical. The case studies have shown the central importance of clear management structures in coping with the challenges of distributed collaboration." (Dutton, 2008) Page 35. The terms 'leadership' or 'facilitation' may be more applicable than managerial in volunteer collaborative decision-making. Whatever the terminology used, imparting some level of structural organization to chaotic and random social interactions is necessary to produce collaborative work.

The effectiveness of any decision-making process is regulated by the support resources available. The process flow, along with accompanying decision support resources, integrates structure and resources. The number and kind of decision support resources which could be provided to the virtual community is limited only by one's imagination; however most seem to fall into one or more of several categories as follows:

Communication

Communication methods are clearly an integral part of effective decision-making. It is the ability to communicate which allows individuals to establish and participate in social networks and communities of interest. Social networks facilitate communication amongst vast numbers of individuals across time (asynchronous) and space in traditional individual-initiated contacts, as well as semi-autonomous agent-to-agent initiated messaging.

Social networks

Social networks serve to create and expand relationship and social affiliations among individuals. When coupled with communal decision-making processes, these same networks strengthen the social ties

between individuals who share common interests. However, social networks also provide several critical functions necessary for effective technology mediated collaborative decision-making. These networks allow broad sharing of ideas, and a way to convey preference that is more accurate than any representative or one-man one-vote method presently in use.

Web browsers, the internet, and the wide variety of social media vehicles make practical the direct participation of very large numbers of individuals in any given decision. This in itself makes web based technology mediated collaborative decision-making possible. However, social networks are the first practical convergence of information technology and social behavior capable of supporting the propagation of trust metrics. It is this ability which makes possible the use of election methods that have been impractical before this convergence.

Trust modeling

Propagation of a 'trust metric' by social networks enables the use of weighted election algorithms to reflect a participant's own views as well as their opinion of other participants and the abilities or views of those individuals. How another participant's opinion aligns with their own, and what fractional proportion of their weighted vote they wish to allocate to other individuals, can be used in a distributed representation structure. Multi-level domain-specific trust modeling supports proportional weighted voting simultaneously over more than one topical domain. For instance, an individual's abilities in a particular specialization, their unique knowledge of other topics, cognitive capabilities, or even political beliefs can be domains in which different proportional vote allocation may be made.

Social networks which propagate trust metric in multiple domains increase the fidelity of possible election methods without sacrificing capacity. According to simulations, the traditional method of single degree representation "…results in an exponential increase in decision error as the number of representatives decreases linearly relative to the size of the total population." (Rodriguez, et al., 2004) Page 5. However, by including the knowledge implicit in social networks reflecting trust relationships, the error can be significantly dampened.

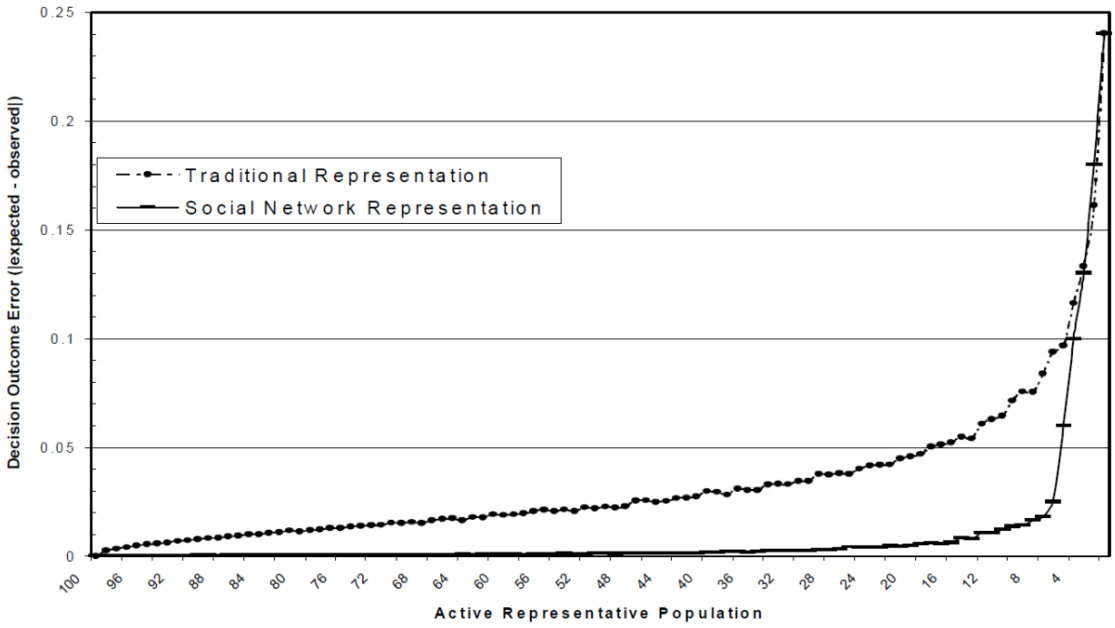

Figure 3: **Traditional vs. social network-based representation outcome error**

Source: (Rodriguez, et al., 2004) Page 4.

Modeling the advantage of trust propagating social networks, Figure 3 shows that traditional representative democracy produces exponential increasing error rates as fewer individuals in a population participate. In contrast, Rodriguez et al. demonstrates that using a trust propagating social network with as few as three degrees of freedom produces dramatically clear improvement in fidelity of representation.

Knowledge creation, legitimization, and management

Davidson & Goldberg stated; "It [the Internet] has also shifted both the perception and the reality of who makes knowledge, how it is authorized and legitimated. The Web has flattened out contributions to knowledge making, making them much less the function of credentialed elite and increasingly collaboratively created." (Davidson, et al.) KL239. Knowledge, rather than being created by experts or a venerable few within academic institutions, is increasingly created collaboratively by groups of individuals, and validated by yet other collaborative groups. The result has been a dramatic expansion in the scope and type of knowledge that can and does exist.

There is growing realization in academia and society that collaborative decision-making is increasingly necessary to effectively address the expanding number of more complex issues arising from competition for finite resources, trade, the economy, military conflict, business, government, and social interaction.

A wiki is a highly distributed way to gather, create, and share collective knowledge. Specifically, a wiki is software that allows users to freely create and edit web-page content using any web browser. The purpose of a wiki is to capture and organize the knowledge structure held by participants within a

networked such that the content is readily accessible to all at little or no cost. The resulting content, within the structure of a knowledge-commons, transcend the abilities of individual contributors. While Wikipedia facilitates the collection of knowledge, it is also an illustration of the potential of non-proprietary, open co-production of new knowledge products.

Autonomous agents' and simulated peers

A promising use of artificial intelligence is the creation of autonomous agents or simulated peers in decision support systems to improve access to widely distributed heterogeneous knowledge. Bradley Goodman said; "The presence of the simulated peer can help ensure the availability of a capable collaborator to enrich learning [and decision-making] through the promotion of reflection and articulation". (Goodman, et al., 2001) Page 11. Social and trust networks provide the medium in which intelligent agents can interact to undertake support tasks.

Election methodology

Election methodology is a special case decision-support need. Other support resources, specifically communication, networks and those facilitating social relationships, are the bases upon which election methods are implemented. The practical use of election methods have been a retarding factor in rendering a collaborative selection that faithfully represents the wishes of a large group. Computer science has produced advanced voting algorithms able to support complex computational and data processes. Many of these advanced algorithms can be applied to representative voting systems among large numbers of participants with statistical fidelity that rivals and possibly exceeds that of existing methods.

Fidelity vs. capacity

Any practical representative structure is a compromise to the ideal of direct electoral participation by all in a population. In terms of communication theory, any form of compromise can be thought of as a compression of the message being sent. In voting processes Rodriguez defines this as 'social compression'. In decision-making as in communications, compression is done at a cost of fidelity. (Rodriguez, 2004)Page 13. Social compression limits the amount of information and the scale of decision-making to one that is practical to implement but which sacrifices fidelity.

Domain faithful vote weighting

Domain weighting of votes and can yield even better decisions than classic Greek democracy. The ability to apply weighted votes across several domains results in a higher fidelity of representation when compared to voting within a single domain. In practical implementation of domain weighted election techniques, the selection of a finite number of domains and their relative weighting in the collective decision is necessary. This task of selecting domain weighting (voting on how to vote) is well within the capacity of web based facilitation tools and social network based decision support structures.

Free-degree representation

While support structures provide for implementation of a large variety of elections methods, those that express a free-degree representation appear to hold the greatest promise for achieving the most efficient election method. A free-degree representation is a characteristic of representative election

methods which dynamically modulates the trust vote of participating individuals across a network according to the dynamic constraints of the particular voting event. The network accommodates near real-time fluctuations in participation levels while maintaining fidelity of representation. (Rodriguez, 2004). Not only can a free-degree representation framework faithfully represent the preferences of a very large population through the voting participation of a small subset of individuals, but the framework enables the parallelization of sub tasks undertaken by a collaborative decision-making group while preserving election fidelity.

EVOLUTIONARY FRAMEWORK

The framework and system modules together provide the flexibility within which the "process" is free to organically evolve. The elements of the framework may be copied, changed, and saved to create modified and "new" versions of structures or modules.

Participants in collaborative decision-making may choose to use particular structures or modules, or create new versions to use in any specific decision-making project. It is through participant ranking of support resources, process structure, etc. that the continued use or eventual abandonment of process elements is determined. This process, which encourages competition between module architectures, yields a constantly improving process as well as the spawning of specialized versions of the process optimized for particular types of uses.

The participatory aspect of modular process and support structure creation are intended to encourage project participants as well as non participants (essentially anyone), to contribute to infrastructure and process by creating new, better, or specialized tools and modules.

BENEFITS AND BENEFICIARIES

The worth of a general purpose collaborative decision-making process is defined by both the tangible and intangible benefits it delivers. It is the aggregation of contributions from large numbers of individual participants which amplifies the benefits of the process by attracting even more participants, increasing available supporting resources, and optimizing process elements.

ADVANCEMENT OF SCIENTIFIC METHODS

Implementation of a virtual collaborative decision-making community creates an observable context for advancement in the study of collaborative processes. The 'mash-up' of computer and social sciences will affect many aspects of society. Improved collaborative methods, the increase in interdisciplinary studies and the greater inclusion of amateur contributions to many areas of study will have broad influence upon sociology, education and the practice of collaborative decision-making.

Davidson & Goldberg relate that; "We find ourselves increasingly being moved to interdisciplinary and collaborative knowledge-creating and learning environments in order to address objects of analysis and

research problems that are multidimensional and complex, and the resolution of which cannot be fashioned by any single discipline." (Davidson, et al.) KL256.

REDUCING THE COST OF KNOWLEDGE

Web based collaborative decision-making can make more economical the gathering and wide use of scattered fragmentary knowledge — formerly too small to be economically collected, or too arcane or scattered for use in encyclopedic knowledge bases — and aggregate that knowledge for use in decision-making processes. The inherent cost to acquire or create knowledge is greatly reduced through communal authentication of ideas. Much of that aggregated knowledge will emerge freely revealed to the public domain.

Davidson & Goldberg refer to John S. Brown's comment that; "it took professional astronomers many years to realize that the benefits to their field of having tens of thousands of amateur stargazers reporting on celestial activity far outweighed the disadvantages of unreliability.", and go on to add that; "The result has been a far greater knowledge, amassed in this participatory method, than anyone had ever dreamed possible, balanced by collective and professional procedures for sorting through the data for obviously wrong or misguided reporting." (Davidson, et al.) KL267.

CIVIC GROUPS, POLITICAL PARTIES, ACTION GROUPS, AND NGOS

Clearly the potential exists for civic, political, and other organizations of shared interest to make use of advanced collaborative methods in pursuit of their social goals.

FINANCIAL BENEFITS

The individual participants in any volunteer collaborative process are motivated by their own interests and desires, most of which are intangible. Intangible benefits, such as a sense of community, feeling of belonging, recognition, creativity and altruism, are strong motivators; however compelling these may be, financial benefits are stronger.

The market disruptive effects of introducing a general-purpose collaborative decision-making process will cross many domains and holds the potential for redefining existing market structures. This restructuring creates new markets in which the needs of the old market participants are better served by the structures of the new. It is the provision of greater value through new market mechanisms that is financially rewarded.

NEW MARKET CREATION

The fundamental element of any market is the individual acting in his or her best interest. Rodriguez, et al. paraphrase Adam Smith on the citizen's role in markets and their collective contribution to market mechanics; "… [in pursuing] his own interest he frequently promotes that of the society more effectually than when he really intends to promote it". (Rodriguez, et al., 2009) Page 5.

A market is based on the attributes of many transactions with sufficient similarity that they can be effectively served by a common set of market mechanisms. These common mechanisms, together with the aggregate of transaction in the market, provide economies of scale to reduce transaction cost to all participants. The combination of many markets, form large overlapping sub and supersets of trade which share a collage of technology based mechanisms.

In addition to pricing as an expression of the momentary balance of supply and demand, each market is the embodiment of dynamic balanced set optimal mechanisms. The introduction of new technology perturbates the balance of market mechanisms as traders, producers and consumers independently use the new technology to reduce costs or increased efficiency. This competition between old technology and new is the natural selection of the fittest tools with which market trades are facilitated.

Markets are often identified by the commodity traded (light sweet crude oil, gold, etc.); however, when a sufficient number of markets using a common technology mechanisms achieve some 'critical mass', a paradigm flip may occurs in which an overarching market emerges which is defined by the technology, (Microprocessor, cell phone) rather than by commodity. (Moore, 2006)

As the efficiency and benefits of general-purpose collaborative decision-making are adopted across markets, its use is very likely to be the dominant collaborative methodology when a series of paradigm flips begin to occur. These flips will create the three overarching markets referred to here as knowledge markets, cognitive labor markets, and decision markets. The creation of these markets in virtual communities of trade will enable even broader individual free-agency by participants who can offer or 'market' their expertise, special skills or cognitive abilities in exchange for direct payment.

Knowledge markets

Knowledge created by individuals or groups can be freely or conditionally revealed. As described above, collaborative decision-making depends on accessing or creating knowledge. The knowledge which is created can be traded and offered as intellectual property both within and beyond virtual environments.

Intellectual property (IP) markets have traditionally had high barriers to entry. Creating and using IP was costly, and it was impractical to participate in the market for most individuals. The use of social networking support structure can greatly reduce traditional barriers to participation, allowing the knowledge products of individuals or groups to be broadly marketed.

The credit for creation, division of compensation, and the administration of knowledge/intellectual property trade can be easily administered through the decision support system. Without high cost of participation, large numbers of individual or group creators of knowledge will produce and offer intellectual property products.

Cognitive labor market

Built upon increasing and broad availability of knowledge, is the expansion of independent providers of cognitive skills for hire outside of traditional employee-employer relationships. The availability of a facilitated process to develop, refine and apply cognitive decision-making skills will attract larger

numbers of participants with the skills for making decisions, solving problems, and exploiting new opportunities. As individual participants become adept at using the available processes and tools, they will form associations of practice with those having complementary skills and offer their services in exchange for financial compensation. A non-participating entity will be able to fund or sponsor a project, tool development, knowledge creation, or some other endeavor external to the virtual environments by compensating the participants with the best skills or experience in a particular domain.

Decision markets

Finally, upon the knowledge and cognitive skills markets will stand decision markets. Decision markets combine the products and services of these two preceding markets with the ability to apply both to the advantage of those willing to take risk and act. Those who can apply decision making skills will consistently create demand for their abilities, and therefore create a decision market.

"Market mechanisms are not only useful for determining commodity prices as they can be generally applied to information aggregation and ultimately, to collective decision-making." And; "Such markets are called decision markets, and similar to a division of labor, the knowledge required to make optimal decisions for a society is divided throughout the population." (Rodriguez, et al., 2009) Page 5

A decision market includes a selection mechanism, which incentivizes participation of those who can skillfully aggregate component knowledge, create meaningful abstractions and new knowledge, and are sufficiently confident in their uncommon knowledge to apply it at some risk for a calculated reward. A decision market also discourages participation from those who are less confident or less knowledgeable. The person with this uncommon knowledge is incentivized to participate more so than if the market closely mimics their knowledge, and thus reap the benefits.

Rodriguez says; "A decision market functions because it guarantees a return on investment for quality information. In this respect, a decision market is a tool for attracting a population of knowledgeable citizens much like a commodity market is a tool for attracting knowledgeable speculators". (Rodriguez, et al., 2009) Page 5. The creation of a general purpose collaborative decision-making process is in essence the embodiment of a decision market.

As in decision-making, a market functions because there are differences in individual knowledge, confidence, incentives and constraints. There is always demand for those with well developed abilities to acquire and apply uncommon knowledge. Currency arbitrage and commodities trading are examples of decision markets. The use of a collaborative decision-making process will not only enable individuals with innate abilities which predispose them to skilled decision-making to participate, it will also grow the number of specialized decision-making markets seeding economic, social and market applications that have not been otherwise possible.

REVENUE OPPORTUNITIES

Experienced individuals forming virtual companies can be compensated for collaborative work products beyond the intangible benefits of membership and contribution which commonly motivate initial participation. Participants demonstrating past decision-making or trouble-shooting abilities can offer their services. Proven abilities solving specific types of problems or specialized skill sets needed to exploit business opportunities will command greater compensation commensurate with supply and demand. Software developers, programmers, mathematicians and others will create intellectual property which they can offer for sale or license.

All participants benefit from the social exposure. The propagation of trust metrics within the social network structure allow individuals and groups to gain recognized domain specific expert ranking for which they can ask appropriate compensation. Their ranking and reputation among peers is directly translatable into traditional dedicated (full time) employment in virtual companies or traditional brick and mortar organizations.

The social trust network, built by attracting participants to the benefits of collaborative decision-making, can become the economic structure over arching a great many disparate markets which already exist. This over arching market is one in which participating members will find their collective abilities more effective, valued more highly, and otherwise enhanced, in comparison to employment in traditional business methods.

ADVERTISING

As is often the case, advertisers strive to model and adaptively target finer granularity of demographics in order to optimize promotional strategies. The particular character of participant demographics of social trust networks established for collaborative decision-making will be particularly attractive to advertisers. The individual characterizations of participant's preferences, their social connections and trust votes will offer detailed insight and access to into a vast population and classes of prequalified individual potential consumers, to which and through which advertisers may influence buying decisions.

BROKERING MARKET TRADE

Facilitating the application and use of general-purpose collaborative decision-making process is accompanied by the opportunity to broker the exchange of intellectual services and property, and derive revenue from trading within decision, knowledge, cognitive skills, and myriad of other emerging markets.

DATA MINING & POLLING

Data mining of information available about the large participant population offers the potential to create and offer for sale, aggregate market trend and economic data valued by business community and

other organizations. Data mining and the ability to initiate targeted preference inquires (polling) provides additional opportunities to generate revenue from knowledge creation.

INTANGIBLE EFFECTS

The major benefits of collaborative decision-making to society are the potential to dramatically improve the efficiency of economic processes and markets to better use resources, but it also has the potential to impact politics, social and environmental problems. The potential to influence these elements of society is expected to be a significant attraction for potential participants and rapidly grow the use and influence of a general-purpose collaborative decision-making offering.

CLOSING SUMMARY

Technology advancements built upon social networking are able to overcome limits to wide spread use of collaborative decision making. Each adoption of a technology has changed how people behave. Society's adoption of social networking, the proliferation of personal electronics, and the participation in Web 2.0, are both a result, and a cause, of changing behaviors. These changes are the techno-social convergence enabling general-purpose collaborative decision-making process.

General-purpose collaborative decision-making will be a primary cause of the restructuring of existing markets, the creation of new ones, and will provide large revenue opportunities for those administering the process and providing infrastructure.

Beyond tangible financial opportunity, large-scale use of collaborative decision-making processes will accelerate evolutionary changes in society which produce other intangible benefits, including:

Academic - Virtual collaborative decision-making communities create an observable context for the study of collaborative processes. Collaborative methods will increase interdisciplinary studies and promote inclusion of amateur academic contributions.

Knowledge cost - Web based collaborative decision-making will make the gathering and wide spread use of scattered fragmentary knowledge more economical. The cost to acquire or create knowledge will be greatly reduced through communal authentication of ideas, and much of the resulting aggregated knowledge will emerge freely-revealed into the public domain.

Civic involvement - Without doubt, collaborative efforts by civic, political, and other organizations of shared interest will be enhanced as the costs of, and barriers to, participation are reduced.

REFERENCES

Carrie James Young People, Ethics, and the New Digital Media: A Synthesis from the Good Play Project [Report] / John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning ; Massachusetts Institute of Technology. - Cambridge Massachusetts, London England : MIT Press. - pp. Kindle Loc 110,115.

Davidson Cathy N. and Goldberg David Theo The Future of Learning Institutions in a Digital Age, John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning [Report] / Reports on Digital Media and Learning ; Massachusetts Institute of Technology. - Cambridge MA, London England : MIT Press. - pp. Kindle Ed Loc 49,190,239,256,267.

Dutton William H. The Wisdom of Collaborative Network Organizations: Capturing the Value of Networked Individuals [Report] / Oxford Internet Institute ; University of Oxford. - Oxford UK : [s.n.], 2008. - pp. 6,7,35,36.

Ellwood Charles A. Sociology and modern social problems [Book]. - [s.l.] : BiblioBazaar, 2006. - ISBN: 1-4264-5248-9 : pp. 33,42, Kindle Loc 337,461. - Amazon.com/Kindle store.

Fischer Gerhard Social Creativity: Turning Barriers into Opportunities for Collaborative Design [Report] / Center for LifeLong Learning and Design, Department of Computer Science ; University of Colorado. - Boulder CO : [s.n.], 2004. - p. 2.

Gee James Paul New Digital Media and Learning as an Emerging Area and "Worked Examples" as One Way Forward, John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning [Report] / Reports on Digital Media and Learning ; Massachusetts Institute of Technology. - Cambridge, Massachusetts, London England : The MIT Press, 2008. - pp. Kindle Loc 315,318,320.

Goodman Bradley [et al.] A Framework for Asynchronous Collaborative Learning and Problem Solving [Conference] = Artificial Intelligence in Education // 10th International Conference on Artificial Intelligence in Education. - [s.l.] : IOS Press, 2001. - p. 11.

Lasker Roz D. and Weiss Elisa S. Broadening Participation in Community Problem Solving: a Multidisciplinary Model to Support Collaborative Practice and Research [Journal] // Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 80, No. 1. - March 2003. - p. 20.

Moore Geoffrey A. Crossing The Chasm [Book]. - [s.l.] : First Collins Business Essentials, 2006. - p. 13.

National Academy of Sciences Beyond Productivity [Report]. - [s.l.] : National Academies Press (www.nap.edu), 2003. - p. 2.

Rodriguez Marko A. Advances towards a General-Purpose Societal-Scale Human-Collective Problem-Solving Engine [Report] / Computer Science Department ; University of California, Santa Cruz. - Santa Cruz : [s.n.], October 2004. - p. 1.

Rodriguez Marko A. Advances Towards a Societal-Scale Decision-Support System [Report] / Computer Science Department ; University of California, Santa Cruz.. - Santa Cruz. : [s.n.], 2004. - pp. 4,13.

Rodriguez Marko A. and Steinbock Daniel J. The Anatomy of a Large-Scale Collective Decision Making System [Report] / Modeling, Algorithms & Informatics, Learning Sciences & Technology Design ; Los Alamos National Laboratory, Stanford University. - Los Alamos NM, Palo Alto CA : [s.n.], 2006. - p. 3.

Rodriguez Marko A. and Watkins Jennifer H. Revisiting the Age of Enlightenment from a Collective Decision Making Systems Perspective[v2] [Report] : <http://en.scientificcommons.org/39737021> / Los Alamos National Laboratory. - Los Alamos, New Mexico : [s.n.], 2009. - p. 5.

Rodriguez Marko Antonio and Steinbock Daniel Joshua Societal-Scale Decision Making Using Social Networks [Report] / Computer Science Department ; University of California, Santa Cruz. - Santa Cruz : [s.n.], 2004. - pp. 2,4,5.

Sowell Thomas A Conflict of Visions [Book]. - New York : Basic Books, 2007. - p. 31.

Sowell Thomas Knowledge and Decisions [Book]. - New York : Basic Books - The Perseus Book Group, 1980. - p. 104.

Steinbock Dan [et al.] Collective Intelligence Quantified for Computer-Mediated Group Problem Solving [Report] / Jack Baskin School of Engineering ; University of California, Santa Cruz. - Santa Cruz : [s.n.], 2002. - p. 1.

Watkins Jennifer H. and Rodriguez Marko A. A Survey of Web-based Collective Decision Making Systems [Conference] // Conference of Human Complex Systems, University of California, Los Angeles Lake Arrowhead. - Lake Arrowhead : Los Alamos National Laboratory, 2007. - p. 3. - JHW2007-1.