Science 2.0

> Copernican challenges face those who suggest that collaboration, not computation are the driving energy for socio-technical systems that characterize Web 2.0.

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The continuing spread of the World Wide Web and mobile communications devices is changing whole disciplines and industries. Entrepreneurs, policy makers, and researchers are recognizing that the many orders of magnitude increase in collaboration through socio-technical systems offers compelling opportunities for business, education, national security, and beyond (*1*). The vital importance of collaboration justifies it as the focus for the next phase of science, whose new research methods could have high intellectual and societal payoffs (*2*, *3*, *4*).

Emerging successes such as scientific collaboratories among genomic researchers, engineering innovations through open source software, and community-based participation in cultural heritage projects are early indicators of the transformative nature of collaboration (*5*). Ebay, Amazon, and Netflix have already reshaped consumer markets, while political participation and citizen journalism are beginning to change civil society. Patient-centered medical information and secure electronic health records are improving healthcare, while creating opportunities for clinical research. MySpace and Facebook encourage casual social networks, but they may soon play more serious roles in facilitating emergency/disaster response (*6*). Social media platforms, such as Wikipedia, flickr, and YouTube, are also stunning success stories of web-based contributions.

Understanding these collaboration-centered social-technical systems could lead to dramatic design improvements that accelerate their adoption and raise their benefits. However, researchers will need to develop new ways of doing science. The traditional sciences of the natural world, Science 1.0, have brought astonishing advances during the past 400 years from moon landings to cellphone networks.

Science 1.0 will continue to be important, but new kinds of science, Science 2.0, are needed to study the integrated interdisciplinary problems that are at the heart of socio-technical systems. The opportunities for Science 2.0 include trusted voting, quality healthcare delivery and robust emergency/disaster response. Collaboration also supports other national priorities such as fighting terrorism, building safe communities, and ensuring workforce competitiveness. The socio-technical nature of these design challenges is even greater in global problems of environmental protection, energy sustainability, and international development.

The guiding strategies of Science 1.0 are still needed for Science 2.0: hypothesis testing, predictive models, and the need for validity, replicability and generalizability. However, the Science 2.0 challenges cannot be studied adequately in laboratory conditions because controlled experiments don’t capture the rich context of Web 2.0 collaboration, where the interaction among variables undermines the validity of reductionist methods (*7*).

In Science 2.0 the rich mix of people and technology means that observations, interventions, and data collection situated in real-world environments are necessary (Table 1). Amazon and Netflix became commercial successes, in part by their frequent evaluations of incremental changes to their website design as they monitored user activity and purchases.

Similarly, researchers who want to predict success for online healthcare information groups or citizen journalism projects need fresh research methods and theories (*8*, *9*). Individual outcomes are difficult enough to study, but understanding why Google, YouTube, or Facebook succeeded in the face of lively competition is still more challenging. These socio-technical systems are best studied at scale, in the real world by rigorous observations (studying successes and failures), carefully-chosen interventions (changing interfaces or privacy rules), and ambitious data collection (analyzing all public user activity). When adequately replicated, these quantitative and qualitative empirical studies can lead to predictive models and effective simulations that guide future designers and researchers.

Science 1.0 heroes such as Galileo, Newton, Faraday, Maxwell, and Einstein produced key equations that describe the relationships among gravity, electricity, magnetism, and light. By contrast, Science 2.0 leaders are studying trust, empathy, responsibility, and privacy. The great adventure for the next 400 years will be to define, measure, and predict the interaction among these variables so as to accelerate scientific discovery, engineering innovation, e-commerce, and education (*10*). The 5-fold growth of research on privacy and trust is apparent in the past 5 years, while empathy and responsibility are just beginning to capture attention, sometimes under different terms.

Science 2.0 researchers are adopting observational and case study methods as they collect quantitative and qualitative data to gain support for their hypotheses about whether trust increases empathy and privacy promotes responsibility (*11*, *12*). Their work methods are in harmony with research initiatives on web science (*13*), creativity support tools, online education (*14*), socially networked communities, etc.

Advancing Science 2.0 will require a shift in priorities to promote integrative thinking that combines computer science know-how with social science sensitivity. Science 2.0 researchers who develop innovative theories, hypothesis testing based on case study research methods, and new predictive models are likely to lead the way. The quest for empirical validity will drive research beyond what laboratory-based controlled studies can provide, while replicability and generalizability will be achieved with greater effort through multiple case studies.

Just as technology-centered researchers measured progress in petabytes of storage or petaflops of processing power, collaboration-centered researchers can measure the growth of peta-collabs of cooperation and peta-contribs of assistance.

Some Science 1.0 proponents see their work as hard science and have little respect for the softer social sciences that are part of Science 2.0. However, the brittleness of hard science laboratory results applied to real-world systems becomes increasingly clear, and the payoffs of softer, yet rigorous social science methods become more attractive.

Science 1.0 remains vital but this ambitious vision of Science 2.0 will impact research funding, educational practices, and evaluation of research outcomes. Science funding agencies will face resistance as they promote a Copernican-scale transformation that seeks to make a safe space for Science 2.0. Forward-looking scientific journal editorial boards and conference program committees are already shifting their attention to new topics and opening their doors to new scientific research methods. Pioneering educators have begun changing their curricula, focusing on collaboration strategies and teaching new research methods. The innovators are courageously taking on new challenges, but they should be ready for the resistance to novel ideas that has always been part of science. In that way Science 2.0 is part of a great tradition.

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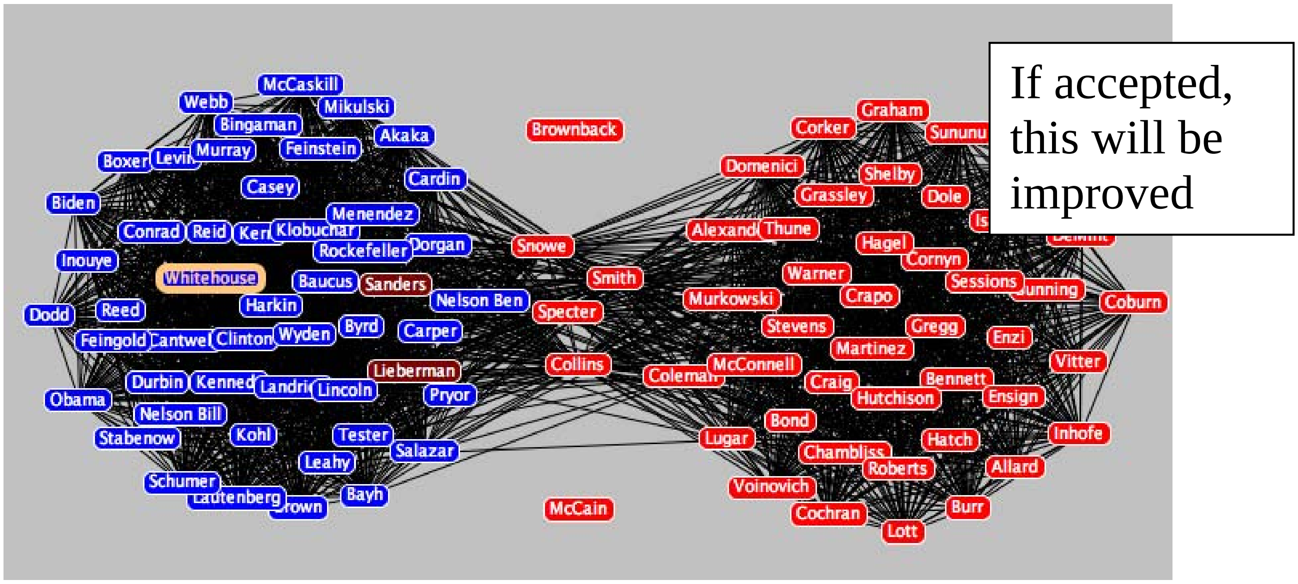

Figure 1: Collaboration between pairs of Senators is shown by connecting links. The blue Democratic Senators are at the left and red Republican Senators on the right. Brownback and McCain were campaigning for the Presidency and did not vote often enough to be linked. http://www.cs.umd.edu/hcil/SocialAction

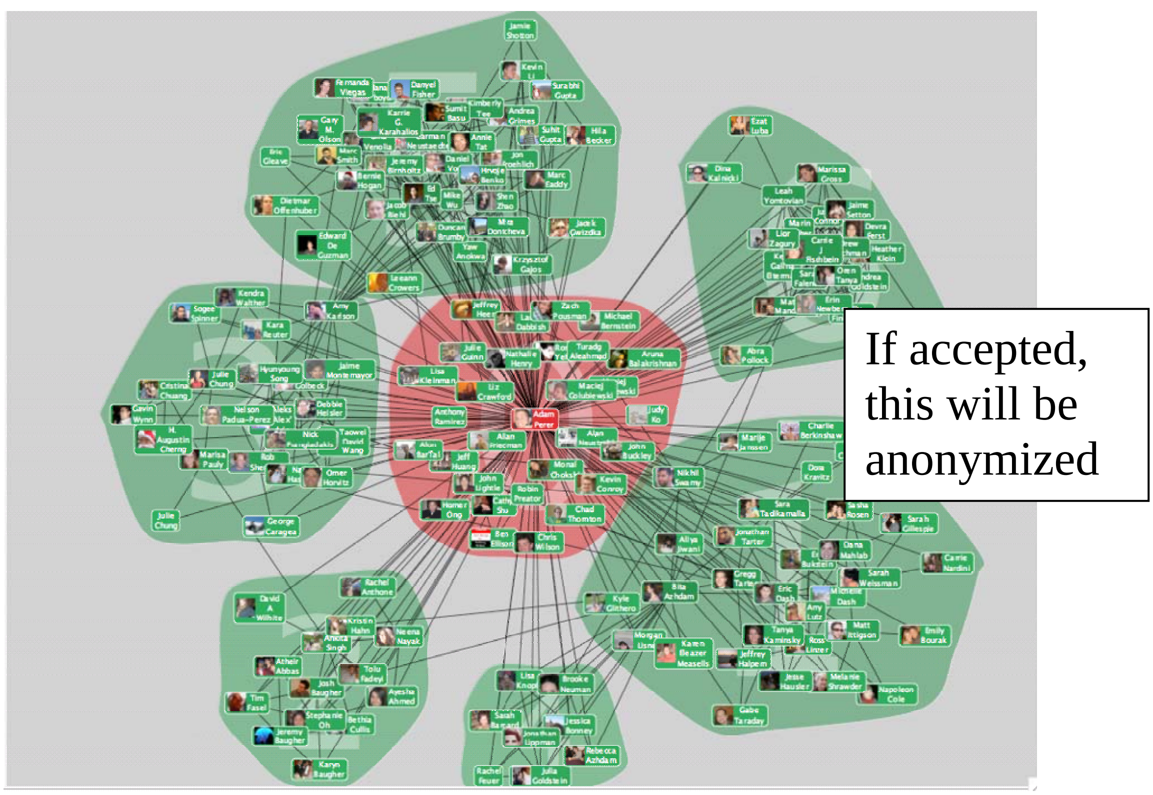

Figure 2: Six clusters of friends who are richly connected (work colleagues, college friends, high school friends, etc.) are shown in green regions, while personal friends that are not in the clusters gather round the central individual in the red region.
http://www.cs.umd.edu/hcil/SocialAction

Science 1.0	Science 2.0
Differences	
Material properties of the natural world	Human collaboration in the made world
Reductionist	Integrated
Controlled Experiments	Interventional experiments, logging, long-term case studies, observation
Conducted in laboratory	Situated in the real world
Requires repeatability	Emphasizes validity
Quantitative	Quantitative & qualitative
Similarities	
Hypothesis testing	
Predictive models	
Replications expected	

Table 1: Comparing Science 1.0 and Science 2.0 by looking at the primary differences and similarities