Evolutionary Development

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ABSTRACT
The increasingly common creation of large, important, complex systems through "open peer projects" is a rich source of insight into the Future of Making. We should learn what has made open peer practices so effective, and apply those insights to Making. Our conclusion is that open peer production is supporting evolution of complex systems with powerful tools, and practices for collaboration, on-boarding of new community members, and capture and navigability of history. Our position is that the future of making should incorporate this framing and such tools. We believe that these practices can be applied beyond current open peer projects to make, in a better way, a better world. (A position paper for Critical Alternatives 2015 workshop W12: The Future of Making.)

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INTRODUCTION
There are hard problems in the world. Ones that deserve the creativity, skills and effort of many people. Ones that will take exploring lots of alternatives, trying and learning, combining parts of different solutions to create even better solutions. Solutions will vary depending on circumstances, but different solutions have to be compatible enough to deliver more benefits than conflicts. The process of finding, sharing and implementing solutions needs to work when it gets large, even world-wide. We have been saying for some time [1,2] that problems like these require: local *responsiveness*, non-local *coherence*, and the ability to *scale*. And we have wondered how technology can be brought to bear to improve our processes on these dimensions.

Conversations that span large groups and large distances in time and space are not new. They go back at least to the invention of writing. They include the "great books" conversation that spans the time from Homer to the present, and to some degree the entire literate population of the world today. Less obviously but just as significantly are the collective "making" of skilled practices such as those of agriculture, practical geometry, architecture, schools of design, disciplines of engineering, the law, and governance.

With each advance in communication — speech, writing, printing, rapid long distance messaging, broadcasting, digital networks — we have seen new possibilities for large scale social practices to emerge, diversify, and jell into new social institutions. Some argue that these advances have always been on an exponential curve, but until recently the rate of change has been slow enough that the shape of the curve was hard to perceive. In our lifetimes, however, the rate of change has accelerated to the point where it is clearly driving the evolution of our institutions.

To deal with this rate of change we need to consider *how* advances in communication lead to change in social institutions. The development of new communication tools is entwined with the development of new practices and new institutions. For example, writing was not invented simply to communicate better. Our earliest examples of cuneiform record accounting data such as quantities contributed to and withdrawn from granaries. This writing enabled a far more persistent and accurate community memory, and in turn led to new, more abstract kinds of rights and obligations.

Over the following several thousand years, evolving communication technologies opened up the possibilities for new social institutions, but then the institutions had to grow in the new territory, realizing some possibilities and blocking others. These technologies enabled major new growth in such domains as law, tax collection, definitions of land ownership, military organizations. They also enabled the emergence of science, engineering, mathematics, philosophy, history and literature through the large scale literate conversation around the Mediterranean.

Improvement in communication has enabled institutions (e.g., the Roman Empire and the Catholic Church) to achieve considerable coherence over large areas and significant time periods. However this large scale coherence has come at a high price. For the last few millennia, nearly all institutions that have been carrying out large scale, complex, interdependent tasks have imposed strong control through hierarchical organization. Although there are a few important exceptions (e.g., the development of modern science), the pattern has been so close to universal that we tend to take it as a natural law: "Big, complex projects require strong hierarchical governance."

OPEN PEER PROJECTS
However, with the advent of modern communications and computing, this "law" no longer holds. New governance

possibilities have opened up, and new kinds of institutions have grown up in this new territory. The exponential improvement in communication, storage and computation in the last few decades has led to the emergence of a radically new kind of institution, generically called "open peer projects." These allow large and diverse groups to form, to discuss and experiment with alternatives, and to synthesize and distribute their results, with no one in charge and giving orders. The speed and quality of large scale projects has increased, and their effective cost has fallen dramatically.

Wikipedia—the defacto encyclopedia at least for English-speakers—is perhaps the best known example, based on on-going contributions from hundreds of thousands of contributors all over the world.

A somewhat less well-known, but even larger and more powerful, example is *open source software development*. Open source projects are based on voluntary collaboration among developers—in some cases as many as a quarter of a million in a single project. Open source practices provide ways to *explore alternatives*, *manage projects*, and *coordinate* between people who may never meet, and indeed who may not even speak a common language.

These new institutions have demonstrated that large complex projects can succeed without any centralized control, and furthermore can beat the productivity, range of exploration, coherence, scale and speed of response of comparable centrally-managed projects, all at immensely lower cost. Further, they have shown a superior ability to address issues where the solution, and even the desired goal, is not known at the outset and indeed is developed as everyone proceeds. These successes rest on practices involving *concurrent independent exploration of alternatives* that can later be *merged* into systems that are more coherent than any of the explored threads.

Wikipedia and Open Source Software projects are visible and commonly-known examples of such *open peer projects*. Others include: mapping (Open Street Map), molecular biology (Gene_Wiki), research mathematics (PolyMath), and scholarly publishing (ArXive):

We believe that many domains of society could benefit from open peer practices and tools. For example:

- Printable 3D models of commonly needed objects: The development of repositories of printable models is already underway, in step with the development of 3D printing, but this development is still at an early stage.
- Climate models: Climate models already exist, are computational, depend on huge piles of input data, and are subjects of both active development and active debate. Some technically sophisticated people justify their suspicion of climate models by complaining that the models and data aren't openly available. The models would most likely be improved by wide scrutiny and experimentation.
- Economic models: Economic models are math intensive; some depend on lots of data, but most depend on only a few time series. There are large piles of data openly available. Obviously any models would be very contentious, but the process of open peer modeling would help to bring issues into focus and might even resolve some questions and reduce pre-mature action.
- Drug trial data curation and analysis: All the data for drug trials should be made public; this is already widely recognized and the political push for it is underway. As the data becomes available, peer projects to analyze the data and to develop better analysis tools could be very important -- could in fact save a lot of lives.
- Curation and analysis of educational testing data: This data is being created largely by public organizations under government mandate, so it should be possible to make it publicly available. We often see reports based on summary statistics but peer projects might be able to come up with much more interesting patterns.
- Legal code: Clay Shirky has suggested peer projects to consolidate the legal code. Right now, laws are rarely available in a consolidated form; instead new laws amend old ones, leading to a very distributed and hard to understand tangle of overlapping material, likely with significant internal conflicts. In addition to consolidating the law itself, this sort of project could consolidate the legislative and external debate that embeds the legal decisions — which is already used by judges to interpret the law. Of course once we've got the legal code online in peer projects, we - collectively - can start to develop and improve it. This seems like an ideal focus for open peer development. Furthermore proposed changes could be backed up and challenged by economic and social modeling, also fed by peer curated data.
- Historical archives: These are increasingly moving online. This includes documents, of course, but also other historical leavings, including artifacts, fossils, bones, buildings, and archeological digs. Simply being able to annotate these and index and search the annotations would be very powerful. Further analysis tools would be a bonus.

Note also that in many of these domains, the results to some extent *are* the summarized debate. For example, the legislative debate surrounding a law, or the issues raised during analysis of drug trials, are essential context for understanding and interpreting the resulting decisions. This is in contrast to open source software development where the *work* of creating and debugging code is quite separate and distinct from the work of *managing* code development. This makes the open history of peer projects even more valuable for this kind of domain. We also suggest that even software development might be improved by extending the

code-management practices to include the discussions within which it is embedded.

EVOLUTIONARY DEVELOPMENT

All of these peer projects have been, or would be, enabled by better communication, storage and computation, but that is not sufficient. The projects also depend on using these better resources through open peer practices. Furthermore, they depend on automated support for multiple concurrent streams of interacting development. In this pattern, things advance as a wave does, with every region of the wave responding to local conditions (responsive), spreading and merging with and altering others, and the wave as a whole seeking some or many points of convergence (coherence). And waves can get large (scalable).

In a different sense, this pattern of development has been around much longer even than writing, longer than any of our technology, and indeed longer than homo sapiens as a species. Open peer development proceeds through local changes, diffusion of the changes, competition between alternate branches, merging and consolidation. This very same pattern can be seen in the evolution of species and ecologies: mutations are the local changes, and the processes of diffusion, competition and consolidation are the evolution of populations. The development of cultures and languages also follows the same pattern, through the local change, diffusion, competition, merging and consolidation of linguistic artifacts, including memes, practices, vocabulary, and syntax. Science too fits the pattern, with decentralized generation and review of experimental results, and development and revision of models, theories, and laws. We therefore have come to refer to this pattern as *evolutionary development*.

As we have said, evolutionary development is hardly new. What *is* new about the emerging open peer practices of evolutionary development is that they enhance collaboration, the on-boarding of new community members, and the capture and navigability of history. This makes open peer development *easier to join, faster, more accountable to its participants*, and *more efficient*. Although this is only a change in degree, the effect is great enough to cross a threshold, dramatically increase the speed and diversity of development projects, and repeal of the "law of centralized control".

What, then, makes the evolutionary development practices of open peer projects so effective? Our analysis of existing examples has lead us to the following preliminary conclusions:

- Complete record: Contributors can learn from their history; which means they are able to review history; which means capturing history as it happens. Ideally they get a complete archive of all changes, which records every significant move, but does not get in the way of continuing to change things.
- Independent activity: Contributors can work independently without being tied to some central organization; and they can merge their work with the work of many others with whom there has been no anticipated plan to merge, no intervening communication, or even any awareness that their activities are happening and related.
- Archive of discussions: Contributors can capture issues that concern them, share them with others, discuss them (and capture the discussion for later review), and propose and negotiate relationships between them. The results are accessible to anyone, whether old hands or newcomers.
- Sharing: Contributors can package up pieces of work that they have been doing, together with its history, and hand it off to others.
- Voluntary participation: Each project can attract and use volunteer contributions. Projects let anyone explore the work that has been done, observe current work in progress, and participate whenever they want. This means that the process is not driven by schedules or by assignment of tasks, and that contributors can join and participate much more easily.
- Concurrent development: Each project can ensure that that no participant can cause substantial damage to the whole, or hold up the show. Contributions are made in a ways that can be tracked, evaluated and integrated optionally and reversibly.
- Testing: The project can test whether a given change improves things or makes them worse. Further, these tests are retained and reused to ensure that subsequent changes continue to leave things functioning properly.
- Open-ended content: Contributors can hold open-ended discussions of issues that span specific parts of the existing system, or that fall outside structure of the work itself.

This may seem demanding — perhaps even utopian. But these requirements are routinely met by thousands of open peer projects, involving hundreds of thousands or even millions of contributors worldwide. These projects already build and maintain many important components of our technical environment, and they are evolving into an essential component of supporting our economy and society

These requirements are met by a combination of highly evolved institutional practices, and tools that support and, increasingly, directly embody those practices:

- Version management: The capture of history, packaging of results, merging of multiple contributions, tracking specific changes and so forth is supported by version management. Originally based on manual practices, these practices have now largely been built into version management software.
- History capture: Tracking of issues, discussion of designs, planning complex activities, maintaining institutional memory of previous discussions, are

supported by ticketing systems, email archives, discussion forums and wikis. Typically, changes to the system being built, changes to documentation, new issues, and discussion (via email, chat or other media) are intertwined in a web of mutual references. Here again, these tools evolved through increasing automation of evolving practices, as those practices became increasingly routine.

WHAT CAN WE DO?

We believe the potential benefits of open peer projects are enormous and that it would be extremely valuable to open up these "best practices" to the widest possible audience and range of applications.

At the same time, our analysis of discussions in open peer projects, and in Open Source projects in particular, suggests that there is much more that can be done to make these discussions more effective and efficient. We aspire to support collaborations that are:

- open: anyone can participate, see the current state and its history, contribute their own material (e.g., new material, changes to material, comments on material, comments on comment);
- versioned: by default all history is retained, information retained is immutable, and exploring alternative changes and then re-establishing coherence is easy and safe;
- multi-local: participants can do whatever they want to their own local version, and then share changes with others as they wish;
- coherence conducive: sharing updates, and merging updates in ways that maintain and increase coherence, is as easy as possible;
- extensible: easy to tie in new types of content supported by any application (e.g., text, images, documents, videos, ...);
- multi-grained: updates may be very small (as in chat exchanges), or very large (e.g., whole documents, or systems);
- domain-spanning: collaborations can arise around any subject matter, in any domain; as they grow they often engage other domains and other projects.

We are proceeding by building prototypes, integrated at three layers (*storage*: for holding of the stuff of conversations, *domain*: for the concepts and substance of conversations, and *interaction*: for manipulating the domain material). We are seeking to make each layer a user-accessible, construction-oriented, evolvable tool-set; and the whole platform to be evolvable and open.

We are currently prototyping construction sets for accessible versions of some domains of open source practices (e.g., ticketing). We are building our initial prototypes in JavaScript so that they will be accessible to everyone through web browsers. We are using emerging reactive frameworks, server-side JavaScript, and document databases to get things running quickly. We expect the results will be portable to any modern platform.

Our medium-term goal is to evolve from the prototypes into production-grade construction sets, with a fairly wide range of pre-built functionality.

Our long-term goal is to contribute as much as possible to the broad movement to integrate peer project practices, infrastructure and institutions into the lives of everyone on the planet, so that humanity will have a better shot at working on and through the truly hard problems we face.

IMPLICATIONS FOR MAKING

This all suggests that making in the future, and indeed right now, be thought of as a open peer activity. Our view is that such making is essentially evolutionary: alternatives are tried in concurrent threads, evaluated in diverse contexts, and effective pieces merged to yield results that are more effective than can be achieved through any single thread alone: a wave, or the flow of a braided stream.

Further, because we can reflect on our activity, we embed our making in thought (design), and our design in talk (conversation).[3] The capture and navigability of history recursively makes design and conversation themselves into matters that are made in our making of everything else. We can accelerate and improve our making through broadening our focus to include the conversations that make up both the alternative threads and the branching and merging of evolution.

Open peer tools and practices are already well-suited to supporting the making of complex digital artifacts, as shown by the amazing experience of open source software, Wikipedia and other examples. We believe they will contribute to large-scale evolution of much better results in many fields. These tools and practices for evolutionary development should be integral to the future of making.

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