IBM Institute for Business Value

Small worlds: The social approach to software delivery

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By Patrick Howard, Dorit Nevo and Pat Toole

Senior executives recognize that software is a source for sustained economic performance and market advantage; however, the complexity of software-intensive systems can be a barrier to business initiatives. We believe time-based performance has never been more important for competing effectively in today's tough global markets, requiring many organizations to rethink their approach to software delivery. The stream of new innovations from mobile to social underscores the urgency for effective software management practices, not only within the CIO shop, but in concert with business units that are consuming these services. Our experiences at IBM, following 36 months using innovative social practices in software delivery and a large-scale study on the results, highlight the transformative outcomes available to enterprises embracing modern methods.

Software, complexity and the critical path

The pressure for speed and performance in today's tough markets is relentless, a point readily appreciated by business executives and CIOs. New and old competitors enter and exit markets with a dizzying rate of speed and innovation. While business model innovation is a priority for most senior executives, barriers to change persist with legacy systems, which impede rather than promote time-to-value execution. IBM's C-Suite surveys underscore this point. Senior executives have articulated the need for creative and collaborative leadership to break through on escalating complexities.[1]

To deliver incremental improvements of standard practices in these markets would not suffice. What is needed is radical new thinking about traditional delivery models that moves from the hierarchical, closed, and resource-focused model to an open environment that embraces community, social recognition, transparency and outcomes.

Facebook, for example, knew the power of social. Within five months of opening access to its technology platform, an extended community of software developers posted more than 6,000 new applications, enhancing value for all site members. This milestone was reached six months before Apple opened its app store in 2008.[2] Since then, more than 500,000 apps have been delivered by Apple's extended community of software developers, demonstrating the kind of spontaneous innovation that is heavily studied but hard to replicate.[3]

At IBM, we were interested in employing the same social power *internally* to spur productivity in software delivery. We approached this topic with trepidation, however, recognizing the diversity of requirements across thousands of software engineers and projects. We needed tangible results, with credible and repeatable processes, that could scale from small enhancements to large multi-year programs. We also needed to validate the productivity gained from this transformation, so that it could be matured and promoted with our worldwide workforce.

We operate in more than 160 countries, with a broad array of operational demands and sophisticated application systems in areas such as high-tech manufacturing, supply-chain management, corporate functions and sales. Our software development practices, as measured by independent industry groups, are mature. We invest heavily in integrated tooling for our software engineers. We field a highly talented workforce of technical professionals. Nevertheless, internal software applications seemed to be on the critical path for many of our major business initiatives, impeding time to market. With each new business initiative, system updates are typically required in applications such as product catalogs, logistics or customer service. The complexity of these legacy systems varies, and may require months to propagate even the simplest of requests. The business had plenty at stake in these fast-paced markets and was demanding concrete actions to compress cycle time in software delivery.

As part of our root-cause analysis, we examined a subset of our projects and attempted to identify hurdles to cycle-time performance. We quickly noted that the potential points of failure in any single project were manifold, with a complexity grid of riveting scale when considering the interdependencies that may impact schedule. *The unifying force in all of these projects was the professional, drawing on his or her expertise and relationship network to solve problems and identify solutions.* Our teams, operating from locations around the world, were tackling tough problems, mostly through the help of conference calls, emails and instant messaging. Of course, disciplined life-cycle methods and automation structured the production of project artifacts, but human interactions were still core to execution. While the social practices were a little dated, and the reliance on tribal knowledge was pervasive, the outcomes were pretty clear: *the better the social interactions, the better the results.*

Consequently, in 2008 we launched a community model incorporating a suite of social capabilities for software development that touched platforms, practices and people. Within the context of our globally integrated enterprise, we created "small worlds" in which people could network rapidly within gated communities, reaching knowledgeable workers with experiences relevant to the problems at hand. As a result, our cycle time in project delivery was reduced by 30 percent, while quality was enhanced by 20 percent.[4] We reduced costs significantly, while increasing the scope of work delivered.

After 36 months and a large-scale study of the results, this report describes the model and our insights on its contribution to the business. We offer two important contributions to the reader. First, we provide a detailed account on how social tools and capabilities can be leveraged *within* the organization. Second, we provide empirical evidence linking such application to value and performance.

The community model: elements of design

Developing our community model, we knew that the mere presence of social technologies would have little influence on our delivery challenge. In our globally integrated enterprise, we source talent worldwide and deploy professionals in our delivery models to drive outcomes. Some of this talent includes subcontractors with highly specialized skills, or vendors with specific expertise pertinent to their products. We needed to ensure that our model and tools could support these cross-boundary teams in structuring work, bridging cultures, building trust, managing communications, dispatching assignments and socializing results.[5] Consequently, our model introduces new practices that encourage collaboration, promote trust, align contributions and empower teams. This integrated set of capabilities was guided by foundational social principles in three areas: *platforms*, *practices and people*.

Social platforms

The research on "small world" and six degrees of separation is covered extensively in literature.[6] It caught our attention as we thought about the objectives of our communities. After all, our project teams are comprised of knowledge workers engaged in problem-solving activities. If the solution for a problem was not evident or, more important, if the problem had already been solved, our teams needed to network to the right subject matter expert in a few hops, no matter where that person resided. Just as important, professionals with expertise on a subject needed to have the freedom to engage and propose solutions, even if no one was asking for help.

But in structuring our social platform for engagement, we knew that context counted. We wanted to avoid generic communities and random networking by faceless people. Our advantage was a highly skilled and specialized workforce, with project managers, business analysts and architects boasting decades of experience in key dimensions of our business. We needed social networks structured around small worlds, to concentrate the energies of our teams in relevant domains.

George Stalk's landmark study on time-based performance helped shape our strategy, focusing our attention on the business outcomes required, not just software delivered.[7] Through our enterprise process framework, we organized our teams worldwide into 130 communities, each one aligned with one of the 14 enterprise business processes based on applications managed. With this business framework, we designed and deployed an ecosystem where people had a natural affinity with the mission of their community. The software developers working on customer service systems in growth markets like India or China were in community with architects managing call center apps in mature markets like the United Kingdom or Japan. Projects managers running our supply chain in Asia Pacific were visible to teams developing new procurement practices in other business units. The alignment by enterprise process ensured that experts on the business process and associated application sets were operating together in community.

Small world and social enablement

Our 130 small worlds are gated and well structured. Each community is managed by a business and IT leader, and community leaders manage all the projects funded for the set of applications governed by that community. A governing principle in our model is that only members of the community work on the applications in the community. While open access is a social practice that has value, we knew in our design that authenticated expertise was critical to the network of trusted relationships. We needed an environment where busy professionals knew if they reached out and across their projects, organizations or countries, that it would help, not hinder outcomes. Project managers pressed by deadlines don't need to sort through a million hits on Google. At the same time, with membership of these communities ranging from 40 to more than 500 professionals, the network needed to be vibrant and healthy, with appropriate incentives in place to drive productive interactions.

While the business design of the social platform was our top priority, technology counts as well. We understood the importance of a friction-free environment, where tooling matched the networking requirements of these specialized communities. The roster of available tooling to facilitate networks is vast. We quickly narrowed our choices to those social technologies that would enhance the developer experience, improving collaboration in design, code and testing activities. With our global workforce, we needed to capture insights in-context through synchronous and asynchronous communications. The complexity of software engineering demanded a social platform that reinforced engineering disciplines. We provided cloud-enabled technologies as well, facilitating speed in provisioning environments. This is one element of our model that went viral, with more than 10,000 professionals boarding the platform within 180 days of launch.

Illustration of IBM software delivery communities

Global Credit Community (GCC: Founded February, 2009)
Enterprise Business Process: #4 Order to Cash
The GCC manages software delivery for IBM Global Financing, an IBM business unit that provides financing and leasing options to clients purchasing IT technologies and services. The GCC community manages the global credit application and the credit information system for IBM. The global credit application is a web-based application deployed to more than 50 countries in support of IBM Global Financing operations, helping to manage risk and serve customers seeking leasing options for acquired products and services. The GCC community has a total of 63 members, who are resident in and operate from four countries.

Human Resource Community (Founded July, 2009)
Enterprise Business Process: #10 Manage Human Resources
This worldwide community supports human resources business processes, including talent, compensation, workforce diversity, workforce management, benefits and global administration. The community provides support across a worldwide population of more than 400,000 employees and manages a wide range of applications and technologies. There are multiple project teams in this community, helping to deliver key applications in support of the workforce, as well as drive new innovation for workplace transformation. The HR community has in excess of 290 members, operating from more than ten countries.

Social practices

To support community work and development, we sorted through a variety of social practices, selecting those that appeared to be pertinent to software delivery in a corporate environment. With the help of focus groups of community and team leaders, we refined our thinking about the relevant set of practices that could help contribute to the specialized mission of the communities. Across our complex technology landscape, these practices needed to lighten the workload, simplify global execution and bring the value of the model to the forefront.

We identified a set of practices we believed were essential to lift productivity of our teams. Broadly categorized, these practices are either *workforce related*, requiring members of the team to adopt new techniques in the way they interact and solve problems, or *work related*, entailing the adoption of new methods for planning, structuring and dispatching work to the community and project teams. (see Sidebar: "A sample set of social practices.")

We also understood that practices take practice. Our change-management program included a measurement process to map progress in adopting and maturing these new capabilities. We wanted to be social in the way we measured our communities, and agreed that all results would be published for review by all teams, effectively providing visual benchmarks on what was working and what was not. Teams that excelled in certain areas were drawn on to help others who lagged. We created leader-boards to celebrate successes and used the information to zero in on parts of our business where more help was needed. One of the important outcomes from this process was the speed at which we identified genuine technical barriers among legacy applications architecture, where practices and methods, like agile or component-based development, could not be readily adopted. While this represented real hurdles in cycle-time compression for new enhancements, it also highlighted parts of our application portfolio where investments could be targeted to refactor the systems.

As noted in our sample set of social practices, we thought it was important to communicate openly and promote pervasive transparency across the communities. Although our change-management teams were cognizant of information fatigue and publishing too much data, we selected a few strategic indicators that could be used by our community leaders in promoting change among their teams, illustrated in Figure 1 (*page 6*). The first chart depicts a few of the vital signs of community health, indicating the rate at which social tools were being employed by a community, or the level of community contributions being made. The second chart depicts the level of maturity of the community, measured through a periodic survey in which all members across all communities participate. It is presented in the context of our enterprise process framework, further highlighting the progress being made in enabling time-based performance across our major business initiatives.

Social people

The third component of our model is arguably the most important. With adoption of the model, we were ultimately looking to enable people. Although disciplined software engineering processes, modern tooling and standard methods are foundational elements of a well-run IT shop in any company, the dynamic we were looking to create required voluntary engagement of our people. Across our communities of knowledge workers, we were interested in accelerating value and promoting transparency and innovation as behaviors.

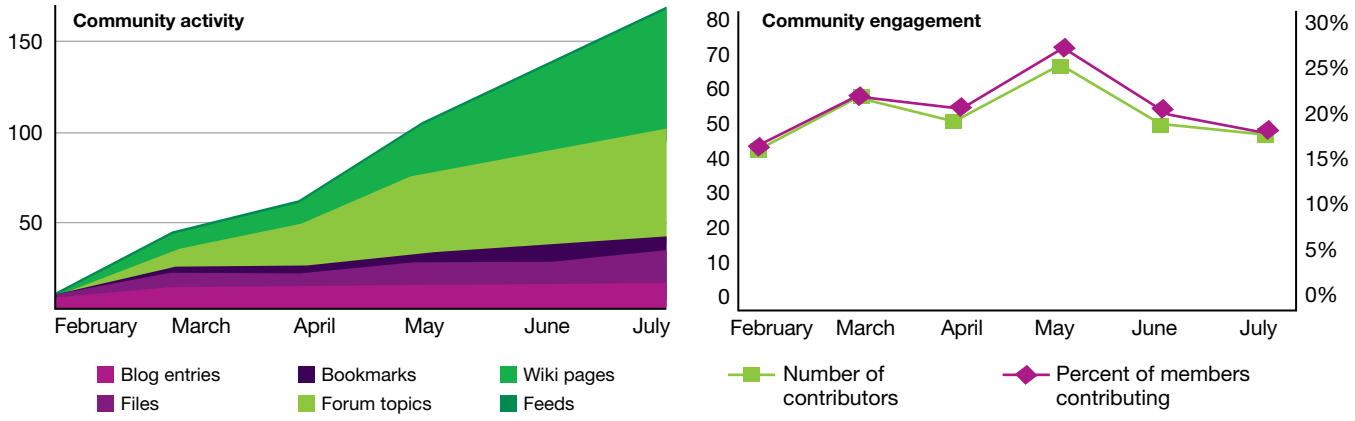
Although we believed a well-designed platform and set of practices would spur adoption across our delivery teams, we also wanted to provide all professionals with a mechanism to differentiate their performance based on results delivered. In other words, we were interested in identifying the pace setters, those individuals who had expertise in thriving with this time-based model and were making consistent, valuable contributions. These are the professionals who knew that, in a globally integrated delivery model, meeting or beating delivery dates on components has implications for the whole team and,

A sample set of social practices

- We deliver through community. Every professional working on business applications for our CIO is a member of the community.
- All members of a community are visible to one another. All professionals and vendors are registered, with role profiles and other essential information.
- We deliver transparently. All work items, assignments, status, deliverables and workloads are visible to all other members of the community.
- We communicate openly. No point-to-point communications. We avoid email and use blogs, alerts, wikis and news feeds whenever possible.
- Be agile. Collaborate with the business through scrums.
- Need work? Self-select through our social site.
- Our communities, professionals and assets all have reputations. The digital reputation is visible (opt-in process).
- Be a time-based competitor and enhance your reputation.
- Software delivery is a team sport. Be social, share knowledge and artifacts through community.
- Have a question? Collaborate. Still have a question? Mass collaborate.

ultimately, the community. They employed their social network to consistently deliver quality outcomes ahead of schedule and help meet time-to-market requirements. As they established their reputations as time-based competitors, we also wanted to ensure that they were visible to the community, to recognize contributions, celebrate results and propagate best practices.

Our digital reputation program went viral, especially among software engineers who are part of Generation Y, sometimes referred to as the "gaming generation." Although social measures are commonplace among consumer networks, this was the first social reputation program we were aware of implemented at scale in a corporate environment. Our HR teams



- Collaboration is indicated by the level of activity in the community space.
- Community leaders track member engagement and cultivate social health through proactive use of collaborative tools.

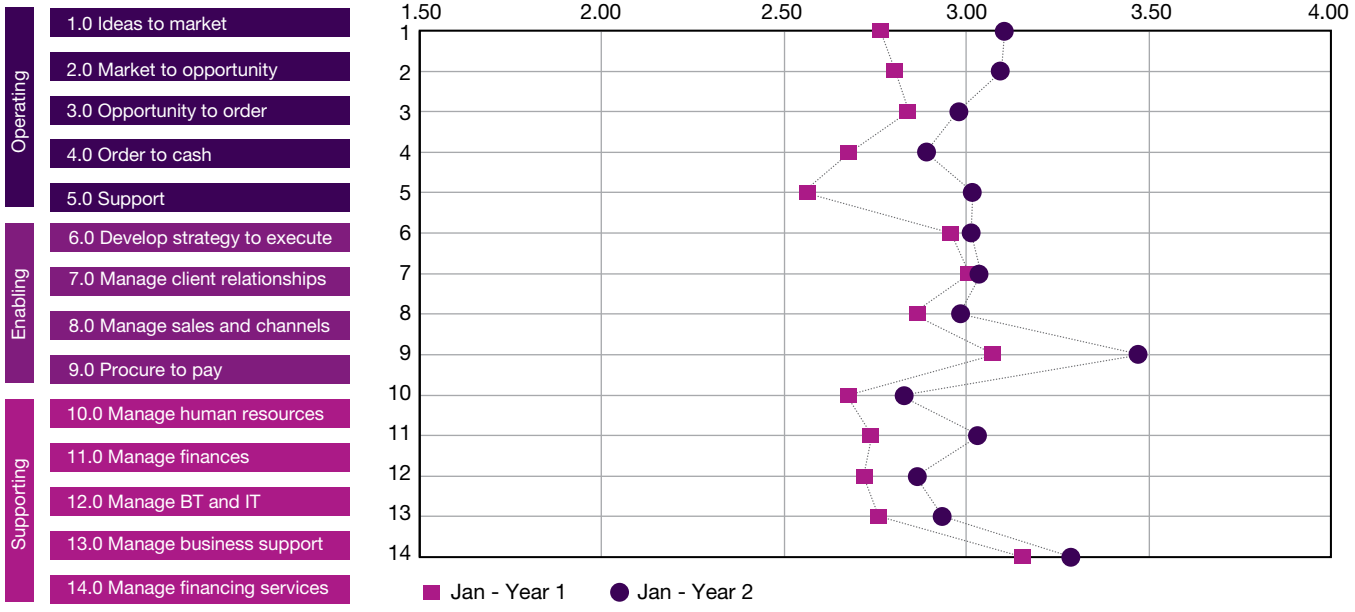


Figure 1: Vital signs: collaboration metrics

worked diligently to understand the parameters of various privacy laws in the countries where our people resided, but ultimately we were able to implement the process broadly, enabling more than 98 percent of our communities.

Every professional carries a scorecard in this opt-in process and gains points for results delivered on a variety of defined project artifacts. The rubric permits additional recognition for asset reuse, since that practice can have the biggest impact on productivity and risk mitigation. The IBM model offers numerous recognition programs at the community, country and global levels. Managers use the information to offer frequent feedback, acknowledge results and understand project contributions. Peers also recognize contributions by posting comments and celebrating results through community wikis.

The digital reputation process takes transparency to another level and triggers the step change in behavior by aligning productivity with outcomes. Auxiliary tools, like blogs, wikis, social networks and tagging, are also employed to help determine levels of knowledge, trustworthiness, cooperation and expertise.[8] It is in the context of community where many of these social practices and outcomes are important, improving the speed and precision at which professionals can network and identify resources to help with problems.

Why this model is different

We described in detail our design elements in creating the community model. This design reflects our objective to employ the "power of social" internally within the organization. Following are what we believe to be the key elements for successfully harnessing social practices internally.

1. Business alignment

From our perspective, governance and business alignment represented the strategic ignition for model performance. The structure, management and alignment of the communities needed to be guided by the business objectives. Our enterprise process framework provided structure and insights to organize teams into communities, helping to create meaningful connections and points of collaboration across our business units. The enterprise process framework provided a natural affinity for teaming, even when working on a diverse set of activities. Business and IT leaders could make tradeoffs and set priorities that were focused and well contained in a smaller world as defined by the business process.

2. Stakeholder buy-in

To promote buy-in, the value proposition for all stakeholders needs to be clear and unambiguous. Although few would debate the benefit of collaboration, the value of leveraging blogs, wikis and social networks to resolve problems and enhance designs is not as evident. Abstract concepts need to be made clear; new methods need to be explained. Further, the relevance of the community to its members is crucial to adoption. Our choice of gated communities, as opposed to the common open-community model, was driven by this recognition and the desire to enable efficient and effective collaboration.

3. Work transparency

The community model gains momentum through hyper-specialization, permitting tasks to be picked up by professionals not otherwise assigned full time to a community or project team, but best qualified to conduct the work. Of course, this is only possible in an environment where work assignments are broadly visible, structured in small components and available for selection through a well-organized and disciplined process.[9] In our model, work is transparent: if individuals have the "free cycles" in their calendar, our practices would permit them to self-select the assignment and deliver the results.

4. Building trust

Open collaboration requires a high level of trust where one person can share work with others and trust that quality results will be delivered. Trust-building practices commonly utilized at the team level should be taken to the community level. In our model, the digital reputation program, work transparency and use of auxiliary tools are all designed to build and promote trust at the community level.

5. Demonstrated value

For organizations, the objective of enhanced workforce productivity through social networking capabilities is more than academic. So that the model can be matured and promoted, organizations need tangible results and the ability to validate the productivity gained from the community model. This is not a one-time exercise. We have implemented an array of measures, focusing on all aspects of the model and targeting communities, teams and individuals, to continuously monitor performance. We have also engaged in a large-scale empirical study to validate the sources of value generated by the model. We describe this study next.

Open collaboration: Business value

The outcomes we have observed from IBM's community model are encouraging. In a large-scale study of 112 of the 130 globally integrated communities, representing more than 5,000 software engineers delivering on 300-plus projects, we noted significant performance improvements in the complex activity of software engineering and delivery by these project teams. Over the past three years, the cycle time across all major programs, measured in terms of days to deliver a unit of software, was reduced by 30 percent. The quality of code, measured in terms of defects delivered to production for a unit of software, improved by 20 percent.[10] While these results have been important for the business, they represent only the start in our push for continuous innovation, leveraging key technologies from our software group and the delivery expertise of our global services professionals.

To better understand the source of these performance improvements, we engaged in an empirical study using the survey method. We obtained data through a large-scale cross sectional survey of 493 individuals in 105 teams across 39 communities worldwide. The detailed study design and execution are described in the "About this research" section on page 11.

The research objectives leading the empirical study were to understand the link from communities to business outcomes, to understand variations in community performance (i.e., to explain why some communities perform better than others on some aspects), and to provide actionable interventions for organizations implementing social networks for technical communities. With insights on these important questions, we wanted to better direct our energies in maturing the community networks and highlighting those few critical practices that would serve the business well.

Community performance: Despite the growing recognition in the importance of communities and their potential business value, models and measurements of community performance are difficult to find. Consequently, we began our investigation of the value of our community model with exploratory interviews aimed at understanding outcomes. The key insight obtained through the interviews was that *communities improve the performance of their member teams*. In other words, measuring community performance requires understanding the link between community membership and project team performance. This link, according to the interviews and based on the organizational team literature, is resource based: *communities provide the social and knowledge resources needed for teams to perform better*.[11]

Social resources: The relationships made available by communities to their member teams can be thought of as a team's social capital. Social capital is the set of resources available to teams from their network of relationships, arising from goodwill and trust among colleagues.[12] An important component of social capital is trust, which has been discussed in past literature as a facilitator of team performance. Groups whose members trust one another are able to coordinate expertise better, utilize their knowledge and have more effective communications overall. A second component is the social network ties – strong and weak – important in providing access to different types of internal or external knowledge that supports innovation and overall performance.[13]

Knowledge resources: A holy grail of software development is reuse, defined as the process of creating software systems from existing software.[14] The ability to reuse any part of an existing software program or application reduces the need for additional design, code and testing work. Communities can make knowledge pertinent to reuse available to the member teams in various formats. For example, tacit knowledge may flow through the social network ties previously described. Members of a community operating together in a trusted network may make recommendations about assets that can be leveraged to solve problems. Here, we focus on a specific type of codified knowledge, in the form of reusable assets (for example code or frameworks).

Communities are responsible for creating and managing reusable assets relevant for their member teams, as well as making those assets readily available. An example of knowledge resources in action might be a community rating of a particular code component, like an error-logging routine invoked when a problem is detected with the value of field entered on a web page. Rather than designing and coding the error-logging routine for a new web application, the senior leaders of the community will promote the use and leverage of the error-logging routing to the professionals designing the new system. Just as important, since knowledge resources are organic and dynamic with time, as new technologies and systems are developed that supersede the capabilities of existing assets, the community's set of social ratings will reflect this change.

Our survey measures of trust, network tie, and assets availability were aggregated to the community level. In addition, we obtained a measure of team performance from both team members and team leaders, and the results were correlated and aggregated for an overall team-performance score. We used the Hierarchical Linear Modeling technique to study the link from community level variables to team level performance.

The results of our surveys clearly showed that communities play an important role in impacting the performance of teams. The statistical model provided strong evidence that community membership was a significant determinant of team performance. In other words, a substantial portion of the variance in team performance was explained by community membership, as opposed to team membership. This finding clearly demonstrates the contributions of the community model to performance. Looking at our hypothesized explanation for this link – that communities provide the relationship and knowledge needed to support performance – we indeed found statistical support in our data. Communities with higher levels of trust among members, and whose members are socially connected to one another, have higher performing teams. Furthermore, communities that have a repository of relevant and well-documented reusable assets also have higher performing teams.

Communities as a team's virtual environment

Our insights from the empirical evaluation of the model are that communities are indeed instrumental in improving team performance by providing the resources needed for the team. Extant knowledge on teamwork in organizations tells us that teams often leverage their environment through various boundary-spanning activities to obtain the physical, intellectual and social resources required for their work. In the case of globally distributed, virtual software teams that span multiple boundaries, such interactions with the environment may be more challenging.[15] What our communities provide teams is therefore a well-defined and relevant environment they can leverage to enhance work. The construction of the communities around our enterprise taxonomy makes them relevant for teams. The social practices encouraged are those that promote trust, collaboration and socialization, ultimately creating a *sense of community* among our globally distributed teams. Other practices are those focused around the interrelatedness of work. These practices ensure that knowledge flows across teams and that relevant knowledge assets are available to all community members.

Through the community model we have managed to create a vibrant professional community whose members trust each other, communicate frequently and share a transparent environment in which roles and responsibilities are clear to all. Reuse and innovation are strongly encouraged and rewarded. We have managed to harness the social power to our software development operation.

Improvement in efficiency, function and capability

While information technologies have driven enormous leverage for companies and enabled society itself, the management challenges of software delivery have produced a "complexity grid" of riveting scale. At IBM, we knew that incremental improvements of our standard software engineering practices would not suffice. We deployed an open-collaboration delivery model that has been deeply embraced by technical and business professionals worldwide and yielded step-change results for the business.

People are at the heart of the social network, and people are able to connect, collaborate, share and work hard for team success and individual recognition when operating in an environment that promotes trusted relationships. In some respects, when stepping back from work that has unfolded over the past several years, the importance of trust is no surprise. While technology, methods and practices can be thought of as the core to the operational design of the delivery model, the scaffolding for the system is trusted relationships. To that end, it helped our leadership teams to ask the question in how trusted relationships were being fostered through the community model.

Our results so far are encouraging. We have seen overall improvements in efficiencies, while stepping up the pace of delivery on new function and capability. Just as important, our professionals report that they are more productive, with better tools and practices to manage and collaborate more effectively in a global community.

Recommendations

Social transformation of the software delivery network enhances the productivity of all professionals engaged in the process – from the point that a new business initiative is planned until the program is deployed for the company. Executives should consider the following steps in evaluating the opportunity of "social" for their business:

- Develop a business case, looking at the quantitative opportunities for enhanced productivity, cycle-time reduction and quality improvements in software delivery for the enterprise.
- Segment the opportunities, identifying the parts of the business where the greatest pressure for speed and performance exists. Align investments and change programs with the highest priority business initiatives of the company.
- Analyze the demographics of your software developer community – and solicit active engagement of these professionals on the "social agenda." Chances are many of them are pretty heavily engaged already in the social revolution.
- Assess your measurement framework and ensure that the most important elements that are influencing time-based performance on your programs are being reported and reviewed in your management system.
- Anticipate that a change program of this magnitude will require direct attention of senior executives. The journey is a challenge, but the results are worth the investment of time and energy.

About this research

Sample

The sampling frame consisted of 112 communities worldwide. Due to the hierarchical nature of the data (individuals nested within teams, nested within communities) we randomly selected 50 communities. Community leaders were contacted by an email and asked to nominate three or four projects for the survey. Subsequently, the leaders of these project teams were contacted by email and asked to respond to the survey, as well as to distribute it to several other team members. For all respondents, information on their teams and community

membership as well as their roles (team leader or team member) was maintained and used in subsequent analysis and aggregation of the data.

We obtained 493 completed and usable responses from individuals in 105 teams across 39 communities worldwide. Six communities had only one team respond to the survey, nine communities had two teams respond, thirteen communities had three teams respond, and the remaining eleven communities had four teams respond. The majority of teams (90 out of the 107) provided responses from the team leader as well as two-to-five team members. Eight teams provided responses from the team leader and one other team member. The remaining teams provided responses from the team leader and six-to-nine team members.

In terms of the type of projects, 42 teams were responsible for maintenance projects, 43 teams were responsible for enhancement projects and 22 teams were responsible for new development projects.

Finally, the majority of individual respondents were between the ages of 25 and 48 (approximately 80 percent). Sixty-eight percent were male. Nearly 95 percent of respondents had at least a Bachelor's degree. The median tenure in the organization was 6 years, and the median project tenure was 22 months. About half of the teams have worked together on other projects in the past. Finally, when asked to indicate the number of team members the respondents worked closely with the median response was seven team members.

Measures

Dependent variable: Team performance was measured using six items adopted from Hinds and Mortensen.[16] Respondents were asked to compare the performance of the current team to the very best team they have worked with the past, on the following aspects: efficiency, quality of deliverables, innovation, work excellence, adherence to schedule/budget, and problem solving. Responses were provided using a five-point scale, from "much lower performance," to "much higher performance," anchored by "same performance" in the middle point.

Independent variables: Trust was measured using a scale adopted from Jarvenpaa & Leidner.[17] Network ties were measured using a scale adopted from Williams.[18] The scale for asset availability was developed for this research. Table A1 shows the factor loading and reliability scores for items in the three scales.

Construct	Factor 1	Factor 2	Factor 3
Bridging (alpha = 0.920)	0.773	0.189	0.139
	0.798	0.193	0.035
	0.763	0.233	0.198
	0.718	0.315	0.252
	0.671	0.287	0.244
	0.814	0.098	0.243
	0.754	0.084	0.246
Trust (alpha = 0.863)	0.11	0.701	0.18
	0.267	0.635	0.238
	0.121	0.706	0.08
	0.202	0.761	0.105
	0.191	0.753	0.195
	0.199	0.796	0.136
Assets (alpha = 0.919)	0.305	0.206	0.801
	0.291	0.295	0.733
	0.243	0.204	0.831
	0.267	0.21	0.813

Table A1

Table A1 provides the factor loading matrix and Cronbach's alphas for each of the independent scales. Cronbach's alpha for the team performance scale was 0.953.

Data aggregation

Data were aggregated to team level. Agreement and reliability scores for aggregation were measured using $R_{wg(j)}$ (James et al., 1984) and ICC(1) (Bliese 2000), shown in table A2.

Scale	$R_{wg(j)}$	ICC(1)
Performance	0.904	0.06
Trust	0.918	0.11
Network ties	0.897	0.17
Assets	0.907	0.12

Table A2

Data analysis

The design of the study assumes that community membership of each team affects teams' performance. This approach requires the analysis of community-level effects on team performance. We used Hierarchical Linear Modeling (HLM) which is the appropriate technique to test cross level relationships. An HLM has many of the same assumptions as OLS models, with the exception of the independence of the error structure. The strongest assumptions of the HLM model are normality, lack of multicollinearity and a stable error variance structure. All of these assumptions have been checked and our data complies well within theoretically established cut-off points. The model was fit using the R package for statistical analysis. The parameter estimation was done using Restricted Maximum Likelihood (REML). And the model selection process was done using Maximum Likelihood (ML).

Variable	Coefficient	p-value
Trust	0.2073241	0.0052
Network ties	0.2925865	0.0000
Assets availability	0.1673073	0.0096
Team members' innovativeness (control)	0.0883592	0.2291
Team tenure (control)	0.0014787	0.0502

Results

To learn more about this IBM Institute for Business Value study, please contact us at ibv@us.ibm.com. For a full catalog of our research, visit ibm.com/iibv.

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