# Engineering 2.0: Exploring Lightweight Technologies for the Virtual Enterprise

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**Abstract.** In a Virtual Enterprise setting, it becomes increasingly important to make sure that knowledge and expertise created in one discipline, domain or company is correctly understood and quickly utilized by other actors throughout the value chain. This paper discusses why lightweight technology seems like a particularly promising concept in this context, and why Virtual Enterprises could benefit from learning more about tag clouds, mashups, wikis, and other 'lightweight' technologies, as complements to the large-scale, arguably 'heavyweight', product life-cycle management (PLM) systems of current practice. The paper draws on data from a number of product development projects – ranging from the development of manufacturing tools and industrial drive systems, to aircraft engines and armored terrain vehicles. The paper identifies both the kinds of problem typically experienced in the Virtual Enterprise, in relation to knowledge sharing, and explores ways in which lightweight technology might be adapted to solve them.

**Keywords:** Lightweight Technologies, Knowledge Sharing, Virtual Enterprise, Engineering 2.0, Collaboration.

## 1 Coopetition in Virtual Enterprises

Traditional extended enterprises are often led by a single *Original Equipment Manufacturer* (OEM), which can normally put its suppliers under contractual obligation to share data, information, and knowledge through one or several information systems of the OEM's choice. However, in the case of a *Virtual Enterprise* (VE), the issue of what to share with others and how to share it is not as easily resolved, since a VE is essentially a network of independent companies, including suppliers, customers and even competitors, that are *"…linked by information technology to share skills, costs, and access to one another's markets. It will have neither central office nor organization chart. It will have no hierarchy, no vertical integration."* [1] Defined in logical terms, not physical, the VE is based on the idea of organizations gaining access to more resources than they currently have available, without having to expand.

Ray Noorda, founder of Novell, noted that companies need to simultaneously compete and cooperate, thus coining the term *coopetition* [2], which essentially deals with the interplay between competition and cooperation. Partners in a VE may choose to work together with the aim to collectively enhance their performance by sharing resources, risks, and rewards – and they may, at the same time, work independently to improve their own performance and market attractiveness. For instance, two independent airline carriers, such as Singapore Airlines and Qantas Airlines, can compete against each other for landing slots, gates, freight contracts and passengers, while cooperating to share the development cost of the Airbus A380 aircraft that are part of their current fleet expansion. On a larger scale, these companies are also part of separate airline alliances, the *Star Alliance* and the *oneworld Alliance*, which further blurs the lines between who is a customer and who is a supplier in the global value chain. Note that a jet engine manufacturer, such as Rolls-Royce, might develop engines to be used on both Airbus and Boeing aircraft, which are ordered by different airliners, which are partners in different airline alliances, etc. Considering this from a supplier perspective, issues of what to share and what not to share become increasingly difficult. Since 'collaborating with the enemy' is becoming increasingly common in the domain of global product development, being able to handle the rapid transformations in and out of such alliances is critical. Virtual Enterprises usually dissolve at the end of each project, and partner companies need to know, in terms of sustainable knowledge sharing, what they can bring into the partnership and what they can take from it in the end.

## 2 Toward Life-Cycle Commitments

To further raise the bar for VE partners, there is also a change in the ways in which different parts of product development companies need to address their contributions to a product's total life-cycle performance. This change is brought about by an increasing interest in providing 'functions' rather than 'hardware'. For example, aircraft engine manufacturer Rolls-Royce offers its customers 'Power by the Hour' deals in order to *"improve product availability and reduce the cost of ownership by tying a supplier's compensation to the output value of the product generated by the customer (buyer)."* [3] This performance-based model means that customers only pay for the result of the product use, i.e. what ultimately adds value, rather than for the time and material associated with repairs and overhauls.

From a product development perspective, the most important thing to highlight here is that although many products in today's marketplace might be *sold* as functions, they are rarely *developed* with a focus on function (i.e. use of performance). The scope of product development activities is rapidly changing to encompass aspects related to the total life-cycle commitments of VE partners, which means that these companies need to rethink how knowledge is created and shared across the many boundaries of the global value chain.

Pointing to the relative ease with which many consumer-product companies can reverse-engineer competitors' products in a matter of days, Sheffi [4] notes: *"Making stuff—that's easy. Supply chain, now that is really hard."* If we put this quote in the business-to-business context of a VE developing functions rather than simply reverse-engineering 'stuff', then we can see the challenges of both integrating the supply chain into the development activities, and sustaining an exceptionally close supply-chain partnership throughout the life-cycle of the provided function. Since a jet engine, for example, could be kept in service for as much as 30-40 years, and since providing a function means that the functional product provider cannot longer earn money on the aftermarket (i.e. they keep ownership of the product through its entire life-cycle) [5], knowledge from the 'later' phases of the product life-cycle (i.e. production, use, maintenance, recycling, etc.) now needs to be used as a knowledge foundation in the earlier phases of the product development process. It is most advantageous to make changes at the preliminary design phase, since it will become more expensive, more difficult, or even impossible to compensate or correct the shortcomings of a poor design concept in the later life-cycle phases. So, in order to provide products, or functions, that truly meet the full range of life-cycle demands and needs, it is highly important to investigate how downstream knowledge could be made available to a wide range of actors, to improve early-stage decision making in cross-functional product development teams.

A key challenge in such boundary-crossing product development work is that different VE partners use different technological systems to create, store and share knowledge. Further, in this kind of setting, the starting position for collaboration means that the product development team, as a whole, usually does not have a previous history of working together – there are fundamentally no 'shared assumptions' of how collaborative work proceeds within this VE. One of the success factors in this kind of collaboration is the ability to effectively and seamlessly assemble and utilize, drawing from the different VE partners' pool of resources, various combinations of specific capabilities needed for the project at hand. There is an inevitable flux of team members over time in such projects, and since the VE practically dissolves at the end of each project, the resources invested in such a dynamic collaborative arena have to be reasonable.

## 3 Research Approach

The research presented in this paper has been performed within the Faste Laboratory, a €24M, 10-year, VINNOVA VINN Excellence Center for Functional Product Innovation at Luleå University of Technology in Sweden, and within the VIVACE Project, a €70M, 4-year, Integrated Project in the aerospace domain of the EU Sixth Framework Programme (FP6). The research has involved four companies from the Faste Laboratory, and five companies from the VIVACE project, and while the overall research agenda has been broader, this paper focuses particularly on examples of how practices for knowledge sharing in industry need to change in order to meet higher demands on cross-functional and cross life-cycle integration of knowledge. Since both research initiatives involve close industry-academia partnerships, the research approach has been highly participatory, with several multi-day workshops, virtual meetings and company site visits during the course of the projects. Informal interviews have been used as a complement when the above channels of communication have not provided enough detail.

The paper draws on data from a number of product development projects, related to several different products in various industry segments – ranging from the development of manufacturing tools and industrial drive systems, to aircraft engines and armored terrain vehicles. The data presented below both identifies the kinds of problem typically experienced in the VE, in relation to knowledge sharing, and is tied to discussions about the ways in which lightweight technology can be adapted to solve them. We have not attempted to produce requirements or evaluate a technology; we have focused on understanding the kind of problem that exists before rushing to design solutions, meaning that the concept of 'lightweight technologies' should be considered as an umbrella term pointing to a wide range of technologies with certain characteristics that are elaborated upon below.

## 4 Engineering 2.0: Lightweight Technologies in Engineering

This paper makes the assertion that lightweight technologies show serious potential when it comes to effectively sharing knowledge between actors partaking in product development in a VE. Here, the term 'lightweight' fundamentally means that such technologies require little time and effort to set up, use and maintain. Also, they are lightweight in that they do not impose a pre-defined structure, but rather lets structures evolve over time as an almost organic response to the activities, practices and interests of the knowledge workers that use these technologies as part of their everyday work.

Since this work draws it context from the fields of engineering and product development in primarily business-to-business situations, we have chosen to summarize these lightweight technologies in the term 'Engineering 2.0'.

While McAfee's concept of 'Enterprise 2.0' includes *"new digital platforms for generating, sharing and refinding information that are focusing not on capturing knowledge itself, but rather on the practices and output of knowledge workers"* [6], Engineering 2.0 is specifically targeting how such technologies and approaches could benefit globally dispersed engineering teams, working in business-to-business contexts of the VE kind, where the available technology support for knowledge sharing still mainly centers around Computer Aided Design (CAD), Product Data Management (PDM), or Product Lifecycle Management (PLM) systems, complemented with online collaborative workspaces and web conferencing systems to support both asynchronous and synchronous collaboration.

One of the main misconceptions of engineering work, in our opinion, is that the very embodiment of decisions and product properties into 3D models and product structures implies that all the relevant data, information and knowledge has already been captured, and is easily accessible from the above systems. It should be noted that lightweight technologies of the Engineering 2.0 kind are not intended to replace CAD/PDM/PLM systems, and we do not intend to devaluate the hugely important work being done in that arena. Rather, we argue, Engineering 2.0 is about finding new ways to deal with new problems that engineers are likely to face when moving into the development of 'functions' in a VE context, and we should recognize that these new problems are not likely to be adequately addressed by 'heavyweight' systems alone.

As noted earlier, there are a number of unique features of this emerging industry context:

1. Virtual Enterprises are 'loosely' coupled networks of independent partners, established on a project-by-project basis.
    a. Knowledge workers in enterprise-wide teams do not normally have a shared history of working together.
    b. Knowledge workers in enterprise-wide teams do not normally have a shared knowledge base with lessons learned, best-practices, etc.
    c. Knowledge workers move in and out of enterprise-wide teams as different competencies and capabilities are needed.
    d. Knowledge workers in enterprise-wide teams do not normally have a shared set of technological systems to create, store and share knowledge.
2. Development of 'functions', rather than 'hardware', as part of total life-cycle commitments radically changes the scope and objectives of engineering activities.
    a. Knowledge workers will need to increasingly work in highly cross-functional, cross-disciplinary, enterprise-wide teams.
    b. Knowledge workers will need to develop closer relationships with customers and suppliers, to better understand the desired 'function' to be developed.
    c. Knowledge workers will need to improve their understanding of their contribution to the overall development and product life-cycles.
    d. Knowledge workers will need to make their knowledge available to a much larger audience than before, and will also need to use knowledge from many more sources than before.

Due to these characteristics, our research focuses particularly on knowledge that currently resides outside of the traditional scope of product development teams. We have chosen to refer to such knowledge as 'downstream knowledge', since we are mainly interested in identifying and utilizing knowledge assets that normally would not enter the scene until after a design concept has already been selected. For example, the same fundamental knowledge assets might be used for the purposes of both product development and opportunity management, but since there are different competencies involved with different goals and motivations, it is crucial to be able to share this structuralized knowledge on an adequate level of detail or abstraction depending on each particular setting. An important aspect of these knowledge assets is that they can be found in a wide range of professional domains – both within the own company, and at customers and partners. Thus, the overall research agenda seeks to address how boundary-crossing teams across the VE can decrease the start-up time for new product development projects by rapidly identifying and effectively utilizing a shared knowledge base from day one (i.e. rather than starting from 'scratch'). Also, it addresses how these various teams can successfully create, share and utilize 'generic' knowledge, i.e. making sure that the knowledge assets they create are easily available to other teams in the VE, regardless of what domain of expertise they are working in.

Admittedly, we struggle a bit with the words to use here, since 'what engineers do' is changing to include a larger part of the value creation activities in a product development process that is also increasing its scope. Are they engineers? Are they product developers? Are they function providers? Are they knowledge workers? Let us leave that discussion to others, and simply highlight the notion of Engineering 2.0 as something different from 'traditional' engineering and product development. The organization is different, the team composition is different, the objectives are different, and the responsibilities are different. In our opinion, the technologies most suitable for effective knowledge sharing will be different, too.

### 4.1 From Weak to Potential Ties

While teamwork in the networked organization has been a hot topic for quite some time, we could argue that the potential for improvement in technology-mediated collaboration is still huge. It has been observed that engineers and scientists very often turn to a person for information rather than to a database or a file cabinet, and people seem to rely heavily on colleagues that they know and trust. Our research indicates that 'knowing who knows' [7] is crucial in global engineering design teams and while that seems to be a commonly accepted feature of collaborative work, it also poses a severe threat to VE:s, where this kind of 'engineering know-who' [7] is not as easily developed as in more traditional enterprise settings. The increasing globalization and the influx of VE thinking means that engineers are working together with more people than ever before, but often with very limited knowledge of who they are actually working with, what their collaborators know, and to what extent they can be trusted. To achieve effective global design teams, it is crucial to address and deal with such issues of 'social disconnectedness'.

In the context of manufacturing tool development, one of our informants noted that your ability to access and try to better understand customer needs fundamentally depends on whom you talk to in the customer organization. 'The customer' is more than one person, and the answers vary from person to person, and are also dependent on the bias of the person who is asking the questions. A similar problem as highlighted by an informant at the industrial drive systems company:

*"Different functions meet the customer at different occasions. It is not easy to merge. Who has the complete picture? Customer value is dispersed across many different persons who have different information about the customer need. We have different persons at the customer site as well: technicians, purchasers, service-personnel, etc."*

The concept of 'weak ties' [8] points to the value of establishing personal relationships that transcend local relationship boundaries both socially and geographically. For example, Granovetter's research on weak ties has indicated that a person looking for a job is, for certain professions, more likely to find a new job through an acquaintance rather than through a close friend, much because the acquaintance is more likely to move in other social circles, and is also more likely to possess other information than what you already have. So, this is particularly interesting when it comes to product development activities, since that is a field where knowledge workers are explicitly interested in avoiding redundancy, and instead seek novelty and innovation. However, what would be the output if VE:s could also better harness the power of 'potential ties' [9]? This notion includes *"…a still-larger set of fellow employees who could be valuable to our prototypical knowledge worker if only she knew about them. These are people who could keep her from re-inventing the wheel, answer one of her pressing questions, point her to exactly the right resource, tell her about a really good vendor, consultant, or other external partner, let her know that they were working on a similar problem and had made some encouraging progress, or do any of the other scores of good things that come from a well-functioning tie."* [10]

To really harness the knowledge that is dispersed across the VE, we need to recognize that the foremost experts on your products might not be on your payroll, and that there might be 'hidden experts' around the enterprise, who are willing to volunteer outside of their official job description [11]. Also, of course, these potential ties could be 'lead-users' [12], in any part of the customer network, offering their advise and experience, whether you asked for it or not. Social networking software, such as LinkedIn or Facebook, and blogs and wikis are some of the ways in which engineers can both increase the density of their weak ties, and get connected to people with knowledge and experience that is new and possibly complementary rather than well-known and possibly redundant.

### 4.2 From Personal to Public Benefit

This paper discusses lightweight technologies for knowledge sharing, and if a technology is perceived as 'lightweight' or not naturally depends on the benefits derived from using such technologies. If the personal benefits are large, i.e. if the return on investment is high enough, users might even tolerate a slow and tedious system because the results are considered worth the extra effort. Similarly, even the lowest threshold could be considered too large if the results are not benefiting the user. One could argue that one of the reasons why many projects are poorly documented is that project participants have difficulties seeing the benefits of making this extra effort to capture rationale, experiences, lessons learned, etc. The people who have to do the extra work are normally not the people who will reap the benefits.

Tang et al [13] performed a study on how knowledge workers in a workplace environment store and manage files on their workplace computers, to see if any social patterns could be identified for the benefit of the company. The interesting thing here, from an Engineering 2.0 perspective, is that identifying these collaboration patterns did not require any additional work by the user. These patterns fell out of the work users are already doing in managing and storing files concerning information that they care about.

When attempting to lower the threshold for knowledge sharing, this is a highly appealing concept. If what people are doing as part of their everyday work produces traces and patterns of how they create, use and share knowledge, why not use these traces and patterns to achieve public benefits across the VE? The social effects of using social software are sometimes unintended – which is something of a paradox. Knowledge workers do not have to put extra effort into sharing knowledge across social networks, but other people in the enterprise can still make sense and use of the traces they produce. In a VE context, where the social ties between knowledge workers are relatively few and weak, or even non-existent, to start with, the ability to derive public benefits from personal actions is very interesting. Here, the concept of a 'folksonomy' [14] makes sense, much because, as opposed to a taxonomy, people *"…are not so much categorizing, as providing a means to connect items (placing hooks) to provide their meaning in their own understanding."* [14] This provides opportunities to find emergent vocabularies and trends, and since information tagged for personal use can benefit other users [15] across the enterprise, this could allow knowledge workers to find people across the disciplinary, departmental and organizational boundaries of the VE. Rather than relying entirely on up-front decisions about where in the enterprise to look for relevant knowledge and persons, finding people who tag items the same way they do, will allow knowledge workers to find social groups based on similar interests and ways of speaking and acting, rather than based on where they are placed in the organizational chart.

Paying attention to customers' everyday, internal discussions about how they use, or even modify, a product could sometimes be more useful than first-hand accounts of what the customer need is perceived to be. On this point, one of our informants working in the manufacturing tool business commented that a source of innovation could be to look at situations when their customers actually use their products in unanticipated ways:

*"…when you look at the customers, they use certain hardware. There are situations where the customer has created the innovation by using the hardware in a certain way. Customers use the product differently than we had thought during development, and this can be an opportunity for innovation if we get to know this."*

Apart from the benefits related to uncovering knowledge that you could not normally access through conventional interviews or observations, McAfee [6] points to some interesting networking effects. As more people author, link, search and tag information, the emergent structure becomes increasingly fine-grained: *"They can make large organizations in some ways more searchable, analyzable and navigable than smaller ones, and make it easier for people to find precisely what they're looking for."* [6] Here, concepts like tag clouds and social bookmarking could provide some of the lightweight capabilities to create public benefits from personal actions.

### 4.3 From Predefined to Emergent Structures

One of the defining features of lightweight technologies is that they do not impose a predefined structure to how these systems 'should' be used. The intelligence of such systems is, instead, provided by users in low threshold ways, where control is shared with users to create value [11]. These technologies *"…are trying not to impose preconceived notions about how work should be categorized or structured. Instead, they're building tools that let these aspects emerge."* [6] This means that there are no predefined roles, identities, or privileges; there are no workflow or process steps to follow; there are no specific data formats to adhere to, and there are no 'required' fields to fill out. [9] In the case of social bookmarking, people self-define their tags using words that mean something to them at the time, rather than categorizing their bookmarks according to a predefined taxonomy. For example, a customer statement that is captured in the context of a request for a maintenance engineer, might be very interesting for an engineer working with concept development in the early phases of product development. However, if categorized only according to the corporate taxonomy, that piece of knowledge is likely to stay hidden in the 'aftermarket' document archives. In our work in the aerospace domain, we have discussed that the 'context' of a specific engineering activity is constantly emerging. If we, for example, take six relevant context dimensions (product, activity, project, gate, role and discipline) into consideration, we can easily assume that engineers switch roles and projects as time goes by, and that different knowledge is needed at different gates and in different projects, etc. A challenge here is to make sure that just because the context dimensions might have been defined at one point in time, the knowledge attached to a certain context might be highly relevant in other contexts.

If we can assist knowledge workers in contributing to a continuously emerging 'folksonomy' [14], rather than merely adhering to a predefined taxonomy, we should be able to better support the serendipitous discovery of information or knowledge that we would not have discovered by traditional searches in the enterprise knowledge base.

### 4.4 From Lookup to Exploration

While it is always beneficial for knowledge workers to know where to get their facts checked and their questions answered, it is not merely the Wikipedia effect we are striving for when discussing the potential benefits of an Engineering 2.0 approach. We believe that one of the most promising aspects of such technologies is that they can help knowledge workers move beyond known-item searches, fact retrieval and question answering [16]. In the context of product development activities of the kind described earlier, it is highly interesting to assist knowledge workers in more exploratory and investigative activities, which are *"…more concerned with recall (maximizing the number of possibly relevant objects that are retrieved) than precision (minimizing the number of possibly irrelevant objects that are retrieved)."* [16, p.43]

One of our informants working with manufacturing tool development noted how the domains of product development and opportunity management were starting to become increasingly intertwined with the move towards developing 'functions':

*"Earlier, we talked about product properties. Now it is about demands on the result of the product in use. This is needed to sell service-intensive products. We want*

*to acquire the needs, and then be able to translate these into the products and services that need to be created."*

Moving away from the hardware-centric view of product development means that we must give engineers (and other actors throughout the value chain) opportunities for serendipitous knowledge discovery, where they can 'stumble upon' relevant knowledge, where they can browse a wide variety of topics that makes sense to others, and where they can gain a deeper understanding of what knowledge other people find useful and how they choose to deploy that knowledge. When we cannot easily find a match between a well-defined 'need' and a well-defined 'product property', lightweight technologies could help in exploring a wide range of opportunities, from a wide range of perspectives, with very little effort.

### 4.5 From Directional to Intersectional

Sir John Rose, chief executive of Rolls-Royce PLC, talks about how Rolls-Royce outsources and offshores about 75% to its global supply chain, keeping the 25% which are the *"…differentiating elements…the hot end of the engine, the turbines, the compressors and fans and the alloys, and the aerodynamics of how they are made."* [4, p.459] Rose further notes that while companies are becoming increasingly specialized to meet market demands, this specialized knowledge will only address parts of any meaningful business or social challenge, which means that innovation comes from putting specialties together in new and different combinations. [4, p.457]

Johansson [17, p.2] argues that companies need to step into the intersection of fields, disciplines and cultures to combine existing concepts into extraordinary new ideas, which implies that we need to harness the knowledge and intelligence of people who are not 'officially' on the team, who are not 'supposed' to have an opinion, and who are not 'familiar with' the specifics of the particular project. To us, this seems like an excellent pool of resources for innovation, if we can utilize it at a low overhead. At Stanford University's 'd.school', this integration of perspectives is visible in their ambition to create 'T-shaped' people, who *"maintain the depth and focus of a single discipline while adding a 'crossbar' of design thinking that drives the integration of multiple perspectives into solving real problems."* [18] The vertical part of the T represents depth in a particular discipline, and the horizontal part of the T represents a broader 'empathy' when it comes to respecting, valuing and embracing a diverse set of disciplines and perspectives. We believe that Engineering 2.0 is largely about providing lightweight technologies that facilitate the 'empathic discovery' of knowledge in a wide variety of knowledge sources spread across the many boundaries of the VE.

### 4.6 From Teams to Crowds

On the web, how many people that link to a particular page is an indicator of how 'good', 'interesting' or 'useful' that page is, but many corporate intranets do not allow their knowledge workers to create such links between the material they produce.

Since a VE is a highly distributed work environment, there is a problem of achieving critical mass in knowledge creation, sharing and discovery. While the number of knowledge workers in the enterprise might be very high, 'knowing who knows' is more difficult than before due to the fragmentation and distribution of knowledge across the enterprise. As noted before, intersectional innovation means that the notion of 'what a team is' has to be reconsidered. Engineering 2.0 implies that the innovation ecosystem of a VE includes "open and amorphous networks of peers" [19, p.257], where the people who contribute with knowledge might not be a part of the team or even the organization, and where community-developed answers and ideas play a major part. If we consider the characteristics of functional product development in VE:s, we can actually see that some of the challenges of that context, i.e. related to diversity and distribution of knowledge workers, are turned into significant opportunities. To tap into the wisdom of crowds, you should keep social ties loose, keep yourself exposed to as many diverse sources as possible, and participate in groups that range across hierarchies. [20] Engineering 2.0 technologies offer the potential to leverage on *"…spontaneous and decentralized forms of mass collaboration"* [19, p.259] in a self-organized way.

## 5 Conclusions

A crucial point we would like to make here is that we believe that engineering, in the context described in this paper, is moving back and forth between 'problem solving' and 'prediction'. When developing 'functions' that are to be included in total-life cycle commitments, engineers are working with a multitude of actors across the value-chain. They need to, collaboratively, figure out how to approach ill-defined problems, and in cases where it is just not possible to reach an agreeable solution, or even shared understanding about what the problem is, they need to make well-founded predictions about what a solution might look like in the future. In our opinion, 'heavy-weight' PDM or PLM systems undeniably play a strong role in virtual enterprise collaboration, but we believe that their strengths in data and information management need to be complemented by more lightweight knowledge sharing systems that are better equipped to enable an open, bottom-up, collective sense-making approach to knowledge sharing, rather than the somewhat controlled, top-down, management approach to knowledge sharing that is common in current industry practice. Both approaches are needed, but we should be clear that we also should expect highly different results from the two. One of the major problems when it comes to knowledge sharing in the VE is the absence of 'shared assumptions' – about how we do our jobs; who does them; how coordination is done, etc. – and a major benefit of lightweight technologies is that they allow such shared assumptions to develop through folksonomies and other decentralized, bottom-up approaches. Further, if we pay closer attention to what documents, data, photos, and stories *really mean* to people, as opposed to what corporate taxonomies and databases they should be put into, what management thinks is most important at any given time, or what the company's product portfolio has looked like in the past – then we can start exploring the true potential of mass collaboration and peer production in a VE context.

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