How Schlumberger Achieved Networked Information Leadership by Transitioning to a Product-Platform Software Architecture

To sustain its competitive position as the leader in providing information solutions to the oil and gas industry, Schlumberger transitioned to a cutting-edge product-platform software architecture by embedding a leading geological modeling software product—Petrel—within Ocean, its collaborative open software platform. The practices it used to overcome the challenges of the transition give rise to three principles that can be leveraged by other companies.1,2

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“We have realized recently that the oil industry could move a little bit faster in the area of software platform. It’s a big focus for the coming future because the platforms are not open, so applications are not easily interoperable. And if they are not interoperable, then, these kinds of loops can’t be closed very well, and analytics cannot be run in real time as this system requires. So software interoperability and connection are absolutely essential ...”
Ashok Belani, Schlumberger Executive Vice President of Technology, September 2013.3

Genesis of a Product-Platform Software Architecture

Increasing business complexity causes firms to view IT as a means to provide much-needed competitive advantage. As a part of their strategic initiatives, firms try to achieve this by orchestrating the multiple components comprising their IT infrastructures. Among the various IT components, the firm’s software architecture, if appropriately managed, can be a game-changer through which diverse strategic benefits can be derived.

Firms can employ two classes of software architecture solutions. First, they can deploy a software-product architecture, which is generally a model-centric solution, comprising a specialized and often siloed product or solution. Such an architecture generally has a proprietary software product as its vital component, with that product under the control of one

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2 The authors gratefully acknowledge the constructive feedback and support received from the editor-in-chief, Dorothy Leidner, and the senior accepting editor. Shirish C. Srivastava also acknowledges the financial support received from HEC Paris Foundation.
3 “Ashok Belani talks about Managing an Integrated Knowledge Network of Innovation,” available at https://www.youtube.com/watch?v=QMT_U7H4Q.
company or a division of a large company and used for a specified set of services. Second, they can deploy a software-platform architecture, or the data-centric solution, which embraces data-driven logic as opposed to the logic encapsulated in software products. This solution extends collaboration and capitalizes on innovation in terms of new services emerging from an ecosystem and can be situated within or outside the enterprise environment.

To gain a competitive advantage, firms can either use software products or software platforms. Firms competing through software products have tried to gain an advantage through proprietary software products. The downside is that the software provider benefits from the resulting license fees. Such firms have also focused their architectural journeys on moving from single applications (silo stages) to rationalized modular stages. In contrast, a firm using a software platform aims to benefit from network effects by providing users in the platform ecosystem with benefits. The purpose of such firms is to achieve market leadership and hence promote the platform as a de facto industry standard. For example, Intel, Sony and Apple succeeded in building platforms that were able to provide them with significant competitive advantage for sustaining long-term platform leadership.

Firms focusing on software architectures have generally leveraged either software products or software platforms individually for attaining a competitive advantage. However, in today’s competitive world, firms have moved from a product-centric approach to a platform-centric approach, but this approach poses two new challenges for the platform owners: (1) dilution of the owner’s control over the platform in the network; and (2) license revenues going to not only the platform owner but also to contributing members in the platform ecosystem. As a consequence, firms are looking at novel ways for enhancing the functionalities of their software products by combining them with the extended reach offered by a software platform architecture. As Schlumberger’s experience shows, such an orchestrated product-platform software architecture can help firms achieve the competitive advantage needed to succeed in today’s business environment.

The product-platform software architecture as deployed by Schlumberger can be defined as: “an integrated software architecture solution developed through transforming a modular software product by overlaying it with an extensible open platform.”

Very few firms have attempted to amalgamate their model-centric (product) and data-centric (platform) architectures into an integrated software product-platform combination. Moreover, no studies to date have focused on the transition process of amalgamating a leading software product with a competitive software platform while maintaining appropriate control over the resulting networked ecosystem.

This article describes how Schlumberger, the world leader in technology solutions for the oil and gas industry, integrated project management and information solutions for the industry, combined its Petrel software product with the Ocean software platform and thus transitioned to the integrated Petrel-Ocean product-platform software architecture. The resulting breakthrough solution fostered networked information innovation while allowing Schlumberger to retain control over the integrated architecture. Schlumberger’s experience offers valuable principles that companies in other industries can apply when building and leveraging software architectures in the present day digital economy. (The research that this article is based on is described in Appendix 1.)

Schlumberger

History

Schlumberger, initially called Société de Prospection Electrique, was created in 1926 by two brothers, Conrad and Marcel Schlumberger. At first, the company focused on prospecting metal ore but gradually moved to prospecting oil.

Since then, Schlumberger has grown in size and scope through multiple mergers and acquisitions to become a global oil and gas company. From its earliest days, the company leveraged the latest technologies and was always on the lookout for fresh ways of implementing new technologies efficiently for achieving its business objectives. Schlumberger not only emerged as a technological leader in the oil and gas industry but is now also regarded as a knowledge visionary that continuously experiments with the latest advancements in ideas, tools and technologies.

With the growing importance of IT in the oil and gas industry, Schlumberger began investing heavily in the latest IT tools, and in 1985, it deployed the Schlumberger Information Network (SINet), the first commercial Arpanet-based intranet. Since then, IT has been at the forefront of Schlumberger’s competitive initiatives.

Corporate Profile
With a workforce of nearly 126,000 from more than 140 nations, today, Schlumberger operates in over 85 countries. It is the world’s leading provider of oil and gas technologies, integrated project management expertise and information solutions to companies around the globe. Its services and products range from consulting to exploration and production. Consistent with its global reach, Schlumberger’s main offices are located in Paris, Houston and The Hague. Its 2014 revenues from continuing operations were $48.58 billion.

Administratively, the company is divided into the following geographical areas: North America, Latin America, Europe, and Africa, Russia, Middle East and Asia. The administrative regions are further subdivided into 35 geographic market regions that provide local channels of information and knowledge to their clients. These regions also serve as platforms for leveraging the technological synergies between Schlumberger and geoscientists who operate through a global network of 125 research and innovation centers committed to excellence in service delivery, anytime and anywhere.

Corporate Values
The three core values of Schlumberger can be summarized as:

1. Belief in the power of people
2. Innovative use of technology
3. Aspiration for profits with a purpose.

Schlumberger realizes that its multinational workforce is an invaluable asset in terms of its knowledge, skills and competencies. Through a carefully planned HR management strategy, the company has developed a unique common corporate culture that promotes excellence in work and encourages outstanding customer service. Schlumberger realizes that the diversity of its personnel is one of its greatest strengths.

In addition to people, technology is at the heart of Schlumberger’s competitive strategy, and it is committed to innovatively leveraging technology for achieving its objectives. Similar to many other leading companies in different industries, Schlumberger continuously aspires to be the leader in IT-enabled innovation in the oil and gas industry.

In addition to its focus on people and technology, Schlumberger also aspires to have high revenues and profits, which are ploughed back into its developmental and operational activities in a safe and responsible manner. Using generated resources, Schlumberger seeks to grow in an environmentally friendly manner by investing in its ambitious and innovative technology-enabled plans.

Products and Services
Schlumberger offers its clients in the oil and gas industry more than 80 years of expertise and best practices that are coupled with its state-of-the-art technology and high-quality support and services. Most national and international oil companies rely on Schlumberger’s know-how to help them increase their oilfield efficiency, lower their exploration and production costs, and improve their productivity by maximizing reserve recovery to increase their asset value in an environmentally friendly manner.

Some of Schlumberger’s important products and services include:

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Schlumberger also specializes in providing management consulting services within the industry and provides innovative IT tools for enhancing exploration and production operations. Schlumberger’s Software Integrated Solutions (SIS) business unit is dedicated to providing IT-enabled services to the company’s internal and external clients.

The Software Integrated Solutions (SIS) Business Unit
Schlumberger’s SIS business unit provides cutting-edge software technology, information

Table 1: Key Events in Evolving to a Product-Platform Software Architecture

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Petrel</th>
<th>Ocean</th>
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<tbody>
<tr>
<td>1990s</td>
<td>Petrel, a reservoir modeling solution developed by Technoguide, became the leader in the oil and gas industry</td>
<td>• Software Product</td>
<td>• Internal Software Platform</td>
</tr>
<tr>
<td>2002</td>
<td>Schlumberger acquired Technoguide and Petrel</td>
<td>• Software Product</td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td>Ocean software development platform commissioned as a layered extension framework for the Petrel software product</td>
<td>• Open Software Product-Platform Architecture</td>
<td>• Internal Ecosystem</td>
</tr>
<tr>
<td>2006</td>
<td>Petrel-Ocean architecture made available to a limited set of companies and divisions but not commercially available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug 2009</td>
<td>Opening the Petrel-Ocean architecture for use by academia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 2009</td>
<td>Opening the Petrel-Ocean software architecture for developing applications for the oil and gas industry community</td>
<td>• Open Software Product-Platform Architecture</td>
<td>• External Ecosystem</td>
</tr>
<tr>
<td>May 2010</td>
<td>Inauguration of Ocean applications (plugins) store</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Launch of plugin acceptance process</td>
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<tr>
<td>2012</td>
<td>Launch of university competitions around the world</td>
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<tr>
<td>2013</td>
<td>Ocean certified partner program launched</td>
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<tr>
<td>2014 and beyond</td>
<td>Extending and integrating Ocean software platform to other Schlumberger software products, such as Studio, Techlog and Avocet</td>
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Consistent with its core values, Schlumberger relies on technology as one of the key drivers for achieving a competitive advantage. National and international oil companies are continuously seeking new solutions for enhancing oil and gas recovery from their existing reservoirs and also for exploring and accessing additional hydrocarbon reserves. These solutions are complex and require both high-end computational power and a significant knowledge of the oil and gas industry. Moreover, they cannot be achieved without the use of sophisticated geo-sensing tools coupled with specialized software platforms that need to evolve in real time in conjunction with the latest knowledge. SIS provides Schlumberger with the expertise to meet these continuously evolving needs by focusing on developing powerful software products and platforms that are essential to compete in the oil and gas industry.

**Transitioning to a Product-Platform Software Architecture**

In the early 1990s, Petrel (developed by a Norwegian company, Technoguide) became the industry-leading software product for reservoir modeling. In 1999, one of SIS’s key initiatives was the development of a single, company-wide software platform—called Ocean—that focused on standardizing software development across the organization and provided a collaboration platform for improving knowledge flows within the organization. In 2002, to consolidate its position as the leading information solution provider in the oil and gas industry, Schlumberger acquired Technoguide and Petrel. But soon SIS realized there was a need to integrate the evolution of Petrel and Ocean into a single software strategy so it could capitalize on the robust application and services interface architecture offered by Ocean, and the momentum and range of capabilities delivered by Petrel. The subsequent integration process led to the modular and scalable product-platform architecture, where the core geoscience functionality was provided by Petrel and the extensibility application programming interfaces (APIs)\textsuperscript{10} and services were delivered by the Ocean framework.

Initially, the Petrel functionalities were provided to all Schlumberger business units through Ocean, but in 2006, the Ocean framework was made accessible to a limited number of Schlumberger’s external partners. But transitioning from Petrel to the Petrel-Ocean architecture was not a smooth journey. There were multiple challenges that Schlumberger tackled through meticulous planning and by following planned practices.

Table 1 shows the key events in Schlumberger’s journey. It illustrates the transition from a leading software product and a leading software platform to a breakthrough integrated product-platform software architecture.

By 2005, Petrel could be accessed by all Schlumberger staff through the Ocean platform. New Petrel functionalities and APIs could henceforth be developed through internal collaboration using the Ocean platform. At this time, the powerful combination of Petrel and Ocean was only used to enhance the internal development process and decrease delivery time.

In 2006, however, Schlumberger realized that it was unable to deliver all the functionalities that the market requires, primarily because of the context-based complexities and the overwhelmingly large number of requests from other players in the industry. Hence, Schlumberger needed additional context-specific expertise and resources to handle the huge inflow of problems posed. As one of the senior managers involved with the Ocean platform at Schlumberger said:

“In 2006, we recognized that we could not deliver everything that the marketplace and the industry wanted in terms of software by ourselves because the complexity of the problems that needed to be solved was beyond what a single company or a single group or a single person could deliver. We had to recognize this limitation and open up our platform to let other experts deliver functionalities to our products; otherwise

\textsuperscript{10} In the context of software programs, an API specifies how software components should interact with each other.
it would not be the success we wanted to have.”

As a consequence, Schlumberger decided to open and extend the Ocean platform to external software collaborators to foster the development of new functionalities for the growing number of new requests from the market.

During the transition journey, Petrel and Ocean evolved from two independent systems with different architectures to a unique amalgamated ecosystem that ushered in a unique competitive advantage. Following the acquisition of Technoguide and Petrel, Schlumberger had two software engineering teams: the Ocean team located in Austin, Texas, and the Petrel team based in Oslo, Norway. To improve collaboration and synchronization, the Ocean team was relocated to Oslo. However, even though both teams were in the same physical location and reported to the same senior manager, they rarely interacted. Collaboration happened mostly at the requirements level (or product analysis level) and during the testing phase. Although the Ocean development cycle had some agility features, in the beginning, the team was still rolling out big monolithic releases. An example of an agility feature is the 30-minute daily stand-up meetings where everyone had a minute or two to say: “Here is what I am going to do in the next 24 hours.” Because of these discontinuities, the road to creating a new product-platform software architecture was not smooth but was littered with multiple challenges.

The Challenges

Despite the strength of its workforce spread throughout over 85 countries and a network of 125 highly competent research and innovation centers, when Schlumberger opened up the Ocean platform to third parties, it was flooded with a large number of new customer requirements that it could not tackle. SIS had neither adequate personnel nor the necessary context-specific expertise to deliver everything the market was asking for. The increasing numbers of customer requests were potential opportunities for Schlumberger that it was unable to exploit because it did not have the necessary skills and expertise. Schlumberger thus had two options: either to restrict the number of solutions offered based on the available internal resources or to seek ways of expanding its resource base by permitting external collaborators to provide solutions through the Ocean platform. In line with its core value of providing maximum service to its customers, Schlumberger decided to open up the Petrel software through the layered Ocean platform to broaden the information innovation network with a view to maximizing customer satisfaction. To achieve this, four challenges had to be overcome. The first related to fostering global innovation and knowledge sourcing as SIS needed capabilities beyond its capacity. The second was to secure the platform to prevent leakage of Schlumberger’s core knowledge. The third concerned regulating and orchestrating the contributors’ network. And the last challenge was to maintain and ensure high quality standards.

Challenge 1: Fostering Innovation and Knowledge Sourcing

The first challenge that Schlumberger faced was to foster sourcing and innovation of competitive expertise not only from its numerous development centers spread around the world but also from outside the company. This meant encouraging contributors by providing them with systemic incentives for contributing to the emerging functionalities and modules (plugins). To capture the value from opening up the Ocean platform, Schlumberger also needed to provide appropriate value to the external contributors. This was a typical case of a two-sided network effect, where the number of external contributors using the platform would serve to reinforce the numbers of additional contributors. Another aspect of knowledge sourcing was related to integration with other systems. How should Petrel exchange information with other platforms to foster innovation?

Challenge 2: Securing Core Knowledge while Ensuring Platform Robustness

The second challenge was to prevent leakage of Schlumberger’s core knowledge embedded within its systems. An industry-wide software platform is not under the full control of the owner. Hence, the challenge was to extend the

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Another inherent challenge was to ensure robustness, which implied that the platform should cope with the ever-growing number of users and simultaneously support the growing number of plugins that may be coded in a variety of programming languages.

**Challenge 3: Regulating the Contributors’ Network**

The third challenge related to the regulation and governance of the emergent knowledge resources. This is especially tricky when the software platform is provided by Schlumberger and the expertise is provided by external contributors. The dilemma that needs to be managed is who owns the generated knowledge? How are the revenues accruing from a particular application (plugin) apportioned between the external contributors and Schlumberger?
Moreover, there can be a situation where the value of a plugin provided by an external contributor overshadows the value offered by the Ocean platform. If a direct competitor to Schlumberger acquires the software company producing such a plugin with a view to gaining control over the plugin, then how should the situation be managed by Schlumberger?

**Challenge 4: Ensuring an Adequate Quantity of High-Quality Contributions**

The final challenge of opening up Ocean concerned the need to assure its users that there would be an adequate quantity of high-quality solutions—plugins made available through the Ocean store. On the one hand, the quality of all new plugins should be checked to ensure their reliability, yet on the other hand, a sufficient number of plugins should be made available on the Ocean platform to ensure that users get the solutions they need and that contributors have an incentive to contribute to the platform. Another aspect of the quality of plugins relates to user support and maintenance. Contributors and partners who embark on a plugin development project need to be trustworthy. They should be responsible for providing the necessary maintenance and support to the end customers. In particular, they should have the capability to provide upgrades to their plugins with every new release of Petrel.

**The Seven Practices and the Three Principles**

Through a systematic analysis of the data generated through interviews and secondary sources, we have identified the seven practices that Schlumberger followed to address the four challenges described above (see Figure 1). Further, from the seven practices, we distilled the three principles that this study offers to firms aspiring to foster innovation by implementing open product-platforms software architectures.

We describe each of the seven practices and the challenges they address by referencing specific instances from the Schlumberger case. Finally, by synthesizing and combining two or more practices, we distil the three principles from this case study that can be used as the point of departure for firms contemplating managing information innovation by opening up their software platforms.

**Practice 1: Identify a Modular Software Product that can be Overlaid with a Scalable Software Platform**

SIS empowered Schlumberger with a leading software product—Petrel—and a powerful software platform—Ocean. Despite their strong potentials, both Petrel and Ocean were individually limited in their functionalities and reach. Petrel was primarily a siloed reservoir modeling application while Ocean was a powerful platform that could support and foster innovation through collaboration across Schlumberger business units. To provide enhanced capabilities and functionalities, Schlumberger integrated Petrel with the Ocean platform so that, together, they can help scale up Schlumberger's innovation capabilities.

On the one hand, Schlumberger's needed to foster external collaboration in addition to internal collaboration by opening up its Ocean software platform to a global network of innovators. On the other hand, Schlumberger also needed to augment the functionalities of the newly acquired Petrel software product by embedding new modules in it. Hence the integrated product-platform architecture needed to provide the functional modularity of Petrel and the volume scalability of the Ocean platform.

**Functional Modularity of Petrel.** Petrel is a specialized and siloed software product based on a model-centric architecture. When Schlumberger acquired Petrel, it was the leading solution for reservoir modeling, but its functionalities were not sufficient to meet the ever-changing requirements of Schlumberger's clients. Over time, clients became interested in additional features and new modules that needed to be suitably incorporated into the Petrel functionalities. A client from an international oil company noted:

"Petrel out-of-the box would not work efficiently for a major IOC. They require extensibility to create their own advantage by developing their own intellectual property or purchasing custom-made modules developed by third parties."
Thus Petrel needed to be upgraded so that additional functionality could embrace both the backend and the frontend without either disrupting current operations or irritating the users. Petrel has been a crucial tool for Schlumberger and its numerous clients; SIS could not have afforded to interrupt Petrel’s operation to make the required changes. Hence, despite the ongoing structural changes to the software architecture, SIS had to avoid disrupting the user experience with Petrel. For example, it realized that even slightly altering the graphical user interface would require fresh training, new documentation, change management and, of course, frustration to users, who generally have low tolerance for operational changes. Schlumberger thus chose to implement the required architectural and system changes incrementally, with no disruption of the user experience. It was not until 2014, 12 years after acquiring Petrel, that SIS decided to revamp the user interface.

**Volume Scalability of the Ocean Platform.** The Ocean architecture, which in contrast to Petrel is data-centric, is intended to work or integrate with any type of siloed software product so it can permit and foster collaboration through an extended ecosystem. Before Schlumberger decided to open it to the external ecosystem, the *raison d’être* of Ocean was mainly to nurture collaboration and innovation within Schlumberger. But once it was opened up, it was like any another open platform that had to compete with the existing systems in place. Hence, it was imperative that Ocean provided a clear competitive advantage to Schlumberger in

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Figure 2: Modular Petrel Domains Enabled through the Scalability of Ocean
the marketplace. SIS achieved this by integrating Petrel with Ocean so that Ocean could become the de facto industry leader that surpassed customer expectations.

Two international oil company managers highlighted the value of the Ocean software platform strategy:

“The Ocean strategy and philosophy of openness, extensibility, quality and footprint were critical in the decision-making process to standardize on the Petrel solution, mainly to counter fears of a lock-in to Big Blue.”

“Open extensibility is required if they [Schlumberger] are going to standardize on any commercial software.”

Petrel was originally written in the C and C++ object-oriented languages, which were state of the art at the time. Ocean, however, originated much later and was developed using the .NET framework. To avoid any disruptions, SIS continued using C and C++ for new Petrel plugins until 2009. Post 2009, all new Petrel plugins were developed using .NET and the C Sharp (C#) programming language to facilitate compatibility with Ocean. The decision to evolve from C++ to .NET was purely technical. In summary the final integration of Petrel and Ocean to create a product-platform software architecture brought in the functional modularity from Petrel and the volume scalability from Ocean.

Practice 2: Create a Product-Platform Software Architecture by Integrating the Identified Software Product and Platform

To be forward looking and growth oriented, an industry-wide product-platform software architecture needs to be scalable and modular. Schlumberger’s Petrel-Ocean platform was designed to support growth not only in the number of users and contributors but also in the new functional domains that can be added to meet emerging requirements. Soon after the Ocean platform was overlaid on the existing Petrel functionalities, Schlumberger started adding new domains to Petrel to meet growing user requirements. This was possible only because such a scalable extension was planned during the initial design phase. Since Ocean was deployed as a layered extension framework for Petrel, 22 new domains have been added (see Figure 2). This growth would not have been sustainable with the original architecture and was enabled by the functional modularity of the product (Petrel) and the volume scalability of the platform (Ocean). The new Petrel domains are described in Appendix 2.

While discussing the modular and scalable aspects of the Petrel-Ocean architecture, one of Schlumberger’s managers commented:

“Petrel was initially designed to do only one thing—geological modeling—but it grew to do many other things.”

In Schlumberger, this second practice (creating a scalable and modular architecture) primarily addressed the first challenge, of fostering innovation through the addition of new domains, and the second challenge, of ensuring platform robustness when adding new domains (plugins) that may not necessarily use the same coding languages or have similar structures. Augmenting functionality by adding new plugins or providing access to new users and contributors requires a robust system that does not crash under increased workloads.

The innovative product-platform software architecture was essential to orchestrate idea generation and plugin development within the ecosystem while maintaining control over the emerging system. The architectural transformation needed to be done incrementally and seamlessly without disturbing the ongoing operations. As succinctly described by a Schlumberger manager:

“This transition created a situation similar to fixing the engine of a flying plane.”

Restructuring both the Petrel and Ocean architectures was essential to provide access to a global ecosystem, which is the key to fostering innovation by sharing knowledge resources across the internal and external contributors. Internally, knowledge within Schlumberger is distributed across 14 development centers spread throughout the world. A common platform was required for sourcing knowledge from these
internal contributors to develop new plugins. Similarly, sourcing knowledge resources from external contributors required an extensible framework. Overlaying Petrel with the Ocean platform served both these requirements for fostering innovation and knowledge sourcing from multiple partners across the globe. Ocean extended the boundaries of Schlumberger to embrace developments from any software producer in the oil and gas industry, software development companies and academia.

Furthermore, because the Ocean platform was owned by Schlumberger, it prevented the company’s core knowledge from leaking out. It also provided Schlumberger with the freedom to effectively manage the platform, thereby offering a robust and consistent interface to its partners collaborating in the innovation process. Thus the practice of creating a scalable and modular product-platform software architecture contributed not only to overcoming the first challenge of reaching internal and external resources to foster global innovation, but also addressed the second challenge of providing a robust interface and protecting the company’s core knowledge.

Finally, it’s important to note that neither Petrel nor Ocean alone would have achieved the proven success of the integrated platform.

In summary, in today’s economy and ever-interconnected world, a company cannot attain software platform leadership without opening up its platform to the internal and external ecosystems. Further, a modular and scalable architecture is a prerequisite for reaching and extending the network of innovators. By synthesizing and combining the first two practices followed by Schlumberger, we arrive at the first principle:

**Practice 3: Extend the Platform Knowledge Ecosystem by Fostering Partnerships and Alliances**

A software platform is a necessary, but not sufficient, condition for facilitating innovation and knowledge sourcing. The platform owner must also make efforts to extend the network by encouraging external partners and contributors to join the ecosystem. When Ocean became the extensibility framework of Petrel in 2006, it expanded the internal network from the SIS business unit to all parts of Schlumberger. Subsequently, the innovative Ocean-Petrel software platform was opened up to the external ecosystem of contributors and users. This external expansion began with collaboration with academia before extending the network to external software developers and then to the entire oil and gas industry community. Schlumberger’s knowledge sourcing thus became open and global. Innovators and contributors in the ecosystem comprised not only internal Schlumberger employees but also academic contributors.

**Figure 3: Evolution of the Number of Contributors**

![Figure 3: Evolution of the Number of Contributors](chart1.png)

**Figure 4: Evolution of the Number of Development Centers**

![Figure 4: Evolution of the Number of Development Centers](chart2.png)
institutions, software companies and the entire gamut of the oil and gas industry. Figures 3 and 4 illustrate respectively the evolution in terms of Ocean ecosystem users and development centers from 2006 to 2013.

To encourage use of the Ocean platform by multiple contributors and users, Schlumberger introduced different types of licenses to accommodate a variety of user requirements. The type of license depended on the needs of target user segments and differed in terms of pricing and control—ranging from full pricing to free access with commensurate control over the products. The paid licenses were generally for software developers and other companies that might be interested in producing plugins and marketing them with or without using the Ocean store. The revenues were apportioned between external partners and Schlumberger depending on their involvement with and use of the Ocean platform. The free license option was limited to academic institutions; the license allowed them to use the Ocean platform for research and development purposes. The main purpose of the free licenses was to attract the cutting-edge knowledge, skills and competencies that are essential for sustaining a knowledge-based platform.

Through this third practice, Schlumberger addressed the first challenge of attracting innovation and knowledge resources by providing incentives to external partners and academic institutions. Even small software companies were encouraged to develop plugins on the Ocean platform. Furthermore, to address the fourth challenge, of ensuring an adequate quantity of high-quality plugins, Schlumberger introduced a certified partner program.\(^{12}\) The rationale for the program is to identify partners that have a good record of reliability, trust and quality and then to help the ecosystem, especially customers, find potential certified partners that have the necessary competencies to develop plugins for them. Certified partners are encouraged through training and software discounts, Ocean certified partner meetings, annual webinars, help in business planning, and exhibitor and sales engagement opportunities. Schlumberger cannot, and sometimes does not want to, develop all requested plugins. Certifying partners helps source knowledge and extends Schlumberger’s global network of innovators.

In summary, as indicated in Figure 1, this third practice is used by Schlumberger to address Challenges 1 and 4.

**Practice 4: Enhance the Architecture Functionalities by Incorporating Diverse Internal and External Products and Platforms**

Schlumberger realized early on that attaining platform leadership required the platform to be used by many contributors and users so as to leverage the network effects. But different information ecosystems use different software products and platforms. Moreover, ecosystems are not limited to people from the industry, software companies and academia, but also include the different software systems, products and platforms, which all needed to be integrated with Schlumberger’s Ocean platform if the desired objectives were to be attained. For the integration initiative, SIS distinguished between the internal systems within Schlumberger’s business units and external systems spread across Schlumberger’s partners.

To ensure the security of its core, SIS does not actively seek out external software products and platforms to integrate into its platform. Instead, it provides an extensibility framework through Ocean that permits others to integrate with Petrel. Moreover, the platform design enables others to produce plugins that integrate with Petrel data accessed through a communication protocol. As one of Schlumberger’s managers highlighted:

“We don’t integrate with other platforms explicitly; we let other products integrate with our platforms through our extensibility framework.”

For internal integration within Schlumberger, SIS is working on extending the Ocean-Petrel platform to its other software suites—namely, Techlog and Avocet.\(^ {13}\) The company has started integrating Petrel, Techlog and Avocet through the Ocean extensibility framework, as illustrated in Figure 5.

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\(^{13}\) A summary of Techlog and Avocet platforms is available at [http://www.software.slb.com/products/Pages/default.aspx](http://www.software.slb.com/products/Pages/default.aspx).
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Figure 5: Integrated Software Products within Schlumberger through Ocean

Images courtesy Schlumberger

Through this fourth practice, Schlumberger is not only able to source innovative knowledge from within and outside the company but is also able to secure the access to Petrel through the Ocean extensibility framework. The integration and intersection of Petrel, Avocet and Techlog has resulted in the Studio knowledge environment (shown on the right of Figure 5). Studio enables all internal professionals to access the available information, collaborate with colleagues and share knowledge for innovation. Studio empowers a new level of usability and productivity that streamlines and optimizes workflow across the asset lifecycle while also capturing vital knowledge to maximize personal and team productivity. Further, through a systematic distribution of permissions based on the licensing schemes, Schlumberger can also regulate the contributors’ network. Thus, this fourth practice helps to overcome the first, second and third challenges listed in Figure 1.

In summary, after developing an extensibility platform, a company should focus on nurturing resource sourcing by opening its platform to external partners. This can be done through the first two practices described earlier. The third practice concerns connecting with and motivating people, while the fourth emphasizes the importance of integrating, maintaining and expanding the systems and platform network. Thus, after establishing a robust, modular and extendable architecture, companies aspiring to software platform leadership can start opening the platform to the external ecosystem by first extending their partnerships and alliances and second, by integrating with various solutions and systems. By doing this, they will nurture and extend resource sharing, which was initiated by following Practices 1 and 2. Thus, by synthesizing and combining Practices 3 and 4 followed by Schlumberger, we arrive at the second principle:

**Principle 2: Nurture Resource Sourcing by Opening the Platform**

**Practice 5: Establish Governance Processes for Ensuring Quality and Timeliness of Architecture Functionalities**

After facilitating resource sourcing and nurturing it, the next set of requirements for Schlumberger concerned maintaining adequate control over the knowledge resources and their efficient delivery. Ocean offers an extended set of APIs, which developers can use to create new
plugins for specific business or commercial needs. To ensure adequate quality of the plugins made available through the Ocean store, Schlumberger specifies a series of acceptance tests for both internal and external contributors. While running these tests, a newly created plugin is treated as a black box, and the evaluation process is mainly concerned with the functionality and the utility of the plugin, not with the code or architecture used. The rules for the tests assure the quality of the plugins finally incorporated within the Petrel framework and made available through the Ocean store. In addition to the utility and functionality tests, quality validation for plugins covers library compatibility, absence of malware and compliance with SIS user-interface guidelines. In summary, a contributor developing a new plugin for the Ocean store needs to go through the following five steps:

1. Acquire a Petrel license to develop the plugin
2. Reserve a product name in conformance with SIS guidelines
3. Develop the plugin, which then goes through the quality assurance cycle
4. Provide a testing data set along with images and videos in a given format
5. Go through the quality approval and acceptance testing mechanism, which covers functional tests, naming conventions, library use, crashes, colors, look and feel, and scans for malware.

A new plugin can be released at any time and can be incorporated into the latest Petrel version. A major version of Petrel is released every year around June/July and includes any changes to the underlying infrastructure. Incorporating a new functional domain (see Practice 2) would most likely, but not always, wait for a major release. Minor releases, on the other hand, are scheduled every two months. They usually include bug fixes and minor enhancements, and have no impact on the data model.

Note that there is no fundamental difference between the validation process for internal and external developers. All Schlumberger’s internally developed plugins always go through the standard software development processes and quality assurance adopted by the engineering team. The same acceptance and quality criteria are applied for internally and externally developed plugins.

The only difference in the process is with respect to a major release of the Petrel software: all plugin developers should provide an upgrade of their product compatible with the new release. For plugins developed within SIS, upgrades should be released at the same time as the new release of Petrel and within 30 days for plugins developed by other Schlumberger business units. External developers have 60 days to upgrade their plugins following a new release of Petrel. If a plugin developed internally by Schlumberger is not upgraded on time, the issue is escalated internally, and a task force is put in place to remedy the problem. If an external partner does not update a plugin within 60 days, this can be considered as a breach of the agreement and might lead to cancellation of the license.

As of January 2015, there were 33 different active groups of contributors who have contributed 131 plugins available in the Ocean store. Moreover, as can be seen from Table 2, there are more external contributors than internal ones.

Table 2: Distribution of Internal and External Contributors of Plugins Available in the Ocean Store

<table>
<thead>
<tr>
<th>Ocean Store Plugin Contributors</th>
<th>Number of Players</th>
<th>Number of Plugins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schlumberger SIS business unit</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Other Schlumberger business units</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>External contributors</td>
<td>26</td>
<td>71</td>
</tr>
</tbody>
</table>

The external network of innovators, comprising players from the oil and gas industry, software developers and academia, has contributed more to the creation of new commercially and publicly available plugins than the entire Schlumberger enterprise. But Schlumberger realized early on that fruitful participation from external players is possible only if there are adequate controls, especially in terms of quality and delivery.

This fifth practice used by Schlumberger helps to address the challenge of regulating the
How Schlumberger Achieved Networked Information Leadership by Transitioning to a Product-Platform Software Architecture

contributors’ network while simultaneously ensuring there is an adequate supply of appropriate quality. Thus, Practice 5 addresses Challenges 3 and 4 by ensuring proper governance necessary for managing the growing ecosystem.

Practice 6: Orchestrate Solution Development and Distribution through Unconventional Channel Partners

Involving internal and external development partners is just the beginning of a successful software platform. For reaping the full benefits, the solutions produced need to reach all who may need to use them. Realizing the importance of not only developing but also distributing their knowledge-intensive products and solutions, Schlumberger sought to leverage unconventional channel partners. In addition to conventional channel partners and selling plugins through its own Ocean store, Schlumberger actively involved academia as channel partners.

This academic involvement started quite early when the “Ocean for Academia” program was launched in 2009. This program is now part of the new “Ocean Partner Program” and all the certified partner benefits are available to partner universities and academic institutions. The objective of this initiative is to involve the best academic talent in the development of plugins. Moreover, the academic developers may later become licensed partners. Though academic institutions cannot sell their products through the Ocean store, their expertise can certainly be usefully leveraged in marketing the products. Reiterating his commitment for this unconventional channel partner and speaking about the Ocean for Academia program, Meyer Bengio, Schlumberger SIS Vice President Petroleum Engineering, commented:

“This initiative makes Petrel and Ocean software and the essential associated training available to universities’ earth and computer sciences departments.”

This Ocean Partner Program is a part of a broader initiative to reach local communities and governments. Commenting on this, one of the Schlumberger SIS managers said:

“It is a part of the Schlumberger culture and ethic to contribute to the local development of the countries where we operate.”

Schlumberger supports governments by sponsoring their universities and academic institutions. The independent and unbiased research generated at academic institutions can inform governments on oil- and gas-related issues and assist them in making major policy decisions. Moreover, academic sponsorship is viewed as generating long-term economic benefits for Schlumberger by leveraging the trained student pool that can in the future provide the much required talent for the company. For the students, working on a leading industry platform and experience of working on Petrel and Ocean improves their employability.

For example, in 2011, Schlumberger donated Petrel to the engineering department of the King Abdulaziz University in Saudi Arabia, not only to have access to the student talent pool but also to help the local community, which in turn can assist in Schlumberger’s development and distribution efforts. Speaking about this, one of SIS’s local managers said:

“We believe that sustainable development can be best accomplished with the partnership between theoretical education and professional training. We look forward to working closely with the universities and students here to help them acquire experience and develop their capabilities for the benefit of the industry in Saudi Arabia.”

In addition to the learning experience, the community of small software companies and universities can use the Ocean store to market their innovative plugins. Without the Ocean platform, oil companies would not have access to this unexploited talent pool. By involving academic institutions as channel partners, Schlumberger is fostering the sourcing of

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knowledge resources while simultaneously accessing an independent audit of the quality of its plugins by the unbiased academic community. Thus, this sixth practice of investing in students who are future innovators and knowledge providers is helping Schlumberger to overcome Challenges 1 and 4 listed in Figure 1.

**Practice 7: Coordinate Sustained Growth through Communication to Diverse Target Audiences at Multiple Events**

Involving industry players, software developers and academia marked the beginning of Schlumberger’s ambitious Ocean platform program. One of its major challenges continues to be sustaining the interest of those already involved and simultaneously attracting new contributors and users. Schlumberger realizes the importance of leveraging network effects for sustaining a software platform like Ocean. To achieve this objective, usage of the Ocean platform needs to grow in a sustainable manner until Schlumberger attains platform leadership. With this end in view, Schlumberger proactively communicates information about the Ocean platform and Petrel at various software platform events—some of which are exclusively Schlumberger-sponsored events.

The five main communication channels and events through which Schlumberger sustains growth of its ecosystem are:

1. **Ocean website.** The website (www.ocean.slb.com) is the main source of information about the Ocean ecosystem. Information related to all platform events is updated regularly and can be accessed through the website. The website provides access to the Ocean store, which stocks and displays all tested and available plugins that a customer can purchase and use.

2. **User Group Meetings.** Two main user group meetings are organized by Schlumberger every year, one in the Americas, the other in Europe. The main objective of these meetings is to bring together developers, users, industry and academia. The user group meetings foster networking, knowledge sharing and the diffusion of competence. Participants share experiences and jointly collaborate in the workshops. New developments and initiatives are also presented. These activities foster closer collaboration between developers and users, thereby creating a win-win-win situation for developers, users and Schlumberger. Overall, the meetings help to enrich the Ocean platform.

3. **Ocean Plugin Academic Competitions.** Students are invited to design and develop a fully functional plugin. They have to work through an academic institution with a valid license. At the end of the competition, the winning students present their work to representatives of Schlumberger and peers, and are awarded a prize. This initiative began with an event in India but has now expanded to Brazil, Colombia, Malaysia, North America, Mexico and West Africa. To further attract young talent, Ocean for Petrel was introduced recently in two high schools in Texas.

4. **Local Industry Events.** Schlumberger actively participates in local industry events such as local accelerator events, innovation tanks and incubators. Oslo, Houston, Colombia and other cities have hosted such events in the past. Again, these events foster a closer interaction between the industry and Schlumberger.

5. **Participating in International Societies’ Events.** Schlumberger also actively participates in major oil and gas society events such as the European Association of Geological Exploration, the Society of Exploration Geophysicists, the American Association of Petroleum Geologists and the Society of Petroleum Engineers, with the aim of forging institutional relationships.

In summary, this seventh practice used by Schlumberger is targeted at attracting development talent and contributors to the Ocean platform. The practice ensures an adequate quantity of the required knowledge needed to maintain a good supply of quality products and plugins made available through the Ocean platform. Thus, this practice addresses Challenges 1 and 4 shown in Figure 1. Schlumberger is investing time and money in creating a global community of contributors who collaborate and innovate through the Ocean platform.

In conclusion, Practices 5, 6 and 7 used by Schlumberger are related to governance, control and growth of the collaboration among ecosystem developers and users. Specifically, Practice 5 is aimed at putting a qualititative platform governance structure in place, Practice 6 is about the development and distribution of solutions through unconventional channel partners such
as academia, and Practice 7 is about leveraging multiple events and communication channels to sustain growth. Thus, after developing an extensible platform where the sourcing of knowledge is nurtured, it is essential that the knowledge resources are used in a controlled manner to produce useful plugins that are distributed in a judicious manner. Further, to become a software platform leader, a company needs to plan for the growth of users and contributors to leverage the network effect. By synthesizing and combining these last three practices, we arrive at the third principle:

**Principle 3: Foster Control with Collaborative Growth**

### Lessons Learned

The seven practices followed by Schlumberger enabled it to successfully transition from a software product—Petrel—and a software platform—Ocean—to a product-platform software architecture. This architecture provided an extensibility framework to the Petrel functionality for fostering networked information innovation through the involvement of internal as well as external partners. Synthesizing Schlumberger’s practices, we have derived the three principles emerging from this study, which can be used to inform similar future implementations. The seven practices along with the three principles are comprehensively presented in Figure 6, which summarizes the key lessons from this Schlumberger case study.

### Concluding Comments

This article has described how Schlumberger reformulated its information and software innovation strategy by opening up its product-platform software architecture to a new set of internal and external contributors. This open information innovation strategy dynamically evolved with the software strategy as Schlumberger transitioned from a closed software product—Petrel—to an open collaboration.

Figure 6: Seven Practices and Three Principles to Achieve a Product-Platform Software Architecture
system enabled by overlaying Petrel with the Ocean software platform. The combination of Petrel and Ocean created a modular and scalable software platform, or an integrated product-platform software architecture, which provided Schlumberger with a competitive edge in the oil and gas industry. Through a carefully planned software evolution strategy intertwined with an open innovation philosophy, Schlumberger was able to expand the flexible functionalities of Petrel and provide them to a wide range of contributors from the industry and academia through the Ocean platform.

The seven practices used by Schlumberger and the three key principles we have distilled from them can be used as the departure point for companies either transitioning from independent software product and software platform architectures to an integrated product-platform architecture or aspiring to be product-platform software architecture leaders for facilitating open innovation. The success of Schlumberger’s approach can be gauged by the fact that it is now investing resources to replicate its software strategy for its other major software products, such as Techlog, Studio and Avocet.

Appendix 1: Research Method

To identify the practices that Schlumberger used to overcome the challenges in transitioning to its Petrel-Ocean product-platform software architecture, we examined various sources of secondary information, such as company reports, externally available sources and articles that featured this implementation. These sources covered a period of 16 years, from 1999-2015. In addition, we interviewed Schlumberger managers from SIS and other business units, and talked with some of the software development firms that have contributed applications to the Ocean platform. A total of 21 structured interviews, lasting 18.5 hours, were conducted between September 2013 and January 2015. To provide a holistic perspective, one of the co-authors participated in 2014 in the 76th European Association of Geoscientists and Engineers Conference and Exhibition, and the Ninth International Schlumberger Ocean User Group Meeting. We analyzed the interview material and the secondary information to identify the emergent themes and practices described in this article.

Appendix 2: Description of Software Domains Added to the Basic Petrel Functionality

Petrel started in 2002 as a Geographical Modeling Domain Software and since then has grown to include more than 20 domains. Today, the oil and gas industry trusts Petrel in numerous domains as shown in Figure 2 and described below:

- **Geology**: Functionality to interpret geological data (including logs) and model geological settings to better understand the structure and the physical properties of the subsurface.
- **Geophysics**: Functionality to interpret geophysical data (seismic and others) to better understand the structure and the physical properties of the subsurface.
- **Reservoir Engineering**: Functionality to build subsurface models and generate accurate reserve estimates and detailed fluid flow models.
- **Real Time**: Functionality to manage and consume data generated and transmitted in real time.
- **Structural Modeling**: Functionality to build structural models and volumetric models.
- **Next Generation Reservoir Simulator**: Functionality to prepare models and data to be fed to the Schlumberger next-generation reservoir simulator.
- **Seismic Well Tie**: Functionality to interpret and model alignment of well data and seismic data.
- **Fault Analysis**: Functionality to perform detailed analysis of fault planes and fault data.
- **Production**: Functionality to manage, interpret, monitor and forecast production data.
- **Production II**: Upgraded functionality similar in essence to Production described
above, but more oriented to production engineers.

- **Reservoir Seismic**: Functionality to define the reservoir structure and properties and build models of the subsurface using seismic data.

- **Seismic Processing**: Functionality that integrates with the Omega Seismic Processing System.

- **Drilling**: Functionality to model, design, plan and monitor the drilling process.

- **Geomechanics**: Functionality to model the geomechanical properties of a reservoir or overburden.

- **Developer Tools**: Functionality to aid the developer by providing convenience APIs and tight integration with the development tools (Visual Studio).

- **User Experience**: Functionality to customize the user interface in the context of the new user experience available in the 2014 version of Petrel.

- **Well Section**: Functionality to build well cross sections and interpret formation tops.

- **Data Analysis**: Functionality to gather, display, analyze and modify different types of data through custom charts, cross-plots and other visualization tools.

- **Mocking Framework**: Functionality to aid the developer in creating lightweight data objects for convenience and development productivity.

- **Depositional Space Grid**: Functionality to model, interpret and calculate properties in depositional space.

- **Unconventionals**: Functionality to analyze, interpret and model unconventional reservoirs.

- **Studio**: Functionality to manage the large variety of data that is imported, created and used within the applications, including searching mechanisms and indexing schemes for repository systems.

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