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Exploring the Digital Supply Chain: Implications and Models for Online Software Distribution

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Abstract
As a discipline, supply chain management (SCM) has traditionally been primarily concerned with the procurement, processing, movement and sale of physical goods. However an important class of products has emerged - digital products - which cannot be described as physical as they do not obey commonly understood physical laws. They do not possess mass or volume, and they require no energy in their manufacture or distribution. With the Internet, they can be distributed at speeds unimaginable in the physical world, and every copy produced is a 100% perfect duplicate of the original version. Furthermore, the ease with which digital products can be replicated has few analogues in the physical world.

This paper assesses the effect of non-physicality on one such product – software – in relation to the practice of SCM. It explores the challenges that arise when managing the software supply chain and how practitioners are addressing these challenges. Using a two-pronged exploratory approach that examines the literature around software management as well as direct interviews with software distribution practitioners, a number of key challenges associated with software supply chains are uncovered, along with responses to these challenges.

This paper proposes a new model for software supply chains that takes into account the non-physicality of the product being delivered. Central to this model is the replacement of physical flows with flows of intellectual property, the growing importance of innovation over duplication and the increased centrality of the customer in the entire process. Hybrid physical / digital supply chains are discussed and a framework for practitioners concerned with software supply chains is presented.

Introduction
SCM remains deeply rooted in concepts of logistics, as both are often assumed to involve the sourcing, manufacturing, assembly, warehousing and distribution of *physical goods* (Lummus et al, 2001). Physical goods are so defined because they obey physical laws. They possess mass and occupy volume. Over time, they can break down and degrade. It is not possible to create products without first sourcing appropriate materials. Energy (which also needs to be sourced) is expended in transformation and transportation. It could be said, therefore, that a large proportion of SCM has to do with overcoming the constraints imposed by physics on the products under consideration.

With the rise of information technology (IT) and more recently the Internet, however, not all products nowadays can be considered *physical* in the traditional sense of the word. An increasingly important class of products, described variously as digital products, virtual goods or information goods (Shapiro, 1999) has emerged that cannot be considered physical in the traditional sense of the word. Software is one such good.

Characteristics of non-physical products

Andrew Whinston et al., in their book *The Economics of Electronic Commerce* (1997), lay down a few properties of digital goods:

- Indestructibility (the tendency of a digital product to maintain its form ad-infinitum);
- Transmutability (the ease by which a digital product can be modified); and
- Reproducibility (the ease by which digital products can be reproduced, stored and transferred).

From an SCM perspective it is this property of reproducibility in particular that makes digital products so different from physical products. This property has huge consequences so long as there is sufficient storage and bandwidth available to copy, move and transport product (an increasingly valid assumption – see Eldering (1999) and Grochowski (2003)). No raw materials or energy need to be sourced or used up in the process. Replication is instantaneous and need not happen in a location controlled by the producer (i.e. a manufacturing facility). Combined with the free distribution afforded by the Internet, transportation is free and practically instantaneous (bandwidth issues not withstanding). No inventories therefore need to be built up or sales forecasts derived to ensure adequate supply in an efficient manner.

Economists refer to digital products as having an almost zero marginal cost (Shapiro 1999, Whinston 1997). In other words, once the first-copy of software has been developed, the costs involved in creating and disseminating the second (and further copies) can be practically zero. Even when software is distributed physically, marginal costs for software are typically tiny. Hoch (2000), for instance, compared the price for the first copy of Microsoft Windows 95 ($1bn.) to the cost of the second copy ($3). Nowadays, with digital distribution, even this paltry amount would be considered very high.

This ease of replication combined with the "out of control copy-machine" of the Internet (Shapiro, 1999) creates a situation where software, like any digital product, is an abundant good, as opposed to physical products which are typically in scarce supply (Anderson, 2006). Once a copy of software is put up on the Web it is potentially available for download or use by everyone who wishes to use it, at all times and in any location they wish to use it. Furthermore it can be downloaded as many times as the user wishes[1].

Challenges for software companies

The non-physicality of software, while creating huge apparent advantages for companies (i.e. creating a product that requires no investment in manufacturing and warehousing, and where transmission costs are low), has also created significant challenges.

Bandwidth

Bandwidth constraints remain very significant when distributing digital products. Some software products are very large, occupying many gigabytes of disk space. Even high-speed DSL lines may be inadequate as a means of distributing such a large amount of content. The choice of Internet provider is crucial in ensuring high-speed service (Chaffey, 2007). Multiple web-servers are used, balanced equally so that the most traffic can be processed at peak times. In addition, providers closer to the Internet backbone are more likely to provide a better service, however this comes at a higher cost. Partnering with external companies, such as Akamai and Sandpiper, are viable means of addressing bandwidth issues.

The effect of zero marginal costs on price.

While zero marginal cost is a boon from the direct cost standpoint, it also means that market forces will continually act to reduce the price to zero, thus putting pressure on profit margins (Messerschmitt and Szyperski, 2003). Software companies are continually challenged to differentiate their software from competitors.

[1] Companies attempt to limit this property by implementing copy-protection, but it is important to realise that copy-protection is not a natural feature of digital products – it has to be built in as an add-on to enable it to work.

Competition from low-cost producers

Significant costs are incurred in the production of the first software product, however new business models employing the use of low cost and even free programming talent, have served to reduce these costs greatly. Open source software, the most prominent of these models, employs free software expertise in the production of very competitive products[2]. This serves to push commercial software prices down, challenging incumbents to experiment with new means of generating revenue. In the case of open source, companies make profits from related or complementary activities such as software services or hardware. Red Hat, a software service company, generates healthy revenues from support and consultancy relating to its core software product (Linux) which is available for free (Young, 1999).

Copy Protection

After going through the expense of developing a new software product, it is understandable that some software companies might feel aggrieved when people start to distribute their software for free. Messerschmitt (2003) identifies a number of standard approaches to combat software piracy, ranging from technological approaches (e.g. Digital Rights Management (DRM)), legal approaches (e.g. End User License Agreements (EULAs) backed up by audits and threatened lawsuits) and business mechanisms such as differential pricing (Gopal, 2000). Technological approaches can increase supply chain complexity and reduce customer acceptance. Consequently, it is a critical decision for many companies to decide what level of anti-piracy they are going to include with their software. If software companies do decide to implement technology measures then appropriate back-end mechanisms must be put in place to ensure successful operation.

Technology Compatibility

Messerschmitt (2003) points out a key difference between digital and physical goods in that goods such as software cannot exist without a physical support infrastructure (i.e. hardware). In addition, software applications may require layers of other software products to be present on the hardware before it can work properly: an example being the Windows operating system on most personal computers (PCs). Software companies therefore require strong relationships with hardware and platform vendors in order to stay ahead of the technology curve.

Methodology

The focus of the research was to understand the challenges that practitioners encounter with digital distribution and how their organisations respond to the challenges. A distinction was made between typically business related concerns and concerns that specifically apply to distributing software as a digital product.

A number of in-depth, one-on-one interviews were held with software distribution practitioners in 8 companies with a significant software business. In-depth interviews were chosen because the approach was exploratory in nature, with the research laying open the possibility of discovering new data. Bias and error during the interview was minimised through open questioning, assurances of confidentiality and sending the write-ups back to the respondents once completed for their review and approval.

All except one respondent worked in a major global company with revenues exceeding $1bn.

Results

The companies tended to address these challenges with three general approaches: (i) assume that software is like a physical product and adjust availability accordingly; (ii) distribute freely and exploit supply-side limitations elsewhere; or (iii) do not “distribute” at all.

(i) Physical and pseudo-physical distribution

Many companies have chosen to pursue the first approach: born out of supply chains, legacy infrastructures and a competitive landscape that was designed to deal with physical product manufacture. Companies pursuing this strategy act to limit supply through technological copy-

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[2] For example, Mozilla Firefox, Apache Tomcat, Java.

protection measures backed up by legal enforcement. The customer's use of the software is impaired from the outset by highly restrictive licenses that need to be agreed to before the product can be used at all. Then, copy protection measures such as activation keys are included in the software to prevent duplicate copies being made. Complex supply chains need to be developed to support many of these initiatives. For instance, an infrastructure may be required to distribute activation keys in a secure fashion to the correct customers. These processes are complicated where third parties (distributors or resellers) need to be involved. Billing mechanisms may need to be integrated with the distribution mechanisms. Such processes require significant customer support overhead.

(ii) Free distribution

In the second approach, few or no controls are imposed on the distribution of software. Some or all versions of the software are distributed to users with few control mechanisms in place. A number of different approaches were used by these companies.

a) *The total-service based model*. In this model, the software is free to distribute and install. However, associated services such as consultancy, bug-fixing, hardware, training, technical support and customer support (all limited in supply) are available to the customer for a fee.
b) *The customised model*. In this case, the software is freely distributed However, such is the nature of the software that without extensive customisation, it has little value except to the customer for which it is intended. The companies involved deliver large-scale system installations, where the software requires extensive modification before it can be useful to the customer.
c) *The complementary model*. In this case the software is provided to enhance the value of a physical product such as computer hardware.
d) *The premium enticement model*. While basic or limited copies of a version of software are made available at no cost, an incentive is provided enticing users to upgrade their software to a premium version that is charged at a cost. This premium version may contain limited supply features (e.g. a 24x7 support hotline).

(iii) No distribution

The third approach avoids the need to involve product replication at all. In this case the "infinite availability" of software is comparable to a resource such as electricity or water and is made accessible whenever and wherever the user desires it. In the Software-as-a-Service (SaaS) type model, a single instance of software is shared amongst multiple users. Replication is therefore not required. This model is gaining currency over the past few years as bandwidth (speed and market penetration) has increased and concerns over data security are addressed.

Discussion: The changing role of supply chain management

The research has identified three different classes of software distribution models: one which tends to rely on traditional physical infrastructures and paradigms, and two others that better exploit the properties of the digital products. Approaches which are comparable to physical distribution tend to require significant management overhead (forecasting, inventories, copy-protection, license management, bandwidth management, etc.), whereas less *traditional* management is required for free and uncontrolled distribution over the Internet. In other words, from a traditional SCM standpoint, there is a variation in complexity according to the degree to which digital product distribution is made to resemble physical product distribution (Figure 1).

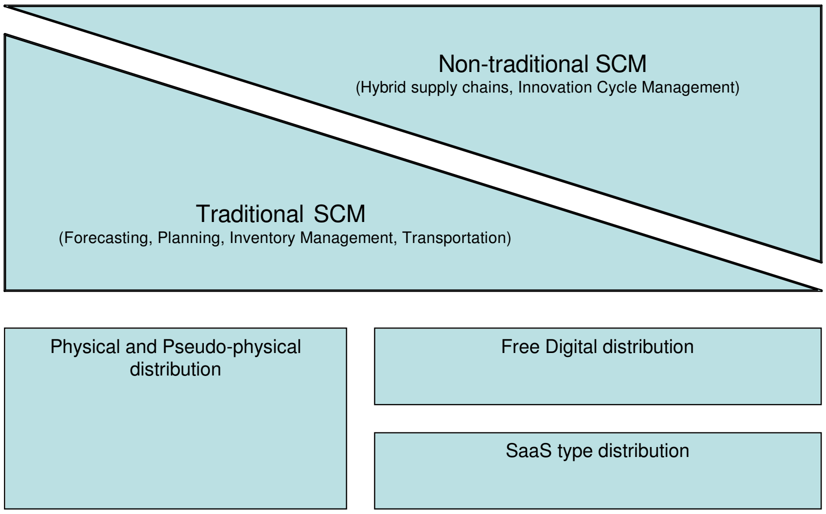

Figure 1: Changes in SCM requirements over the spectrum of digital distribution approaches

What then for the future of SCM in the digital world? While this research reveals that physical and pseudo-physical distribution approaches remain important in the software distribution process, two new supply chain scenarios are postulated. Both scenarios assume that manufacturing and distribution are of minor importance in the world of digital products, and that the right software is instantly available whenever it is required. Both are areas worthy of significant further research.

1) Hybrid physical / digital / service supply chains. In this scenario, the supply or availability of digital product becomes integrated into a more comprehensive supply chain strategy involving physical supply and service based elements. Hybrid distribution leverages the advantages of digital products to improve the performance of more traditional supply chains.
2) Innovation Cycle Management. In this scenario, the focus moves from the flow of *product* to the flow of *innovation* (e.g. ideas, software code, executables, feature suggestions) from first conception, to development, to release, and distribution into the hands of the customer. It is seen as a cycle because the flow of feedback back from customers (a kind of reverse logistics process in the digital world) is crucial to further innovation and new releases of product. The focus of SCM migrates from operational concerns to product development and lifecycle management considerations. This challenge is complex because development is increasingly fragmented amongst different groups (in-house developers, off-shore developers, contractors, specialists etc.), and customers can vary enormously in terms of their requirements, processes and feedback mechanisms.

Conclusion

Digital products such as software will affect the practice of SCM greatly over the coming years; however it is important to make a distinction between the properties of digital products and physical products in planning appropriate supply chain strategies. While pseudo-physical distribution strategies, such as the use of copy-protection, are unlikely to disappear in the near term, it is likely that companies will leverage the free replication properties of digital products to enhance their current supply chains, and that they will put greater focus on the management of the innovation cycle to drive the maximum amount of differentiation and value from their products.

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