The Emergence of Software Product Line Development

by Charles W. Krueger, PhD, BigLever Software

Software companies have been pursuing the holy grail of code reusability since the early days of the UCSD p-System. Then came Modula, objects, and components. The ultimate goal of such efforts has been to create software "factories" that assemble and configure software "parts" that can be reused across a product line. But to date, the industry's imagination in this respect exceeds reality.

Nonetheless, the need for such a development approach is becoming more urgent. In many business environments, companies target the needs of their prospective customers by creating a product line—a portfolio of closely related products with variations in features and functions—rather than just a single product. And for companies that utilize standalone or embedded software in their products, the problem is even greater.

Developing software for a product line is extremely complex due to multiple intertwined products, differing feature sets, and production deadlines—all aimed at moving target markets. These tactical software development challenges are big enough to impede the realization of business-critical goals and strategies. More specifically, they can greatly hinder a company's ability to hit market windows, provide competitive pricing, maximize product quality, and expand the scale or scope of their product line portfolio.

Most reusability successes occur in narrow, lower level domains such as math libraries and GUI frameworks. But in many cases, "reusable" objects are being created on an ad hoc basis by developers who hope their work will prove of use to somebody. Such components are frequently stored in a reuse library with little accompanying documentation, where they sit in the often forlorn hope that they'll be discovered and used. But even when found, many of these components are often passed over because of questions of quality, applicable functionality, and architectural mismatch.

To date, companies have resorted to a variety of methods for managing multiple product lines such as configuration management, version control and branching, and "clone-and-own." With version management, if you're

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THIS WAY OUT

On the venture front, VCs continue to emphasize exit strategies See pages 4-5.

Disadvantage: Microsoft

by Merrill R. (Rick) Chapman

The end of the DOJ's trial against Microsoft left the company guilty but intact, and pundits everywhere proclaimed the boys from Redmond had won a great victory. But losing an antitrust suit to the US government is never a "victory" and the ongoing damage caused by the loss of the case is taking an increasing toll on Microsoft. Periodically the European Commission drags the hapless software maker into court and fines it for failing to build versions of Windows nobody wants and being mean to open source companies and for being a very successful American company. The Koreans have joined in the fun as well. To just make them all go away, Microsoft handed out large bundles of cash to Novell, Sun, Real (even Be! got into the action for $23 million, for god sakes) and a whole wad of state governments. And every time an attorney from Microsoft opens their mouth, he or she gets to listen to a succinct recitation of "the guilty of abusing your monopoly power" verdict as brought to the world by no less a body than the United States of America. As a result, Microsoft can expect to be reaching for its checkbook on a regular basis well into the future.

Another consequence of the legal debacle is that Microsoft increasingly resembles the IBM of the 80s in several interesting ways. There are now plenty of lawyers running around the halls of Redmond making sure the company stays out further legal trouble. There are a wealth of committees and oversight groups dedicated to making sure Microsoft plays nice with the market, at least nice enough to keep the feds at bay. Microsoft is now a middle-aged place to work at, and has a hard time recruiting the hottest talent, though the company remains solidly profitable and can expect to make money over the next few years at a measured pace. That's what the middle-aged do.

The recent Windows Genuine Advantage release fiasco is symptomatic of Microsoft's increasing senescence. In the industry's youth, every major desktop software company experimented with copy protection and then backed away, convinced that by allowing software piracy to continue the gains realized by increased marketshare and category dominance would offset piracy losses. But there are no more marketshare gains to be realized with Windows. Microsoft, to maintain revenue growth, must squeeze its installed base for increased cash, a middle-aged business strategy. And, for Windows users, a dangerous one. Copy protection inevitably makes systems more fragile and endangers customer working environments. Scans of Windows forums reveals a torrent of complaints about WGA threatening to disable completely legitimate systems, both retail and OEM (never mind the spyware issues). As the market moves to a realization of the value of the customer's computing environment, such actions on the part of Microsoft will become not simply embarrasing but politically impossible.

Windows has existed in one form or another since 1982 (the product was offically released in 1985) and after almost a quarter century is a middle-aged software monolith that combines low-level management of hardware with the ability to manage software products and services (your working enviroment). Vista continues this model and the struggle to release the product demonstrates that managing the monolith has become almost impossible. What must occur is for the monolith to be split into a hardware management layer and a virtualized software one. The hardware layer will disappear into the embedded market, and the virtual layer will belong to the user, who will expect complete portability and control. Otherwise, Vista will be the last release of Windows.

using Rational, ClearCase, etc., you check a code branch out for release while another branch remains in the system for ongoing development. Configuration management often involves runtime scripts with conditionals that operate on configuration files. With clone and own you copy an existing code base and modify it to fit a new market's or segment's needs.

The difficulty with all these approaches is that over time they tend to create a series of increasingly "delicate" and difficult to manage and maintain products. As a result, adding a new product to a line is usually a nontrivial business decision. The choice to move forward usually involves complex negotiations between the product marketing and software development organizations, where product marketing proposes a new product with a specific benefit to the business and engineering pushes back or asks for trade-offs with other deliverables due to time and resource scarcity.

To address the need to effectively manage a portfolio of related software products, a new class of software development methods and tools— collectively referred to as software product line (SPL) development—is emerging. SPL flips the traditional product-oriented mindset over and comes up with mechanisms that looks at a code base as "one product" from which a company can quickly develop derivations from a common core asset. The goal of this methodology is to use engineering methods and a series of tools and techniques to create a portfolio of similar software systems from a shared set of software assets. In turn, these use a common means of production to configure and assemble those parts.

Initial attempts at implementing SPL has focused on various UML and feature modeling languages. While these are effective in encapsulating feature sets and differences within members of a product line, modeling tools don't deal well in mapping crosscutting behaviors and features combinations to actual code development. One reason is that managing a capability set for a product with 216 separate features via a modeling framework using boolean switches means tracking a potential number of combinations equal to the number of atoms in the known universe (though we're not trying to account for dark matter in this instance)!
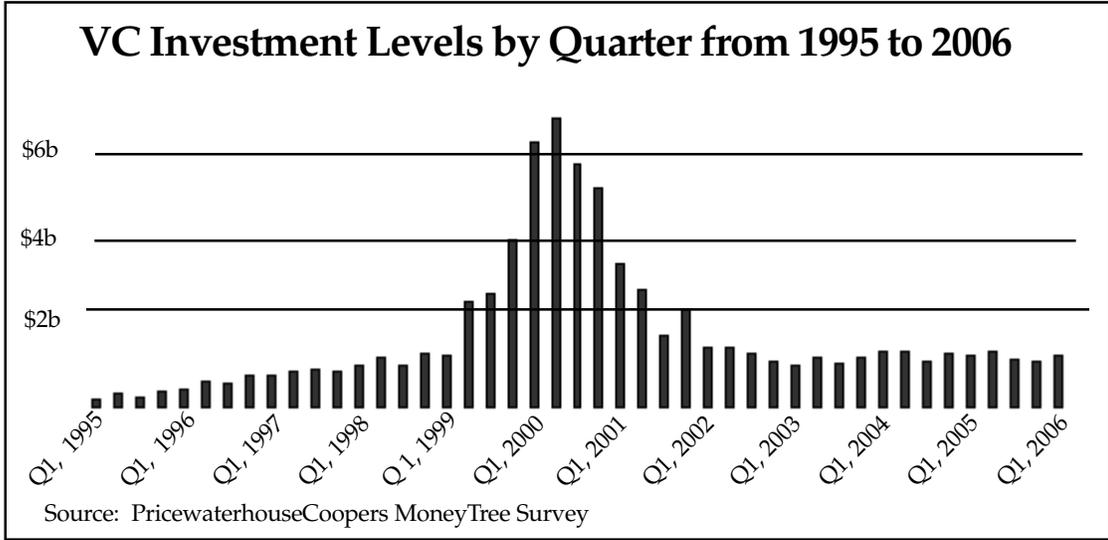
As a result, more robust frameworks for supporting SPL are beginning to appear on the scene. A complete SPL development environment normally incorporates:

- **A feature modeling language**. This will be used by software architects to encapsulate the features that cause variation among the products, model the feature profile for each of the products in the portfolio, and an IDE that allows you to view the code from an SPL level.

- **Variation points.** This is where code used by developers to encapsulate implementation-level differences among the products in the portfolio and the logic about how

"One company I observed went through the business analysis of whether to reduce development overhead by adopting a software product line approach or offshore outsourcing. The company decided that it was strategically and economically advantageous to 'work smarter' with software product line development rather than to 'work cheaper' with offshore labor. Thus, the majority of their development resources remained domestic, while only a small portion their development tasks were sent offshore."

—Charles W. Krueger
BigLever Software

VC Investment Levels by Quarter from 1995 to 2006

Source: PricewaterhouseCoopers MoneyTree Survey

Benchmarks: Q1 Venture Capital Investments

Venture investment in software remains level, with the quarterly undulations that we have been observing for a while now. VCs continue to emphasize exit strategies, investing to bring their maturer ventures to acquisition or to the even rarer IPO.

Software Investment Deals by Stages

Startup/Seed	16
Early	40
Expansion	72
Later	69
Buyout/Acquisition	none
Other	none
Unknown	none

VentureSource (Dow Jones) says that the current pace of exit is so slow that it would take 13.6 years to clear out the present backlog.

The good news is that this slower investment style is leading to better-quality companies; according to the Fenwick & West (www.fenwick.com) study of Bay Area software firms in Q1 2006, "Up rounds exceeded down rounds for the ninth quarter in a row, and by the largest margin since our survey began (74% up vs. 15% down, with 11% flat)." The firm also says that there was "64% average price increase for companies receiving venture capital in 1Q06 compared to such companies' previous financing round. This was also the largest increase since the survey began."

According to Jeff Clavier (blog.softtechvc.com), entrepreneurs are responding by asking for larger funding "for their initial round of financing, especially in last three months. Even at seed stage, it is not uncommon these days to hear about high single digit pre-money ($5M to $8M) . . . ."

The material in this report is largely drawn from the Money Tree Survey by PricewaterhouseCoopers, Thomson Venture Economics, and the National Venture Capital Association, and confirmed or modified by other sources.

The Top 50: Software Venture Capital Investments—Q1, 2006

	Company	Business Focus	Lead Investor	Investment
1	ITA Software	Manage airfare pricing, shopping, seats	Battery Ventures	$100,000,000
2	Coremetrics	eMarketing intelligence ASP	FTVentures	$31,000,000
3	3PAR (3PARdata)	Enterprise storage systems technology	Integral Capital Partners	$30,000,000
4	Incipient	Storage management software	QuestMark Partner	$24,000,000
5	Cybernet Software Sys.	IT solutions involving outsourcing	SAIF Partners	$22,500,000
6	JJWild	Solutions for MEDITECH healthcare systems	Advent International	$20,000,000
7	Command Information	Internet protocol version 6 (IPv6)	Carlyle Group	$20,000,000
8	OnVantage	Meeting and event management solutions	Norwest Venture Partners	$18,000,000
9	Copan Systems	Nearline storage software (MAID, RAID)	Credit Suisse	$17,500,000
10	UNX Holdings	ASP-based institutional trading	Goldman, Sachs & Co.	$16,000,000
11	mFormation Technologies	Mobile-device management software.	North Bridge Venture Partners	$15,300,000
12	Akorri Networks	Cost control and management for IT	Matrix Partners	$15,000,000
13	BlueNote Networks	Enterprise VoIP platform	Commonwealth Capital Ventures	$15,000,000
14	Metaweb Technologies	Web-based storage infrastructure	Benchmark Capital	$15,000,000
15	Snocap (Open Copyright)	Packages music files for retailers	Court Square Ventures	$15,000,000
16	Zimbra (Liquid Systems)	Open Source messaging and collaboration	Duff Ackerman & Goodrich	$14,500,000
17	ROME Corp.	Enterprise financial risk management	Azure Capital; Powershift Ventures	$14,000,000
18	DispenseSource	Inventory managment (MRO) for industry	Inverness Capital; Argentum Group	$13,750,000
19	Sharpcast	Synch svcs for consumer media & info.	Sigma Partners	$13,500,000
20	Sipera Systems	Develops VOIP security software.	Sequoia Capital	$13,200,000
21	Business Events Software	Enterprise business opportunity discovery	Carmel Ventures	$12,700,000
22	HedgeStreet	Market for "event derivative" contracts	Norwest Venture Partners (NVP)	$12,500,000
23	Archivas (Ref. Info. Sys.)	Searchable archival storage software	North Bridge; Polaris Venture Partners	$12,000,000
24	CombineNet	Strategic source/procurement decisions	Advanced Technology Ventures (ATV)	$12,000,000
25	Integrated Media Measmnt	Measures ad impact using cell phones	Advanced Techn. (ATV); Draper Fisher	$12,000,000
26	TACODA	Online ad svcs targeted to behaviors	Rho Ventures	$12,000,000
27	Six Apart, Ltd.	Blogging software, services, tools	Focus Ventures	$12,000,000
28	Dexterra	Mobile workforce solutions	Mesirow Financial	$12,000,000
29	Clearwell Systems (Teneo)	Corporate email intelligence solutions	Redpoint Ventures	$12,000,000
30	Imprivata	Online user authentication using SSO	General Catalyst Partners; Polaris	$12,000,000
31	Centeris Corporation	Manage Linux servers in Windows shops	Trinity Ventures and Intel Capital	$11,500,000
32	Market Force Information	Customer experience information for retailers	Centennial Ventures	$11,300,000
33	Rapt (Rapt Techn. Corp.)	Price and profit optimization solutions	Summit Partners	$11,230,000
34	Sylantro Systems Corp.	Voice & data services using IP telephony	Accel; BCE Capital; Mayfield; Vanguard	$11,000,000
35	Linden Lab	Online 3D entertainment community	Globespan Capital Partners	$11,000,000
36	New Global Telecom	Hosted VoIP and network management	Comcast Interactive Capital	$10,750,000
37	AmberPoint (Edgility	Manages/secures SOA apps at runtime	Meritech Capital Partners	$10,300,000
38	DocuSign	Online document delivery and signing	Sigma Partners	$10,000,000
39	Linux NetworX (Alta Tech.)	Linux cluster-computer applications.	Oak Investment Partners; Tudor Ventures	$10,000,000
40	Splunk	Log viewing and searching tool	JK&B Capital	$10,000,000
41	InSync Software	Solutions for the edge of the enterprise	Rustic Canyon Partners; Intel Capital	$10,000,000
42	Voxpath Networks	Hosted PBX services for SMB	Undisclosed	$10,000,000
43	Finjan Software	Network security appliances	HarbourVest Partners	$10,000,000
44	Solidcore Systems	Hardware change management control	Matrix Partners	$10,000,000
45	La La Media	An exchange for trading used CDs	Bain Capital; Ignition Partners	$9,000,000
46	Chorus Systems	IT Infrastructure Lib. problem management	Core Capital Partners	$9,000,000
47	iConclude Company	Problem management and incident resolution	Greylock Partners; Shasta Ventures	$9,000,000
48	TelTel.com	Presence-enabled VoIP services	Purple Communications Ltd.; Parawin VC	$8,800,000
49	Skybox Security(SecLucid)	Virtual modeling of network security risks	Rembrandt Ventures	$8,800,000
50	Palo Alto Networks	Enterprise network security solutions	Greylock Partners; Sequoia Capital	$8,790,000

to instantiate a variation point based on the product's feature profile. Variation points, which are used in software assets such as requirements, source code, test cases and documentation, enable a single software asset with variation points to be used for all products in a portfolio. This consolidation allows the portfolio to be developed as though it were a single product.

- **Actuators.** Used during the product build, these take a feature profile for a product and instantiates it by composing assets and by instantiating variation points within those assets. The actuator enables **continuous builds** for the entire portfolio (analogous to continuous builds of individual products in agile methods), where any developer can automatically compose and configure all of the assets (requirements, source code, test cases, documentation) for any product at any time, based on the current state of the assets under development.

- **Supporting tools.** These can include semantic and impact analysis, queries, statistics, and feature constraint checking.

Recent advances in the software product line field demonstrate that with the focused, strategic application of these concepts, companies can experience a "discontinuous jump" in their competitive business advantage. For example diesel engine maker Cummins, using an SPL methodology, was able to develop more than 1000 separate products based on just 20 software builds. Their embedded development group can build and integrate the software for a new diesel engine in about a week, as opposed to previous efforts that took 12 months. Nokia is another example of the value of using SPL in the embedded space. In today's market, new phone designs are expected to go from concept to manufacturing within three months. Nokia was an early adopter of SPL and was able to spin new designs and products out much faster than its competition, a key reason for the company's strategic success.

A Gears client (the product developed by my company) recently demonstrated an unexpected business benefit of adopting a software product line approach. As a startup, the company decided to utilize the SPL development approach rather than a professional services business model to provide customer-specific customizations. After proving its business model, the company shifted into an extremely low burn rate and spent six months securing an M&A opportunity with a large company. During this period, a small outsourced development team was able to maintain the company's entire product line portfolio. According to the CEO, a conventional professional services model would have required 10 times the burn rate and would have prevented the company from surviving the M&A process. From the perspective of the investors, the company's use of a software product line methodology produced a dramatically better financial outcome than would have been possible had the company relied on conventional methods.

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Asia Is Coming

By Miro Parizek, Corum Group

Despite the lack of clear regulations and inadequate transparency, we continue to observe rising deal values in the Asian M&A markets, with overall numbers reaching $360B. The anticipation of lucrative growth opportunities seems to outweigh the perceived risk despite expectations of higher interest rates that will increase borrowing costs and put pressure on capital and consumer spending. Nevertheless, Asian companies are targets of acquirers desiring access to the soon-to-be world's largest economies.

And, as domestic Asian markets mature, the influence of these countries on the global economy will rise as well. This is reflected by the increasing investment outflows we have observed over the last decade. Last year Asian investments in the US reached a record-high of $ 45.8B. Many of those investments provided Asian buyers access to well-known brands and natural or technological resources. Included in that was the paradigm-shifting acquisition by Chinese-based Lenovo of IBM's personal computer division for $1.75B.

Over the last few years, we have all observed how India and other Asian countries have been "flattening the world" with their outsourcing services. We have seen how Oracle, SAP and Intel have all set up major development centers in India followed just recently by IBM (again), Nortel and Cisco. Microsoft has set up only its second research center outside of Redmond in China. And, according to a Report From Ewing Marion Kauffman Foundation, among 200 multinationals the trend of corporations sending their research work to China and India will continue.

As that trend continues, Asia is now also cooperating. The first Sino-India software research, education and training base has been established in Chengdu. India's private IT education firm, NIIT, has announced it will train hundreds of thousands of Chinese not only in the area of programming but also in such high-value skills as project management, analysis and system design. The school of thought of many software engineers in Europe and North America has been that the Asians are good at coding, but not at design—they do not possess the creativity and design skills needed to develop software. The question remains how long before that changes, or has it changed already?

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Company/Description	Acquired by	Price/Terms	Revenues	Multiple
Enabler Informatica SA • *Oracle retail integrator*	Wipro Technologies	$53,000,000 Terms: Cash	$51,000,000	**1.04**
Looking Glass Networks • *Data services*	Level 3 Comm. (LVLT)	$96,000,000 Terms: Cash and stock	$75,000,000	**1.28**
Onyx Software (ONXS) • *CRM software*	Made2Manage	$92,000,000 Terms: Cash	$58,300,000	**1.58**
MphasiS BFL • *Indian outsourcing company*	Electronic Data Sys. (EDS)	$380,000,000 Terms: Cash	$210,000,000	**1.81**

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New and Interesting Reads

- *Lead Generation for the Complex Sale* by Brian J. Carroll, McGraw Hill, 2006. This is a solidly written book that focuses on a topic of eternal interest to sales and marketers everywhere. Before purchasing a copy of *Lead Generation*, be aware that the book is aimed primarily at companies selling enterprise products with long sales cycles; B to C companies will find less of interest here. While not ostensibly a book aimed at the software industry, many of the book's case studies and examples are derived from or refer to software firms.

  The book's coverage of the process of defining leads, developing them, and handling the coordination between sales and marketing is comprehensive and the suggestions offered can be executed by a company of any size. We also like that the book doesn't focus solely on web and Internet marketing; telesales, events, and tradeshows are also discussed in depth. One caveat we have to offer is that the case studies, while offering useful metrics on outcomes, never refer to indentifiable companies or individuals; it's always "a company did " or "a CEO wanted." The most effective references are those that discuss real people at firms I've heard of.

INFORMATIONWEEK EDITOR ROB PRESTON ON MICROSOFT LAWSUITS AND COMPETITION: "I'm not about to defend Microsoft's every business practice as legitimate, nor am I capable of assessing the merits of every case brought against the company. But Microsoft can't make a move these days without some competitor, former competitor, or would-be competitor issuing legal papers. Can't someone kick the snot out of Microsoft in the marketplace without a court-ordered escort?" (Quoted in InformationWeek, 06/13/2006)

"MICROSOFT REPORT" EDITOR ED BOTT ON MICROSOFT'S WINDOWS GENUINE ADVANTAGE UPGRADE: "Someone at Microsoft just pushed the Stupid button. And things aren't going to get better until they stop pushing it." Quoted on http://blogs.zdnet.com/Bott/?p=76, 06/13/2006)

MICROSOFT OFFICE PROGRAM MANAGER BRIAN JONES ON ADOBE: "This really is one of those cases where you just have to shake your head. Adobe got a lot of goodwill with customers, particularly in government circles, for making PDF available as an open standard. It's amazing that they would go back on the openness pledge. " (Quoted on http://blogs.msdn.com/brian_jones/archive/2006/06/02/613702.aspx, 06/02/2006)

GOOD MORNING SILICON VALLEY EDITOR JOHN PACZKOWSKI ON GOOGLE SPREADSHEETS: "It's high time, isn't it, that Google cops to having designs on Microsoft's software business. The company now offers an e-mail program with built in IM and upwards of 2.5 gigabytes of storage space , an HTML editor and a calendar program. It's developing a universally accessible network drive and likely a Web-based word processor as well. And now it's got a spreadsheet program to boot. And it insists it has no plans whatsoever to compete with Microsoft's core PC software business? Please." (Quoted on Good Morning Silicon Valley, 06/06/2006)