


Software Product Lines: Reuse That Makes Business Sense

Paul C. Clements

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-2612

 Software Engineering Institute | Carnegie Mellon © 2007 Carnegie Mellon University

Software Engineering Institute (SEI)

Department of Defense R&D Laboratory (FFRDC)
Created in 1984
Under contract to Carnegie Mellon University
Offices in Pittsburgh, PA; Washington, DC; and Frankfurt, Germany
SEI Mission: advance software and related disciplines to ensure the development and operation of systems with predictable and improved cost, schedule, and quality.



 Software Engineering Institute | Carnegie Mellon SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

SEI Technical Program

Networked Systems Survivability

- Survivable Systems Engineering
- Survivable Enterprise Management
- CERT Coordination Center
- Network Situational Awareness
- Practices Development and Training

Product Line Systems

- **Product Line Practice**
- **Software Architecture Technology**
- **Predictable Assembly from Certifiable Components**

Dynamic Systems

- Integration of Software-Intensive Systems
- Performance-Critical Systems

Software Engineering Process Management

- Capability Maturity Model Integration
- Team Software Process
- Software Engineering Measurement and Analysis

Acquisition Support

New Research

- Independent R&D
- International Process Research Consortium
- Software Engineering for Computational Science and Engineering
- **Ultra-Large-Scale Systems**
- Mission Success in Complex Environments



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

3

Mission of the SEI Product Line Systems Program

The Product Line Systems (PLS) Program

- creates, matures, applies, and transitions technology and practices
- to effect widespread product line practice, architecture-centric development and evolution, and predictable construction
- throughout the global software community.

With regard to its software product line effort

- Make product line development and acquisition a low-risk, high-return proposition for all organizations.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

4



Our Customers and Collaborators

Daimler Chrysler
Caterpillar
Foliage
Intuit
NCR
Northrop Grumman
Pitney Bowes
Raytheon
RIM
Robert Bosch Co.
Siemens
Unisys
Visteon
LLNL
FAA
NASA: JSC, KSC, JPL
NASA: Goddard
NRO: CCT
JNIC
DMSO
US Army: FBCB2, CECOM, ATSC, FCS, AMTS
US Army: ASA(ALT), Aviation, TAPO, BC
US Navy: Navsea, DDX, OAET, CLIP
US Air Force: F-22, JMPS, ESC





ABB
Philips
Lucent
AT&T
Hewlett Packard
Thomson-CSF
Ericsson
Schlumberger
Nokia
Telesoft S.p.A.
Boeing
CelsiusTech
Avaya
Fraunhofer
IBM
Microsoft
Motorola
Cummins, Inc.
General Motors
Lockheed Martin
Salion, Inc.
MarketMaker
Argon Engineering
Agilent







Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University


5

Business Success Requires Software Prowess

Software pervades every sector.
Software has become the bottom line for many organizations, even those who never envisioned themselves in the software business.

Cell Phone Today	Cell Phone in 2010	This year's cars	Cars in 2010
~2 million lines of code	~ 10 million lines of code	~35 million lines of code	~ 100 million lines of code



Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

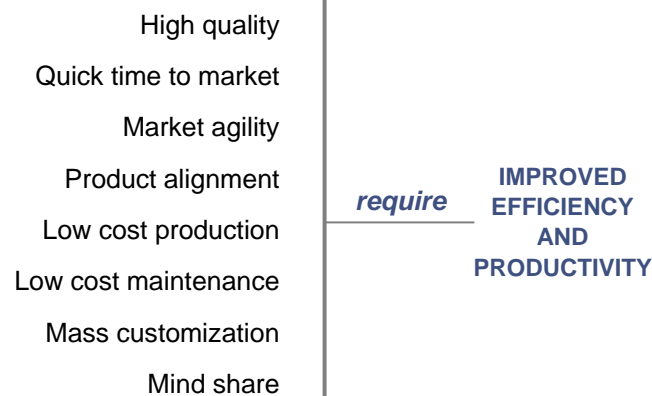
6

Universal Needs

- Deploy new products (services) at a rapid pace
- Accommodate a growing demand for new product features across a wide spectrum of feature categories
- Connect products in increasingly unprecedented ways
- Exploit a rapidly changing technology base
- Gain a competitive edge

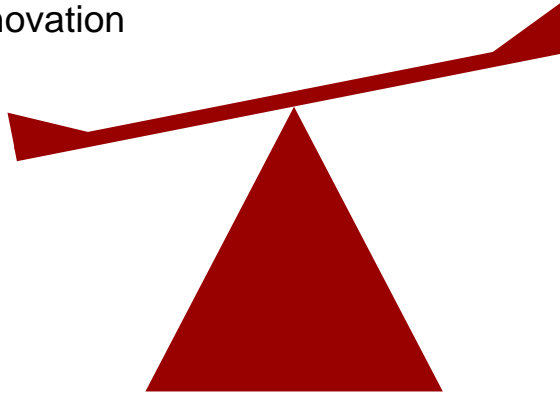


Universal Business Goals



Software (System) Strategies

Process improvement
Technology innovation
Reuse



Few Systems Are Unique



Most organizations produce families of similar systems, differentiated by features.
A reuse strategy makes sense.



Reuse: An Early Topic of Discussion

*“My thesis is that the software industry is weakly founded, in part because of the absence of a **software components sub-industry**.”* [McIlroy, 1969]

*“Most industry observers agree that improved software development productivity and product quality will bring an end to the software crisis. In such a world, **reusable software** would abound.”* [Pressman, 1982]

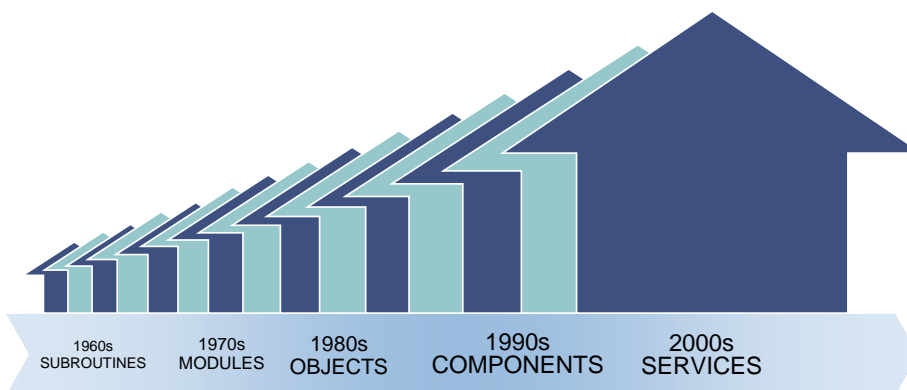
*“What is needed is the ability to create **templates of program units** that can be written just once and then tailored to particular needs at translation time. As we shall see, **Ada** provides a general and very powerful tool to do just this.”* [Booch, 1986]

*“If one accepts that reusability is essential to better software quality, the **object-oriented** approach provides a promising set of solutions.”* [Meyer, 1987]

*“**Reusable components** would be schematized and placed in a **large library** that would act as a clearing house for reusable software, and royalties would be paid for use of reusable components.”* [Lubars, 1988]



Reuse History



*Focus was small-grained, opportunistic, and **technology-driven**.
Results did not meet business goals.*



The Real Truth About Reuse

Reuse means taking something developed for one system and using it in another.

“The XYZ System is built with 80% reuse.”

A statement like this is vacuous.

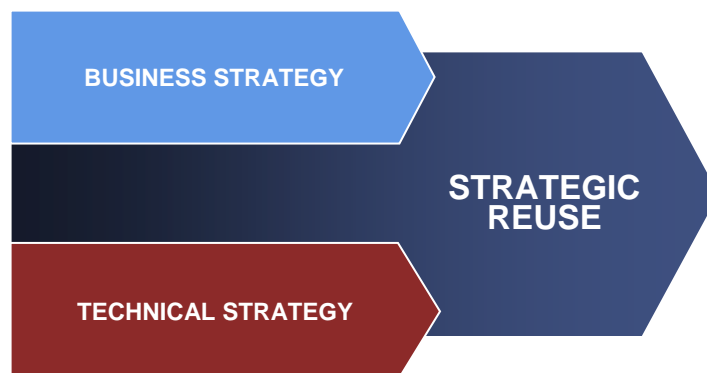
- It is not clear what is being reused.
- It is not clear that the “reuse” has any benefit.

Reusing code or components without an architecture focus and without pre-planning results in

- short-term perceived win
- long-term costs and problems
- failure to meet business goals



Imagine Strategic Reuse



Celsiustech: Ship System 2000

A family of 55 ship systems

- Need for developers dropped from 210 to roughly 30.
- Time to field decreased from about 9 years to about 3 years.
- Integration test of 1-1.5 million SLOC requires 1-2 people.
- Rehosting to a new platform/OS takes 3 months.
- Cost and schedule targets are predictably met.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

15

Cummins Inc.: Diesel Control Systems

Over 20 product groups with over 1,000 separate engine applications

- Product cycle time was slashed from 250 person-months to a few person-months.
- Build and integration time was reduced from one year to one week.
- Quality goals are exceeded.
- Customer satisfaction is high.
- Product schedules are met.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

16



National Reconnaissance Office/ Raytheon: Control Channel Toolkit

Ground-based spacecraft command and control systems

- First system had 10 times fewer defects than usual.
- The incremental build time was reduced from months to weeks.
- The system development time and costs decreased by 50%.
- There was decreased product risk.



Software Engineering Institute

CarnegieMellon

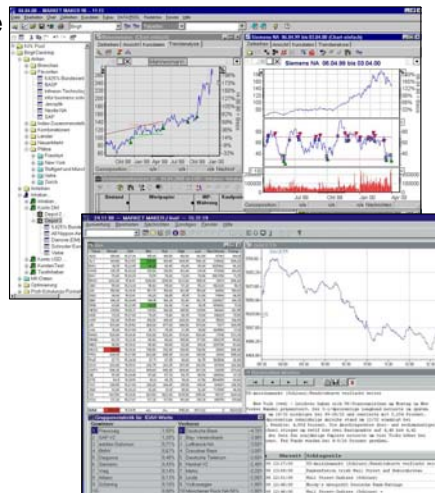
SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

17

Market Maker GMBH: Merger

Internet-based stock market software

- Each product is “uniquely” configured.
- Putting up a customized system takes three days.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

18



Nokia Mobile Phones

Product lines with 25-30 new products per year versus 5 per year originally.

Across products there are

- varying number of keys
- varying display sizes
- varying sets of features
- 58 languages supported
- 130 countries served
- multiple protocols
- needs for backwards compatibility
- configurable features
- needs for product behavior
- change after release



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

19

How Did They Do It?



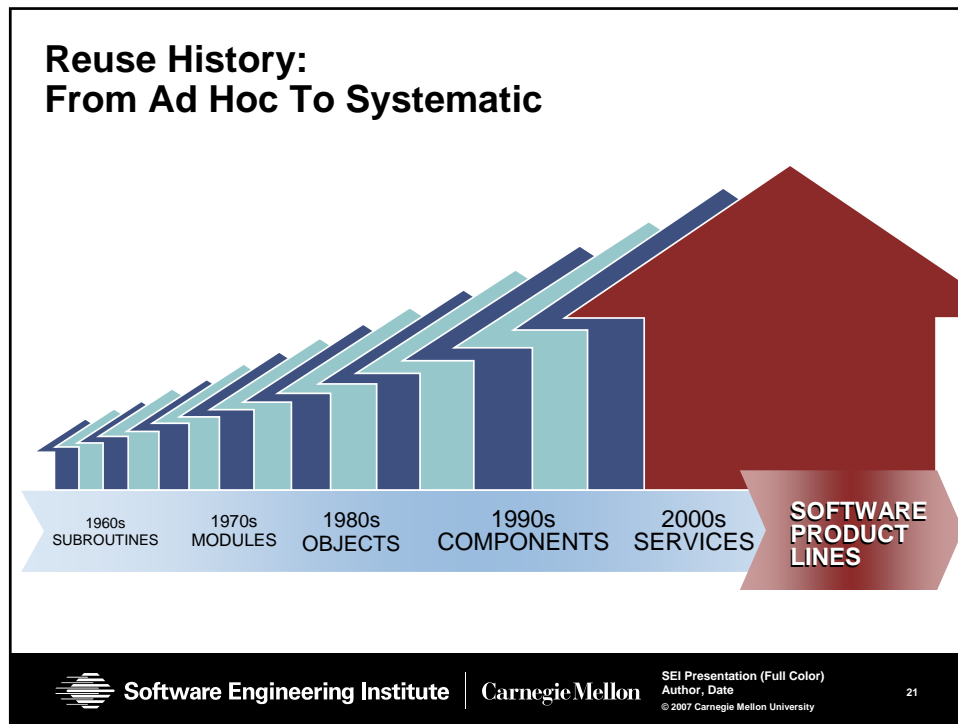
Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

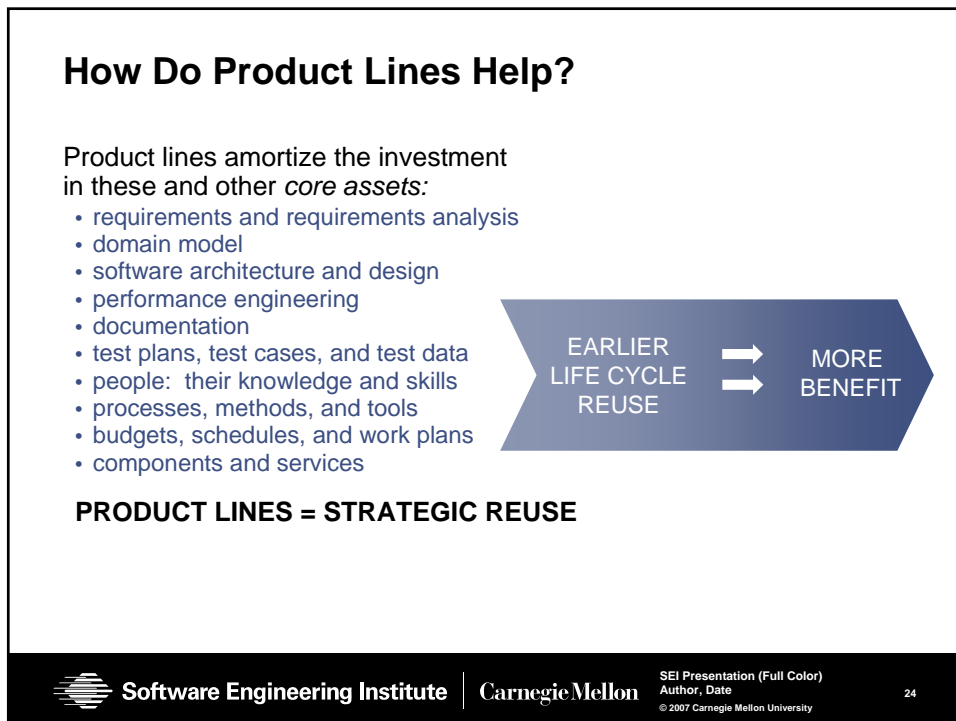
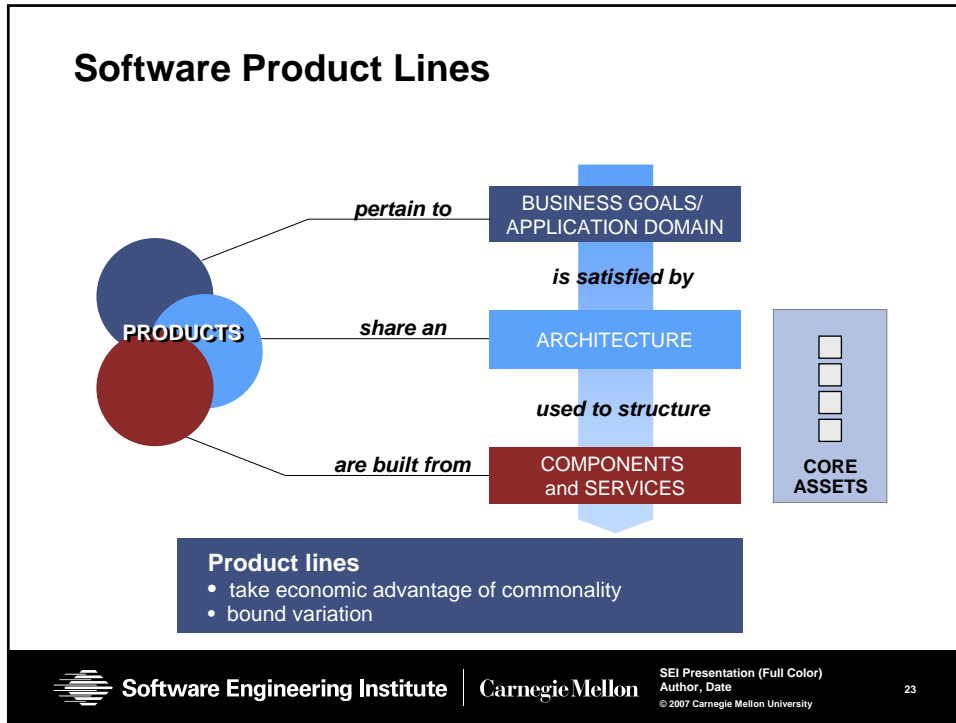
20





What Is A Software Product Line?

A software product line is a **set** of software-intensive systems sharing a **common, managed set of features** that satisfy the specific needs of a **particular market segment or mission** and that are **developed from a common set of core assets** in a **prescribed way**.



The Key Concepts

Use of a core asset base in production of a related set of products

Software Engineering Institute | Carnegie Mellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

25

The Key Concepts

Use of a core asset base in production of a related set of products

Architecture Production Plan Scope Definition Business Case

Software Engineering Institute | Carnegie Mellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

26

Software Product Lines Are Not

Fortuitous small-grained reuse

- reuse libraries containing algorithms, modules, objects, or components

Single-system development with reuse

- modifying code as necessary for the single system only

Just component-based or service-based development

- selecting components or services from an in-house library, the marketplace, or the Web with no architecture focus

Just versions of a single product

- rather, simultaneous release and support of multiple products

Just a configurable architecture

- a good start, but only part of the reuse potential

Just a set of technical standards

- constraining choices without an architecture-based reuse strategy



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

27

Software Product Lines Are

Software product lines involve strategic, planned reuse that yields predictable results.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

28



Widespread Use of Software Product Lines

Successful software product lines have been built for families of among other things

- mobile phones
- command and control ship systems
- ground-based spacecraft systems
- avionics systems
- command and control/situation awareness systems
- pagers
- engine control systems
- mass storage devices
- billing systems
- web-based retail systems
- printers
- consumer electronic products
- acquisition management enterprise systems
- financial and tax systems
- medical devices
- farm manager software



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

29

Specific Examples - 1



Feed control and farm management software



Gas turbines, train control, semantic graphics framework



Computer printer servers, storage servers, network camera and scanner servers



Bold Stroke Avionics



Internet payment gateway infrastructure products



Customized solutions for transportation industries

E-COM Technology Ltd.

Medical imaging workstations



AXE family of telecommunications switches



Firmware for computer peripherals



Lucent Technologies
Bell Labs Innovations

5ESS telecommunications switch



Elevator control systems



Mobile phones, mobile browsers, telecom products for public, private and cellular networks



Software for engines, transmissions and controllers



RAID controller firmware for disk storage units



Interferometer product line



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

30



Specific Examples - 2

PHILIPS

High-end televisions,
PKI telecommunications switching
system, diagnostic imaging equipment

Rockwell Collins

Commercial flight control system avionics,
Common Army Avionics System (CAAS),
U.S. Army helicopters

symbian

EPOC operating system



Test range facilities

RICOH

Office appliances

SALiON

TARGET. WIN. DELIVER.

Revenue acquisition
management systems

TELVENT

Industrial supervisory control
and business process
management systems



Command and
control simulator for
Army fire support

BOSCH

Automotive gasoline
systems

SIEMENS

Software for viewing and
quantifying radiological images



Climate and flue gas
measurement devices



Support software



Pagers product line



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

31

Example Organizational Benefits

Improved productivity

- by as much as 10x

Increased quality

- by as much as 10x

Decreased cost

- by as much as 60%

Decreased labor needs

- by as much as 87%

Decreased time to market (to field, to launch...)

- by as much as 98%

Ability to move into new markets

- in months, not years



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

32



Costs Of A Software Product Line

Core Assets	Costs
Architecture	Must support variation inherent in the product line
Software Components	Must be designed to be general without a loss of performance; must build in support for variation points
Test Plans, Test Cases, Test Data	Must consider variation points and multiple instances of the product line
Business Case and Market Analysis	Must address a family of software products, not just one product
Project Plans	Must be generic or be made extensible to accommodate product variations
Tools and Processes	Must be more robust
People, Skills, Training	Must involve training and expertise centered around the assets and procedures associated with the product line



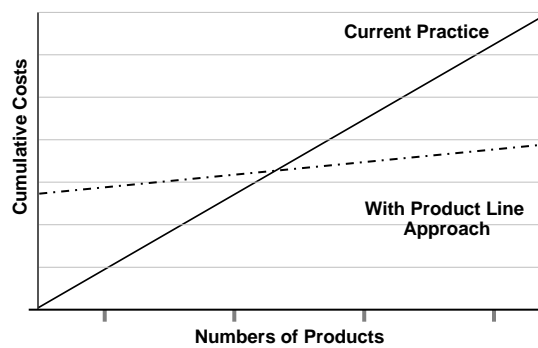
Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

33

Economics Of Product Lines



Weiss, D.M. & Lai, C.T.R..
Software Product-Line Engineering: A Family-Based Software Development Process
Reading, MA: Addison-Wesley, 1999.



Software Engineering Institute

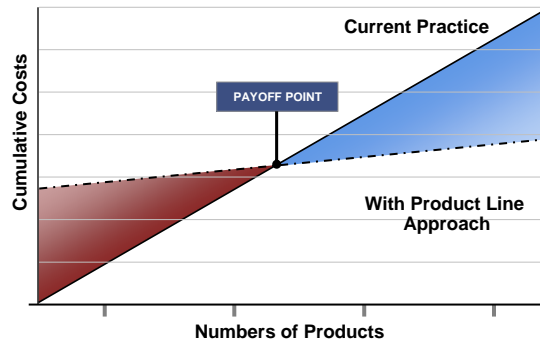
CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

34



Economics Of Product Lines



Weiss, D.M. & Lai, C.T.R..
 Software Product-Line Engineering: A Family-Based Software Development Process
 Reading, MA: Addison-Wesley, 1999.



Software Engineering Institute

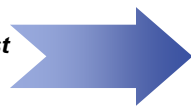
CarnegieMellon

SEI Presentation (Full Color)
 Author, Date
 © 2007 Carnegie Mellon University

35

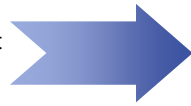
Why Is Software Architecture Important?

Represents *earliest* design decisions



- hardest to change
- most critical to get right
- communication vehicle among stakeholders

First design artifact addressing



- performance
- modifiability
- reliability
- security

Key to systematic *reuse*



- transferable, reusable abstraction

The **right architecture** paves the way for system **success**.
 The **wrong architecture** usually spells some form of **disaster**.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
 Author, Date
 © 2007 Carnegie Mellon University

36



Product Line Practice

Contexts for product lines vary widely, based on

- nature of products
- nature of market or mission
- business goals
- organizational infrastructure
- workforce distribution
- process discipline
- artifact maturity

**But there are
universal essential
activities and practices.**



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

37

The SEI Framework For Software Product Line Practicesm

The SEI Framework for Software Product Line Practice is a conceptual framework that describes the essential activities and twenty-nine practice areas necessary for successful software product lines.

The Framework, originally conceived in 1998, is evolving based on the experience and information provided by the community.

Version 4.0 –

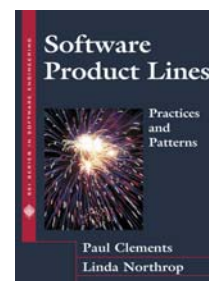
in *Software Product Lines: Practices and Patterns*

Version 4.2 –

<http://www.sei.cmu.edu/productlines/framework.html>

Version 5.0 –

available in early 2007



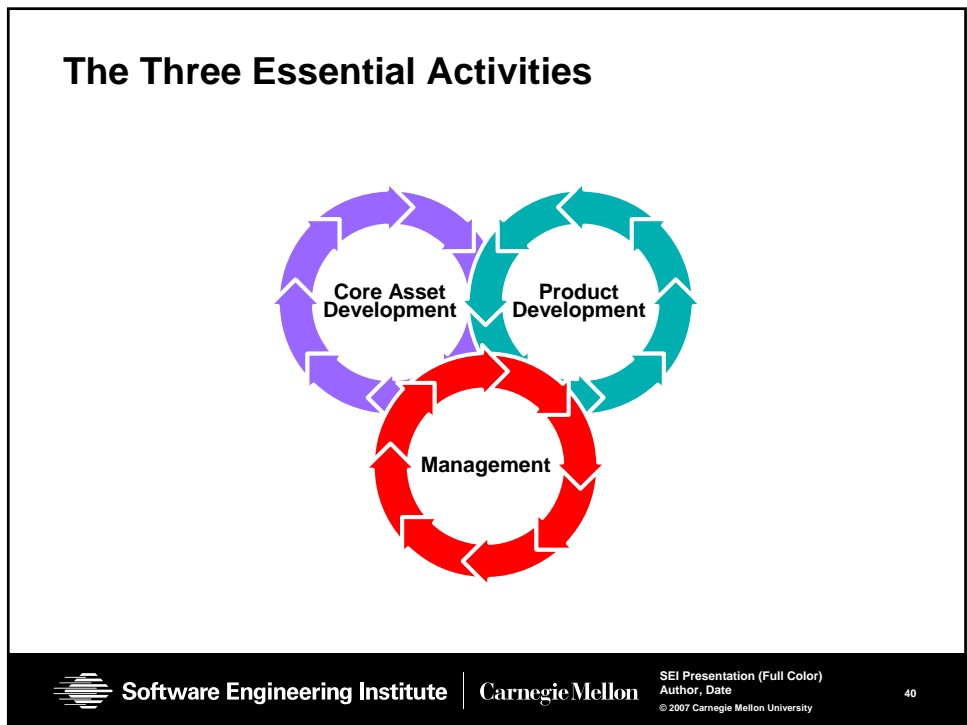
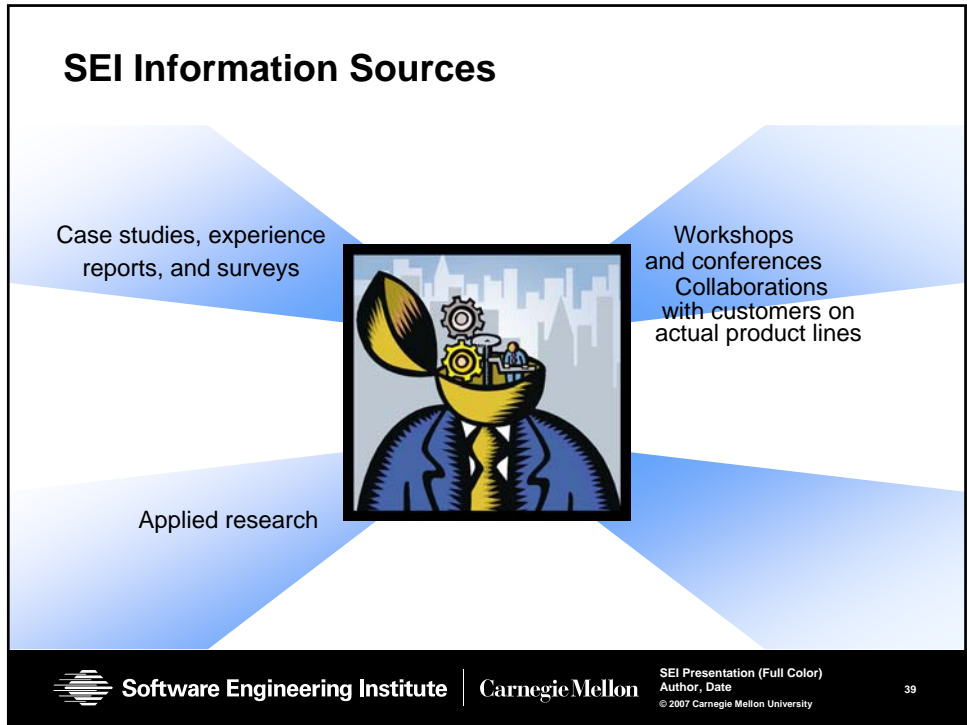
Software Engineering Institute

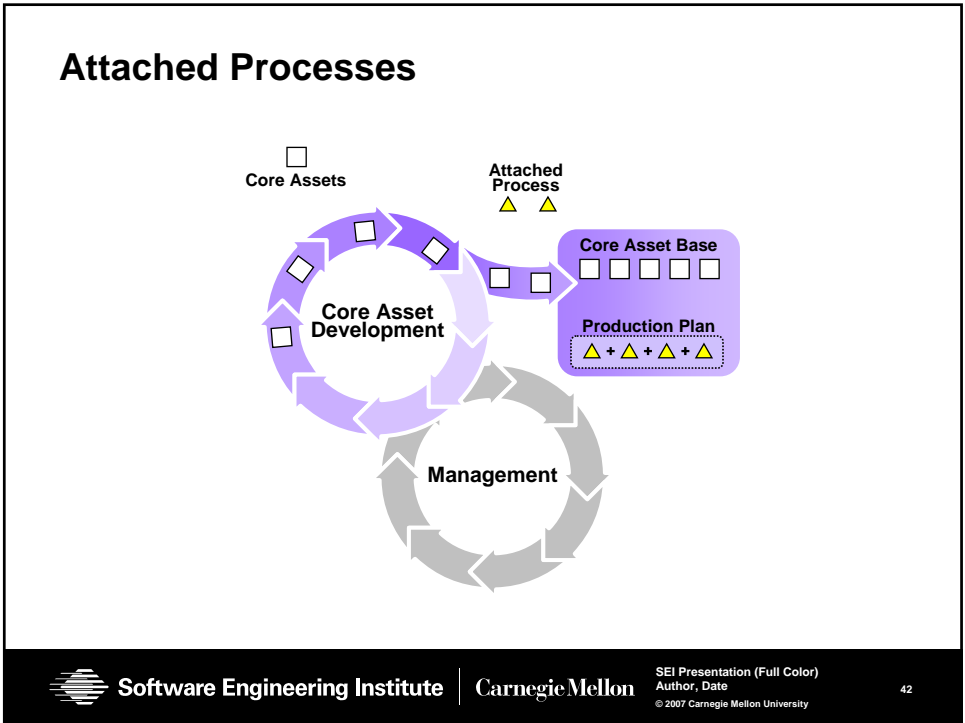
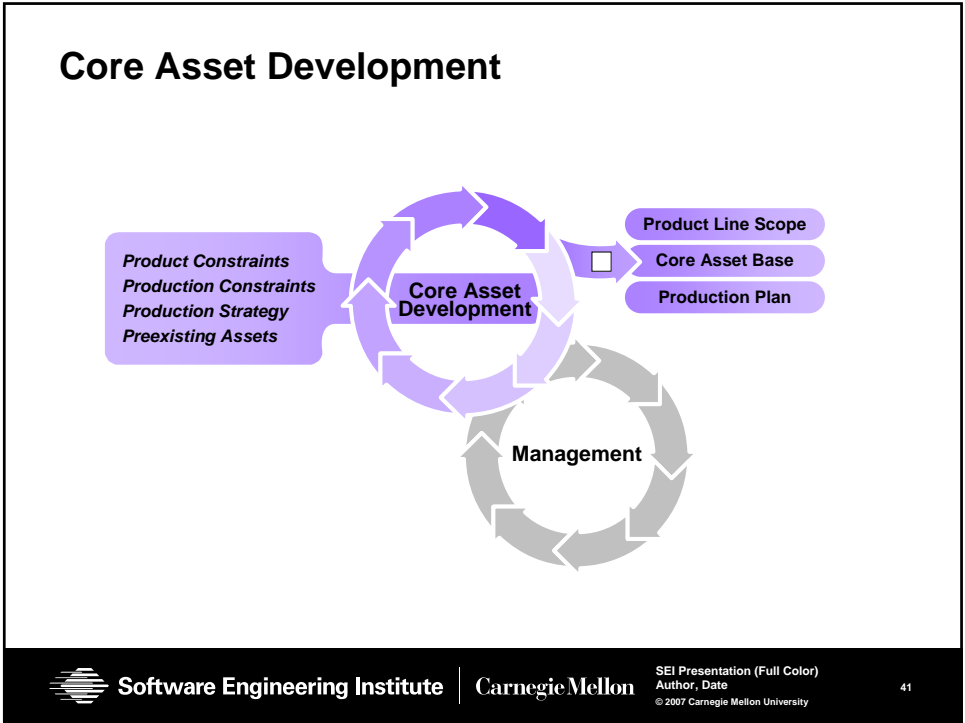
CarnegieMellon

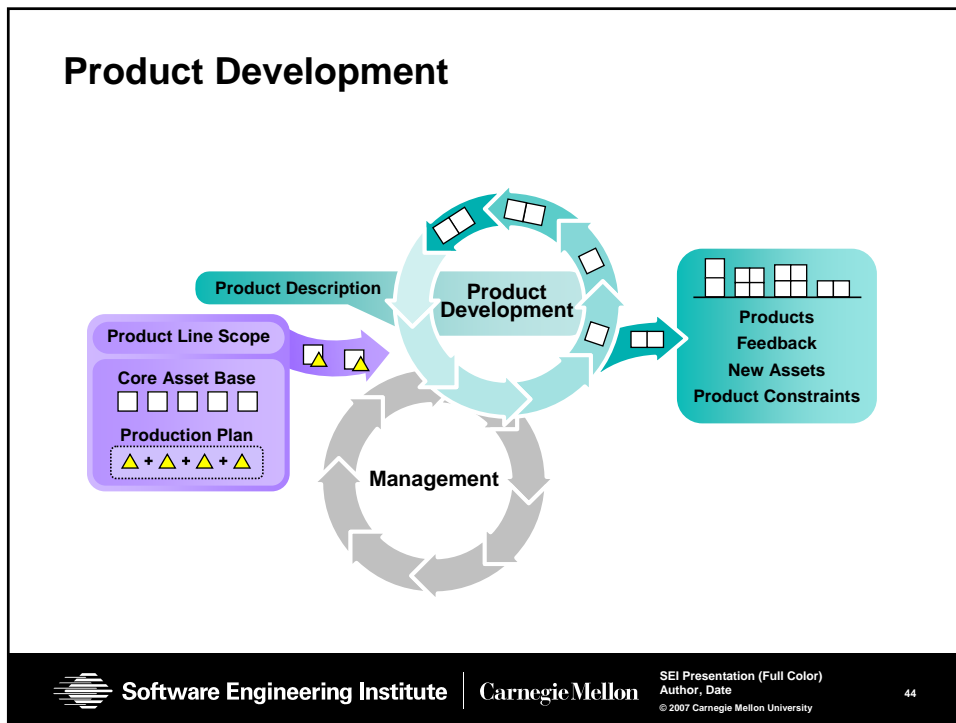
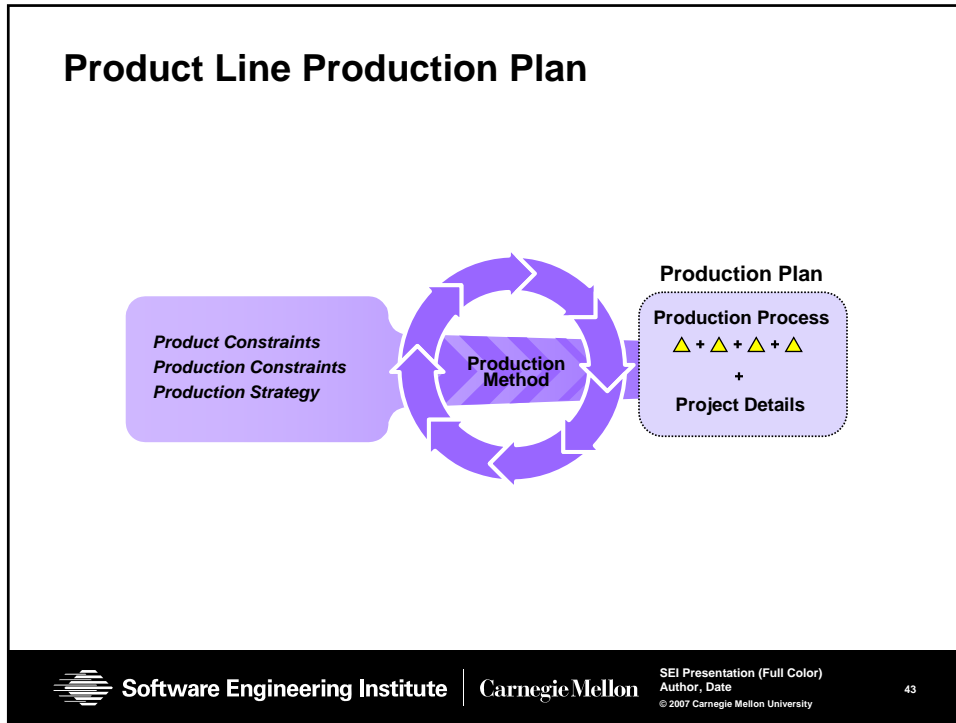
SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

38









Management

The diagram illustrates a management framework. At the top, two grey circular arrows represent 'Core Asset Development' (with a square icon) and 'Product Development' (with a diamond icon). Below these, a larger red circular arrow represents 'Management'. The arrows indicate a cyclical flow between the development phases and the central management function.

Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
 Author, Date
 © 2007 Carnegie Mellon University

45

Management

Management at multiple levels plays a critical role in the successful product line practice by

- achieving the right organizational structure
- allocating resources
- coordinating and supervising
- providing training
- rewarding employees appropriately
- developing and communicating an acquisition strategy
- managing external interfaces
- creating and implementing a product line adoption plan
- launching and institutionalizing the approach in a manner appropriate to the organization

A cartoon illustration of a manager in a blue suit pointing at a green screen with a diagram. In front of the screen, a team of four people in blue suits and yellow hard hats are listening attentively.

Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
 Author, Date
 © 2007 Carnegie Mellon University

46

Managing A Software Product Line Requires Leadership

A key role for software product line management is that of champion.

A champion must

- set and maintain the vision
- ensure that the appropriate goals and measures are in place
- “sell” the product line up and down the chain
- sustain morale
- deflect potential derailments
- solicit feedback and continuously improve the approach



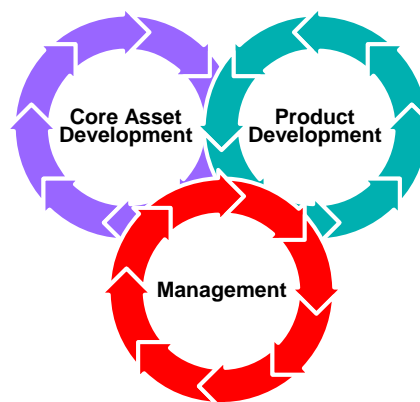
Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

47

Essential Product Line Activities



Each of these is essential, as is the blending of all three.



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

48



Different Approaches - 1

Proactive: Develop the core assets first.

- Develop the scope first and use it as a “mission” statement.
- Products come to market quickly with minimum code writing.
- Requires upfront investment and predictive knowledge

Reactive: Start with one or more products.

- From them, generate the product line core assets and then future products; the scope evolves more dramatically.
- Much lower cost of entry
- The architecture and other core assets must be robust, extensible, and appropriate to future product line needs.



Different Approaches - 2

Incremental: In either a reactive or proactive approach, it is possible to develop the core asset base in stages, while planning from the beginning to develop a product line.

- Develop part of the core asset base, including the architecture and some of the components.
- Develop one or more products.
- Develop part of the rest of the core asset base.
- Develop more products.
- Evolve more of the core asset base.
- ...



Alternate Terminology

Our Terminology	Alternate Terminology
Product Line	Product Family
Software Core Assets	Platform
Business Unit	Product Line
Product	Customization
Core Asset Development	Domain Engineering
Product Development	Application Engineering

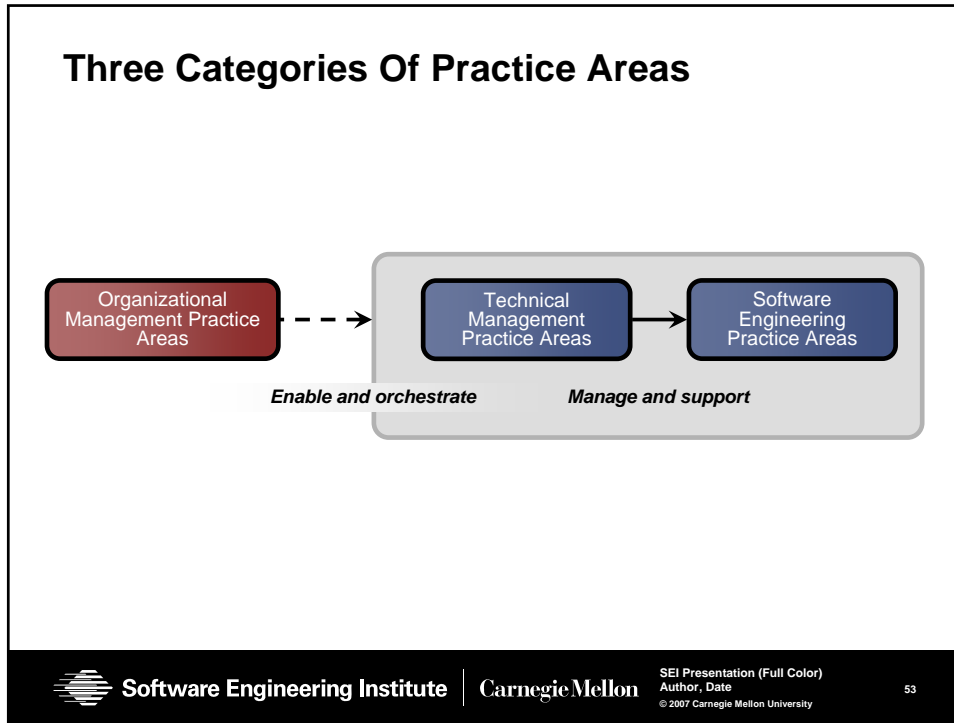


Driving The Essential Activities

Beneath the level of the essential activities are essential practices that fall into practice areas.

A **practice area** is a body of work or a collection of activities that an organization must master to successfully carry out the essential work of a product line.





Framework Version 5.0

Core Asset Development

Product Development

ESSENTIAL ACTIVITIES

PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	Make/Buy/Mine/Commission Analysis	Customer Interface Management
Component Development	<i>Measurement and Tracking</i>	Developing an Acquisition Strategy
Mining Existing Assets	<i>Process Discipline</i>	Funding
Requirements Engineering	Scoping	Launching and Institutionalizing
Software System Integration	Technical Planning	Market Analysis
Testing	Technical Risk Management	Operations
Understanding Relevant Domains	Tool Support	Organizational Planning
<i>Using Externally Available Software</i>	Key: <i>New Name and Substantial Change</i> Substantial Change	Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training

Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

54

Dilemma: How Do You Apply The 29 Practice Areas?

Organizations still have to figure out how to put the practice areas into play.

Twenty-nine is a big number.



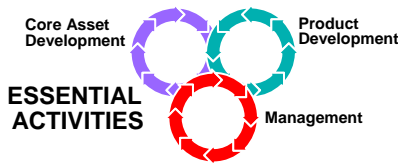
Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

55

Help To Make It Happen



PRACTICE AREAS

Software Engineering

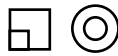
Technical Management

Organizational Management

GUIDANCE



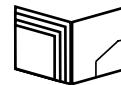
Case Studies



Patterns



Probe



Curriculum



Software Engineering Institute

CarnegieMellon

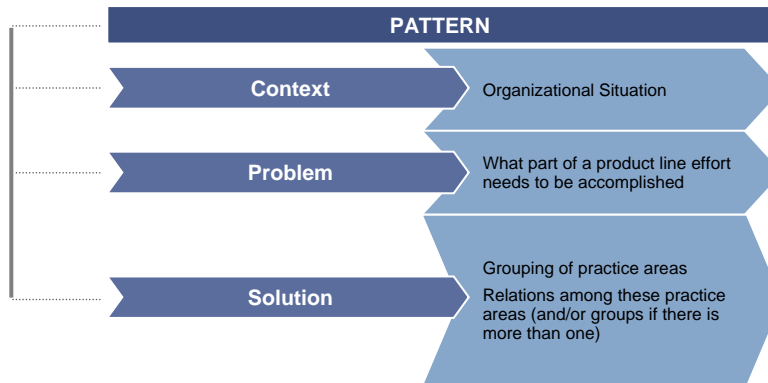
SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

56



Software Product Line Practice Patterns

Patterns are a way of expressing common context and problem-solution pairs.



What To Build Pattern - 1

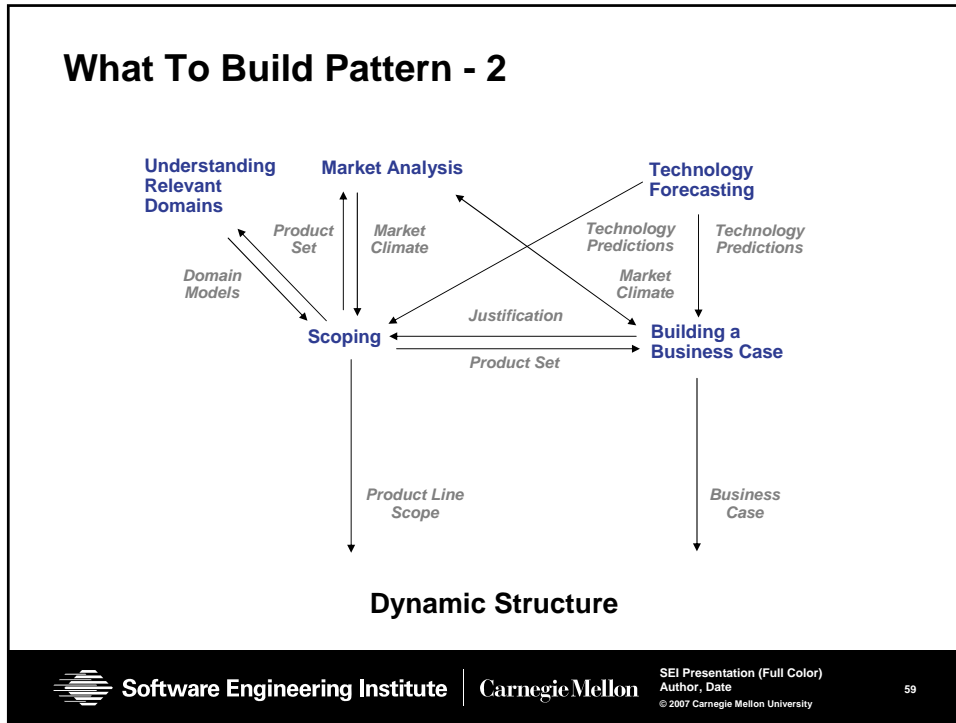
Name: The *What to Build* pattern helps an organization determine what products ought to be in its software product line – what products to build.

Context: An organization has decided to field a software product line and knows the general product area for the set of products.

Problem: To determine what products should be included in the product line

Solution: Determining what to build requires information related to the product area, technology, and market; the business justification; and the process for describing the set of products to be included in the product line.





Factory Pattern - 1

Name: The *Factory* pattern is a composite pattern that describes the entire product line organization.

Context: An organization is considering (or fielding) a product line.

Problem: To map the entire product line effort

Solution: Fielding a product line involves

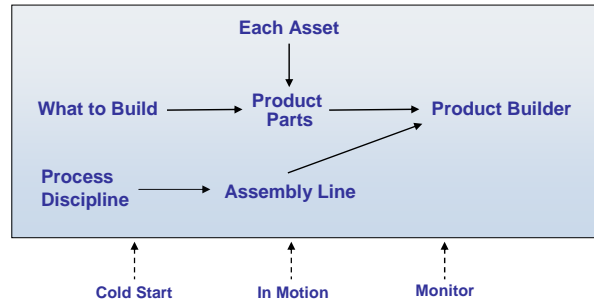
- deciding what to build
- building and running the production capability
- preparing the organization
- designing and providing the product parts
- running the assembly line
- monitoring the process

Software Engineering Institute | CarnegieMellon

SEI Presentation (Full Color)
 Author, Date
 © 2007 Carnegie Mellon University

60

Factory Pattern - 2



Informs and information flow
 Supports

Dynamic Structure



Current Set Of Patterns

Pattern	Variants
Assembly Line	
Cold Start	Warm Start
Curriculum	
Each Asset	Each Asset Apprentice Evolve Each Asset
Essentials Coverage	
Factory	Adoption Factory
In Motion	
Monitor	
Process	Process Improvement
Product Parts	Green Field Barren Field Plowed Field
What to Build	Analysis Forced March



The Product Line Adoption Endgame

To have an *operational software product line*.

To do that, an organization must

- have
 - a core asset base
 - supportive processes and organizational structures
- develop products from that asset base in a way that achieves business goals
- improve and extend the software product line effort as long as it makes sense



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

63

Barriers to Product Line Adoption

- Lack of knowledge
- Need for organizational change
- Cultural resistance
- Lack of sufficient management support
- Lack of necessary talent
- Incompatible development processes
- Globalization of workforce
- Stove-piped mentality
- No clear path to follow

Change management models are useful.

A product line adoption roadmap is helpful.



Software Engineering Institute

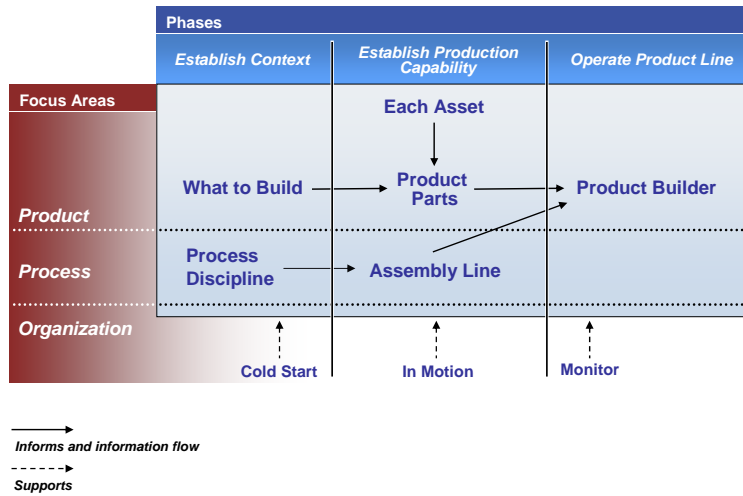
CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

64



The SEI Adoption Factory Pattern



Associated Practice Areas

	Establish Context	Establish Production Capability	Operate Product Line
Product	<ul style="list-style-type: none"> Marketing Analysis Understanding Relevant Domains Technology Forecasting Building a Business Case Scoping 	<ul style="list-style-type: none"> Requirements Engineering Architecture Definition Architecture Evaluation Mining Existing Assets Component Development Using Externally Available Software Software System Integration Testing 	<ul style="list-style-type: none"> Requirements Engineering Architecture Definition Architecture Evaluation Mining Existing Assets Component Development Using Externally Available Software Software System Integration Testing
Process	<ul style="list-style-type: none"> Process Discipline 	<ul style="list-style-type: none"> Make/Buy/Mine/Commission Configuration Management Tool Support Measurement and Tracking Technical Planning Technical Risk Management 	
Organization	<ul style="list-style-type: none"> Launching and Institutionalizing Funding Structuring the Organization Operations Organizational Planning Customer Interface Management Organizational Risk Management Developing an Acquisition Strategy Training 	<ul style="list-style-type: none"> Launching and Institutionalizing Funding Structuring the Organization Operations Organizational Planning Customer Interface Management Organizational Risk Management Developing an Acquisition Strategy Training 	<ul style="list-style-type: none"> Measurement and Tracking Technical Risk Management Organizational Risk Management Customer Interface Management Organizational Planning



What's Different About Reuse With Software Product Lines?

- Business dimension
- Iteration
- Architecture focus
- Preplanning
- Process and product connection
- Maintenance and growth of the reused assets over time – not “clone and own”



Software Engineering Institute

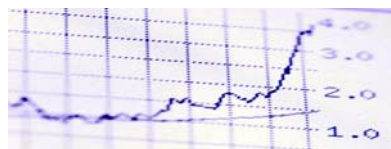
CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

67

At The Heart Of Successful Product Lines

- A pressing need that addresses the heart of the business
- Long and deep domain experience
- A legacy base from which to build
- Architectural excellence
- Process discipline
- Management commitment
- Loyalty to the product line as a single entity



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

68



Summary of SEI Contributions

Models and Guidance

- *A Framework for Software Product Line PracticeSM*
- *Software Product Line Acquisition: A Companion to A Framework for Software Product Line Practice*
- Product line practice patterns
- Product line adoption roadmap
- Pedagogical product line

Methods and Technology

- product line analysis
- architecture definition, documentation, evaluation (ATAM®), and recovery
- mining assets
- production planning
- Structured Intuitive Product Line Economics (SIMPLE)
- Product Line Technical ProbeSM (PLTPSM)
- Product Line Quick Look (PLQL)
- Interactive workshops in product line measurement, variability management, product line management
- Prediction-enabled component technology

Book

Software Product Lines: Practices and Patterns

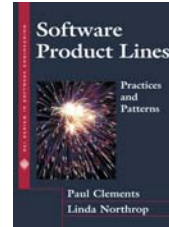
Curriculum and Certificate Programs

- Five courses and three certificate programs
- Product Line Executive Seminar

Conferences and Workshops

- SPLC 1, SPLC2, SPLC 2004; SPLC 2006; Workshops 1997 - 2005

Technical Reports, publications, and Web site



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

69

Final Word

If properly managed, the benefits of a product line approach far exceed the costs.

Strategic software reuse through a well-managed product line approach achieves business goals for:

- efficiency
- time to market
- productivity
- quality
- agility



**Software Product Lines:
Reuse That Makes Business Sense.**



Software Engineering Institute

CarnegieMellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

70



Questions – Now Or Later

Paul Clements

Product Line Systems Program
Email: clements@sei.cmu.edu

Linda Northrop

Director, Product Line Systems Program
Telephone: 412-268-7638
Email: lmn@sei.cmu.edu

U.S. Mail:

Software Engineering Institute
Carnegie Mellon University
4500 Fifth Avenue
Pittsburgh, PA 15213-3890

World Wide Web:

<http://www.sei.cmu.edu/productlines>
SEI Fax: 412-268-5758



Software Engineering Institute

Carnegie Mellon

SEI Presentation (Full Color)
Author, Date
© 2007 Carnegie Mellon University

71

