Domain-specific Engineering for Productivity and Quality

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Domain-specific Engineering

• What is it?
  – Problems it solves
  – Concepts, experience

• How does it work?
  – Creating a domain
  – Producing customized products

• How do you start?
Symptoms of a Problem

• An organization repeatedly builds similar systems, with excessive costs, delays, and errors.

• Customers’ needs are often unclear or misstated.

• With incomplete or unclear requirements, developers resort to arbitrary development choices that are difficult to change.

• Predictable changes in requirements or technology force substantial rework of systems.
Source of the Problem: The Software Process

- Optimized to creating unique products, one at a time, to address precise, unchanging requirements
- Lacks automation beyond record keeping aids
- Results in products that are unreliable and expensive to change
- Level-of-effort funding that conflicts with a need to invest in software capability
The Alternative: Domain-specific Engineering (DsE)

Standardization of the most effective solutions to a class of similar problems

• Identify a product line business area whose customers need similar products.

• Develop a shared understanding of how and why needed products are similar.

• Create a means to produce standardized, customized products rapidly.

• Transition systematically, with tailoring and incremental improvement.
Conventional Organizational Model

Business Area

Project ➔ Product ➔ Customer

User
Organizational Model for DsE
Goals of Domain-specific Engineering

• Customized products in less time at lower cost

• A revised product rapidly when a customer’s needs change

• Less redundant work, due to standardization and reuse, when creating similar products

• A shared understanding of problems and solutions

• A framework for disciplined engineering methods
Implications

• Management focuses on domain investment, not costs of single-product crafting

• Projects focus on resolving key problem/solution variations, with reuse across projects

• Marketing focuses on selling product line capabilities, with better cost-risk estimates

• Fast, flexible responses to diverse and changing customer needs
Benefits

• Cost-reducing standardization:
  – Market-focused business objectives lead to explicit limits on product diversity.
  – The development process is reduced to its essentials for a particular product line.

• Market-responsive flexibility:
  – A product can be tailored to each customer’s specific needs.
  – A new product version can be produced whenever a customer’s needs change.
  – Alternate versions of a product can be built (or modeled) to let a customer choose a preferred solution.
Basic Tenets of Reuse

• The only sound basis for reuse is an envisioned set of **similar** products or components: a family.

• Similarity implies both **commonality** and **variability**:
  – Commonality is the basis for *standardization* of products and process (to form a domain).
  – Variability characterizes the **flexibility** needed to accommodate differences in customers’ needs.

• **Adaptability** is an explicit representation of similarity, characterized by a set of deferred/changable **decisions** sufficient to designate a particular member of a family.
Industrial Experience

• Rockwell
  – Message switching systems software
  – Global Positioning Services

• Boeing
  – Flight training systems software

• Lockheed-Martin
  – Command center software
  – Satellite avionics software
  – Test equipment software

• Thomson-CSF (multiple domains)
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Domain-specific Engineering

Business Objectives

Process Adoption

Domain-specific Engineering

Application Software/System Product

Product Usage

Customer Needs

Customers
The DsE Process

- Business Objectives
- Domain Engineering
- Domain
- Application Engineering
- Application Product
- Product Usage
- Customer Needs
- Market and Project Needs
Activities

• Domain Engineering:
  – Standardize a product family, adaptable to deferred requirement and engineering decisions.
  – Establish a standard process for resolving deferred decisions.

• Application Engineering:
  – Resolve deferred decisions to match customer needs.
  – Mechanically produce a product, adapted to resolved decisions.
A Domain Engineering Process

Domain Management

Domain Definition
  Decision Model
  Process Engineering
  Product Family Engineering
  Domain Verification
  Project Support
A Conventional Application Engineering Process

- Requirements Analysis
- Design
- Implementation

Domain Infrastructure

Requirements Assets
Design Assets
Implementation Assets
A Streamlined Application Engineering Process

- Project Management
- Application Modeling
- Application Production
- Delivery & Operation Support

Product Specification & Validation
Product Generation & Verification
Product Distribution

Domain Infrastructure
Results of DsE

• Customer needs expressed in a standardized, abbreviated form and terminology ensures clearer communication and earlier discovery of unsupported needs.

• Quality improvements in the product family improve the quality of all products.

• Process standardization fosters more predictable schedules and cost estimates.

• Process streamlining, based on a product family, reduces time and effort to deliver similar products.

• Problem and solution knowledge and expertise are more easily shared and extended.
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Is Domain-specific Engineering Right for You?

- There is a viable future market for a line of similar products:
  - Multiple customers with differing needs
  - A single customer who needs multiple versions
  - Customer needs or supporting technologies that are likely to change

- Appropriate management and engineering expertise is available (and, optionally, a legacy of prior products)

- Management is committed to the product line market as a cohesive business area.
**Process Adoption**

- Strategic business process improvement undertaken to institute an organizational capability

- For Reuse-driven Process Improvement (PI_r):
  - Scope is 1 product line business area derived using a domain viability model.
  - Process improvement is guided by integrated process maturity and reuse maturity models.
  - Process tailoring is based on an organizational reuse capability model.
  - Effort is integrated with other process improvement actions (BPR, CMM, technology insertion, etc.).
Risk Reduction

- Tailor domain capabilities to particular organizational needs and capabilities
  - Opportunistic *(enhanced project-level reuse)*
  - Integrated *(collaborative domain/projects operations)*
  - Leveraged *(domain-specific streamlined processes)*
  - Anticipating *(domain-market coevolution)*

- Develop and use domain capabilities in short increments

- Institute continuous improvement
Key Goals

• Organizational commitment
  – Create organizational expertise in Domain-specific Engineering
  – Charter a domain wherever a product line business case exists

• Domain engineering
  – Standardize shared understanding of product line problems and solutions in a product family
  – Create an infrastructure for “manufacturing” standardized products
For Additional Information on Domain-specific Engineering

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