“A Reuse Maturity Model”

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Abstract:

The authors have prepared a draft Reuse Maturity Model to assess organizational processes instrumental to achieving high levels of reuse. This position paper outlines the model and its rationale, and lists sample questions that might be used to determine maturity level. The authors have presented portions of the model informally at prior Software Productivity Consortium-sponsored workshops, and have received initially positive reactions. Participation in the 5th Annual Workshop on Software Reuse would present an additional opportunity to gather valuable feedback. The model, in fact, provides a concise way of gathering information on reuse practices within industrial organizations. Thus, asking attendees to plot their reuse maturity should prove a useful exercise.

The model consists of a maturity framework with five levels: Initial/Chaotic, Monitored, Coordinated, Planned, and Ingrained. Ten dimensions or aspects of reuse maturity have also been enumerated. For each dimension, an attribute or characteristic situation has been specified for each maturity level. Thus, for example, at the Initial level of reuse maturity, we suggest that the dimension “Reuse Inventory (Assets)” would characteristically be a “Salvage Yard — no apparent structure to the collection.” Incorporation of such characteristic descriptions should enable companies to find their place in the maturity framework with a minimum of effort.

Motivation for developing the Reuse Maturity Model comes from observing the enormous impact the Software Engineering Institute's software Capability Maturity Model has had. The SEI has focused attention on process issues in a most remarkable way by examining characteristic engineering practices and providing a means to classify an organization into one of five maturity levels. Moreover, the SEI has established the principle in people's minds that the quality of a software product is dictated by the quality of the processes used to develop that product. We seek to capitalize on that notion by focusing attention on the underlying processes needed to successfully reuse software. Furthermore, the SEI has convinced executive managers that process improvement must come a step at a time, by laying a foundation for process improvement on which other improvement activities can build. We seek to convince executive managers of a similar notion: that a solid foundation for software reuse must be laid and built upon, a step at a time.

We also admire the impact which the SEI achieved with the presentation of an integrated maturity model. Attempts to foster higher levels of reuse may have foundered in the past because they dealt only with technology issues, such as classification mechanisms, or only with business issues, such as data rights. Through our Reuse Maturity Model, we hope to convince executive management that achieving reuse requires a comprehensive approach. Many pieces must fall into place before significant advances can be made. In a manner similar to the SEI model, an organization must satisfy all the conditions for Level 2 reuse maturity in order to lay the foundation for achieving Level 3 reuse maturity.

The Reuse Maturity Model was developed during a year-long system improvement project at Harris Corporation. We identified numerous obstacles that must be overcome in order to achieve high levels of reuse, among them:

> **Cultural:** Incentives and management backing must be put in place; any tendency toward NIH ("Not Invented Here") syndrome must be eliminated.
>
> **Institutional:** A corporate-wide forum is needed to discuss common product areas where reuse could pay off. Points in the product development cycle must be identified where reuse concerns can always be raised and resolved. An ongoing group must take up responsibility for advocating reuse and managing reusable assets on a day-to-day basis — in other words, for making reuse succeed.
>
> **Financial:** The costs and benefits must be understood for a product life cycle based on a "Design for Reuse" philosophy. Reusable work-products must be viewed as capital assets that require maintenance and enhancement.
>
> **Technical:** Guidelines, techniques, and standards for making things reusable must be developed; mechanisms must be put in place to ensure they are followed. Taxonomies and retrieval mechanisms for cataloguing and recovering reusable parts will be needed; assurance mechanisms will be needed to guarantee the suitability of a part for a stated purpose; etc.

Legal: Negotiations must be undertaken to determine how to retain rights to components developed under customer contract and recover costs in a reuse context. Mechanisms will be needed for payment and collection of royalties (ala the music industry) for use and reuse in the commercial arena.

We concluded that achieving reuse must be recognized for what it is: a challenge requiring significant organizational commitment and fundamental organizational changes. Moreover, these changes will not occur overnight, but must be undertaken step by step. The authors hope that formulation of the Reuse Maturity Model will enable executive management to see Software Reuse as an interconnected set of cultural, institutional, financial, technical and legal challenges that must be tackled in coordinated fashion.

Figure 1 presents the dimensions of reuse maturity considered critical in analyzing an organization's commitment to reuse. For each combination of maturity level and maturity dimension, the authors have described a characteristic situation that might exist. Figure 2 was developed for briefing executive management. It describes each reuse maturity level narratively and highlights key realizations and events that might provide the impetus to advance to the next maturity level.

Questions have been formulated to determine an organization's readiness to encourage reuse. A subset of the questions, presented below, suggest a myriad of activities needed to promote reuse.

- Has an incentives program been established (organizational awards, individual awards, etc.)?
- Have metrics of reuse been established? collected? Have savings attributable to reuse been established? Have the costs of non-reuse been identified?
- Is there a designated individual or group responsible for making reuse happen (by collecting reusable things, assessing their quality, enhancing them, etc.)?
- Is there a catalog of reusable components?
- Are life-cycle products (requirements, designs, implementations, documentation, test plans, etc.) all collected?
- Is a central review of all projects performed to assess commonality and reuse potential?
- Is reuse activity linked to strategic business plans (i.e. product development plans)?
- Do training programs exist for reuse?
- Are reuse concerns addressed at various life cycle points (SSR, PDR, CDR, etc.) and incorporated in project reviews?

Figure 1.

Reuse Maturity Framework					
Dimensions of Maturity	LEVEL				
	1 Inital/Chaotic	2 Monitored	3 Coordinated	4 Planned	5 Ingrained
Motivation/ Culture	Reuse is discouraged	Reuse is encour-aged	Reuse is incentivized, reinforced, rewarded	Reuse is indoctrinated	Reuse is “the way we do business"
Planning for reuse	Nonexistent	Grassroots activity	Targets of opportunity	Business imperative	Part of a strategic plan
Breadth of reuse involvement	Individual worker	Work group	Department	Division	Enterprise-wide
Responsibility for making reuse happen (advoca-cy + day-to-day management)	Individual initiative (Personal goal; as time allows)	Shared initiative	Dedicated individual	Dedicated group	Corporate group (for visibility not control) with division liaisons
Process by which reuse is leveraged	Development process chaotic; unclear where reuse comes in	Reuse questions raised at design reviews (After the fact)	Design emphasis placed on reuse of off-the-shelf parts	Focus on developing families of products	All software prod-ucts genericized for future reuse
Reuse inventory (assets)	Salvage yard (No apparent structure to collection)	Catalog identifies language- and platform-specific parts	Catalog organized along application-specific lines	Catalog includes generic data processing functions	Planned activity to acquire or develop missing pieces in catalog
Classification activity	Informal, individualized (“In the head”, “In the drawer”)	Multiple independent schemes for classifying parts	Single scheme, catalog published periodically	Some domain analyses performed to determine categories	Formal, complete, consistent, timely classification
Technology support	Personal tools, if any	Lots of tools, e.g. CM, but not specialized to reuse	Classification aids & synthesis aids	Electronic library separate from development environment	Automated support integrated with development system
Metrics	No metrics on level of reuse, payoff, or cost of reuse	Number of lines of reused code factored into cost models	Manual tracking of reuse occurrences of catalog parts	Analyses performed to identify expected payoffs from developing reusable parts	All system utilities, software tools, and accounting mechanisms instrumented to track reuse
Legal, Contractual, Accounting considerations	Inhibitor to getting started	Internal accounting scheme for sharing costs, allocating benefits	Data rights and compensation issues resolved with customer	Royalty scheme for all suppliers and customers	Software treated as key capital asset

Purpose: GM-level briefing on the characteristic stages of reuse

FIVE STAGES OF REUSE MATURITY

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	Initial/Chaotic	Monitored	Coordinated	Planned	Ingrained
Character-istics	o Reuse is individualized, uncoordinated, unmonitored,etc. o High reliance on people reuse o Frequent resistance to reuse o Costs of reuse are "feared" o Short-term thinking	o Managerial awareness of reuse activities, but little active promotion of reuse. o Costs of reuse are "known" o Basic definitions of reuse are agreed upon o Reuse is viewed as a set of single-point opportunities o Individual achievements are rewarded. o General-purpose analyzers, CM tools, etc. combined to assess reuse levels.	o Organization responsible for reuse o Product Line domain analyses performed o A key business strategy. o Part of AOP objectives. o Investments made in reuse, payoffs expected. o Reuse tactics worked out. o Payoff of reuse is "known" and understood for a given domain. o Shared understanding of all the activities needed to support reuse. o Standardization on components o Tools customized to support reuse.	o Life cycle view of reuse. All costs associated with a component's development and all savings from its reuse are reported. o Have all the data needed to decide which components to build/acquire. o Synergistic processes are in place to support and encourage reuse. o Reuse occurs across all functional areas	o Corporation-wide view. o A discriminator in business success. o "The way we do business." o Outstanding successes have occurred. o All major obstacles to reuse have been removed. o All definitions, guidelines, standards, command media are in place, enterprise-wide. o Domain analyses performed across all product lines. o Fully integrated with development and reporting systems.
Motivation for advancement to next stage		Recognition of competitive pressures	Technology support becomes available	Multi-year commitment; larger benefits sought; 5-year vision of where to get to	Enhance competitive advantage; build leadership position.
Necessary transitional event		GM demands specific, periodic progress reports	Specific AOP objectives are set	Business planning activity addresses life cycle costing.	Institutionalization and acculturation.

Figure 2.

- For the most part, do people work on projects similar to ones in their work experience?

- Is a lessons learned exercise (including characterization of work products) a mandatory part of project closeout?

- Is a use history and a reuse history kept for each item in the inventory?

The authors hope that presenting such questions will help executive managers realize that large-scale reuse is harder to achieve than it might first appear. We hope to convey the message that one person can reuse the tools and components he's built before and a small group can share such things effectively. But large-scale reuse, the kind that results in competitive leverage, requires organizational planning and commitment.

Our Reuse Maturity Model suggests an orderly way to build the basis for reuse, that is, by taking the characteristic description at each maturity level/maturity dimension combination and turning it into a positive activity. For instance, the characteristic description at the Coordinated level/Classification Activity dimension suggests working out a single classification scheme and periodically publishing the catalog of reusable components.

In terms of continuing work on the Reuse Maturity Model, we are just beginning to systematically collect feedback from industrial organizations on its usefulness. Inasmuch as we have seen many Level 1 Reuse organizations, only a handful of companies at the intermediate levels, and can only hypothesize what a Level 5 Reuse company would look like, we expect some significant revisions will be needed to the model. An additional step will be augmenting the reuse maturity questionnaire and organizing subsets of the questions to address each level of reuse maturity separately. We will also consider a scoring scheme to determine an assigned reuse maturity number. While calculating a score is less important than identifying reuse process areas needing improvement, a single-number maturity level nonetheless provides something for people to latch onto. Progress toward reuse process improvement can be more objectively measured.