Achieving Agility and Stability in Large-Scale Software Development

Ipek Ozkaya
Senior Researcher,
Research, Technology, and System Solutions Program

Ipek Ozkaya is a senior member of the technical staff in the Research, Technology, and System Solutions Program at the SEI. She is currently engaged in activities focusing on large scale agile and architecture and works to develop, apply, and communicate effective methods to improve software development efficiency. Ozkaya serves as the chair of the advisory board of the IEEE Software magazine and is also a member of the technical faculty for the Master of Software Engineering Program at Carnegie Mellon University.
**Report Documentation Page**

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

<table>
<thead>
<tr>
<th>1. REPORT DATE</th>
<th>2. REPORT TYPE</th>
<th>3. DATES COVERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 JAN 2013</td>
<td></td>
<td>00-00-2013 to 00-00-2013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. TITLE AND SUBTITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieving Agility and Stability in Large-Scale Software Development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5a. CONTRACT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5b. GRANT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5c. PROGRAM ELEMENT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5d. PROJECT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5e. TASK NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5f. WORK UNIT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. AUTHOR(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnegie Mellon University, Software Engineering Institute, Pittsburgh, PA, 15213</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8. PERFORMING ORGANIZATION REPORT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. SPONSOR/MONITOR’S ACRONYM(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. SPONSOR/MONITOR’S REPORT NUMBER(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. DISTRIBUTION/AVAILABILITY STATEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved for public release; distribution unlimited</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13. SUPPLEMENTARY NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14. ABSTRACT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15. SUBJECT TERMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16. SECURITY CLASSIFICATION OF:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. REPORT unclassified</td>
</tr>
<tr>
<td>b. ABSTRACT unclassified</td>
</tr>
<tr>
<td>c. THIS PAGE unclassified</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17. LIMITATION OF ABSTRACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same as Report (SAR)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>18. NUMBER OF PAGES</th>
<th>19a. NAME OF RESPONSIBLE PERSON</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std Z39-18
Agenda

Concepts of scale and root-cause analysis

Tactics that can help

Examples
Are we asking the right question?

How much should we architect?

• This process, or that one…

When should we architect?

• Balancing anticipation versus adaptation…
Increased visibility into delivery

Focus on Priority

Focus on Integrated Value

Focus on Cost
Polling question

Which software development process are you currently using?

1. Agile software development (e.g., using Scrum, XP practices, test-driven development)
2. Waterfall/phased-based development
3. Rational unified process
4. Organization-specific iterative and incremental development
5. None of the above
Symptoms of failure

- Teams (e.g., Scrum teams, product development teams, component teams, feature teams) spend almost all of their time fixing defects, and new capability development is continuously slipping.

- Integration of products built by different teams reveals that incompatibility defects cause many failure conditions and lead to significant out-of-cycle rework in addition to end-to-end fault-tolerance failure.

- High testing costs result in some testing activities to be eliminated.
A closer look at scale: Scope

- Is the project in a new domain or technology?

- Does the project have new requirements—such as standards compliance, system testing, and integration lab environments—or does it simply have more features, elements, and relationships?

- Is there a need to align systems engineering and software development activities?
A closer look at scale: Team

- Are there multiple teams that need to interact, both internal and external to the organization?

- What are the dependencies between the work products of system and software engineers?

- Have you considered the end-to-end success of features that may require resources from multiple teams?
A closer look at scale: Time

- Does the work require different schedule constraints for releases?
- How long is the work product expected to be in service?
- How important are sustainability and evolution?
Polling question

Are you currently doing development in a large-scale context that can be captured by extended scope, team size, or timelines of scale?

1. Large team size
2. Larger than normal scope
3. Longer development roadmap
4. Product expected to be in service for a long time
5. At least two of the above
Investigate both technical and nontechnical areas, looking at both Agile software development and software architecture fundamentals.
Root-cause analysis

Response to change

• Dynamic environment and changing requirements are understood.
• Necessary technology and processes are identified to respond to change.
• Impact of uncertainty on the project is acknowledged.
• Waste is identified and tradeoffs managed (e.g., technical debt and defects).
Root-cause analysis

Culture

• People are made available (internal and external), including an appropriate number of people who have the right skills and knowledge and clear responsibilities.

• Team members are motivated and empowered by many degrees of freedom.

• Clear communication among teams and team members is established.

• There is high-level management support.
Root-cause analysis

Quality attributes

• The importance of quality attribute requirements is understood.
• Quality attribute requirements are defined and tied to business goals.
• Means for analysis of necessary quality attributes are in place and used to predict system properties.
• Measurement environment is in place to monitor the implemented system quality and “done” criteria.
Root-cause analysis

Architecture

• Evidence is provided that the architecture satisfies quality attribute requirements.
• Appropriate functional requirements are assigned to architecture elements.
• Architectural issues (e.g., technical debt) are tracked and managed.
• Timeline of critical architectural decisions is clear and scheduled.
Tactics to consider

Align feature and system decomposition.
Create an architectural runway.
Use matrix teams and architecture.
Align feature and system decomposition

| Dependencies between stories & supporting architectural elements | Understanding the dependencies between stories and architectural elements enables staged implementation of technical infrastructure in support of achieving stakeholder value. |
| Dependencies among architectural elements | Low-dependency architectures are a critical enabler for scaling up Agile development.¹ |
| Dependencies among stories | High-value stories may require the implementation of lower value stories as precursors.² |


Align feature and system decomposition

Tension between high-priority features (vertical decomposition) and common reusable services (horizontal decomposition)

**Feature-driven approach**
- Feature 1 → Feature 2 → Feature 3
- Vertical decomposition (e.g., subsystems, features)

**Infrastructure-driven approach**
- Applications
- Services
- Drivers
- Horizontal decomposition (e.g., layers)

**Hybrid approach**
- Feature 1 → Feature 2 → Feature 3
- Services
- Drivers

© 2013 Carnegie Mellon University
Align feature and system decomposition
Two examples

Decouple teams and architecture to ensure parallel progress as the number of teams increases.
Create an architectural runway

The architectural runway provides the degree of architectural stability to support the next $n$ iterations of development.

In a Scrum project environment, the architectural runway may be established during Sprint 0.

- Sprint 0 might have a longer duration than the rest of the sprints.
Create an architectural runway

The bigger the system, the longer the runway.
Leffingwell, Martens, Zamora

Use matrix teams and architecture

Establishing the infrastructure

Scrum Team A
Presentation Layer
Common Service

Scrum Team B
Domain Layer
API
Common Service

Scrum Team C
Data Access Layer
API
Common Service
Use matrix teams and architecture

Feature development in parallel

Scrum of Scrums

- Team member with feature responsibility
Use matrix teams and architecture

Different teams are assigned to different features, and some team members are assigned to keep layers and framework consistent.
Use matrix teams and architecture

Different teams are assigned to different features, and a temporary team is assigned to prepare layers and frameworks for future feature teams.
Example 1: Inability to manage scope and time

Symptom

• Scrum teams spend almost all of their time fixing defects, and new feature development is continuously slipping.

Root-cause

• Initial focus was “general” rather than “product specific.”
  — Time pressure to deliver became the top priority.
  — The team delivered an immature product.
  — A plethora of variation parameters interact detrimentally.

• There are three different cycles:
  1. Customer release (annually, many variants)
  2. IV&V Testing (quarterly, 4 variants)
  3. Developmental (monthly, 1 variant)
Solution

Stabilize the architecture.

- Build an architecture for current products.
  - Rules, guidelines
  - Over a few time boxes
- Reduce the number of “variant parameterizations.”
- Make everyone play from the same sheet music.
- Postpone adding new features.

Re-plan the release cycles/time boxes.
Revisit the testing strategy/team assignments against variants.
Example 2: Inability to manage teams and scope

Symptom

- Integration of products built by different Scrum teams reveals that incompatibility defects cause many failure conditions and lead to significant out-of-cycle rework.

Root cause

Cross-team coordination is poor, even though there are many coordination points and much time spent.

- Different teams have different interpretations of interfaces.
- The product owner on each Scrum team does not see the big picture.
- A mismatch exists between the architecture and Scrum development.
Solution

Stabilize to remove failures.

- Postpone adding new features.

Identify and collapse common services across teams.

Use an architectural runway.

- A system that has an architectural runway contains existing or planned infrastructure sufficient to allow incorporation of current and near-term anticipated requirements without excessive refactoring.

- An architectural runway is represented by *infrastructure* initiatives that have the same level of importance as the larger scale requirements epics that drive the company’s vision forward.
Final thoughts

Systematic root-cause analysis is essential for understanding risks arising in large-scale software development.

Embracing the principles of both Agile software development and software architecture provide improved visibility of project status and better tactics for risk management.

- Align feature and system decomposition.
- Create an architectural runway.
- Use matrix teams and architecture.

Architecting is an ongoing activity throughout the software development life cycle regardless of choice of process.
References


Contact Information

Ipek Ozkaya
Senior Member of the Technical Staff
Research, Technology, and System Solutions Program
Architecture Practices Initiative
Email: ozkaya@sei.cmu.edu

Software Engineering Institute
Customer Relations
4500 Fifth Avenue
Pittsburgh, PA 15213-2612
USA
New SEI eLearning Portal Brings SEI Courses to You

The SEI is pleased to announce the new SEI eLearning Portal, a new platform for the development and delivery of SEI eLearning courses to conveniently meet your professional development needs.

The SEI eLearning Portal provides expert instruction as well as exercises, assessments, and other resources, creating a rich educational experience that is accessible by learners worldwide.

- learn at your own pace
- communicate easily with instructors
- access courses 24/7
- study at home, work, or on the road
- read materials online or download for later
- track your course progress

http://www.sei.cmu.edu/training/elearning