Knowledge Sharing Mechanism: Enabling C2 to Adapt to Changing Environments

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Agenda

- Introduction
- History of Software Engineering
- The Unfolding Process
- Image Theory and Differentiation
- Knowledge Insight Model (KIM)
- Knowledge Sharing Mechanism (KSM)
- Analysis of KSM
- Applying KSM to C2
- Conclusion

Introduction

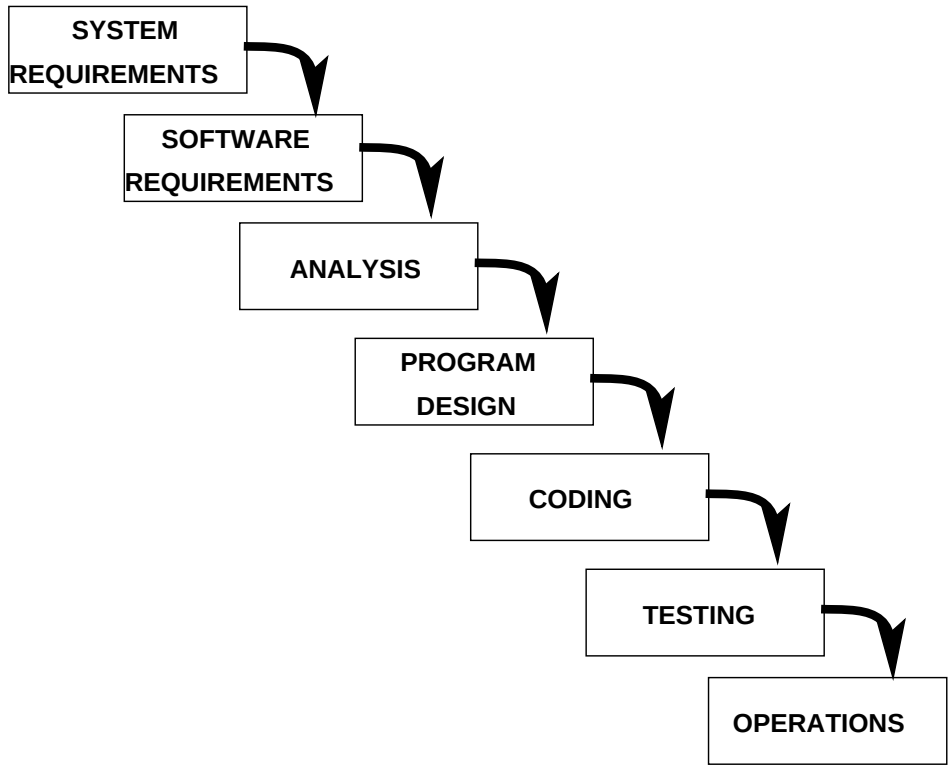
- Research Motivation – Similarity of Software Engineering and Command and Control
  - Instances of Problem Solving
  - Similar histories (Chaos → Hierarchy → Agile)
  - Change and Uncertainty

History of Software Engineering

- Software Engineering
  - Software was an afterthought to hardware, no structured method of development.
  - Growing software complexity resulted in projects being late and over budget (a growing crisis).
  - Phrase coined during 1968 NATO Conference.

History of Software Engineering

- Waterfall Method
  - Winston Royce (1970)
  - Derivative of traditional production methodology
  - Unable to accommodate change



- Agile Methods
  - XP, Scrum, Crystal
  - Agile Manifesto (2001)
  - Embrace change
  - Rapid development and customer feedback

The Unfolding Process

- Christopher Alexander
  - Architect by training, however he has influenced many other disciplines
  - Sought to understand and re-create good design
  - Key note speaker at the 1996 OOPSLA Conference
  - Works include *The Timeless Way of Building*, *A Pattern Language*, and *The Nature of Order* series

The Unfolding Process

- Wholeness and Centers
  - A design that has “life” must have a high degree of “wholeness”
  - Wholeness – “local parts exist chiefly in relation to the whole, and their behavior and character and structure are determined by the larger whole in which they exist and which they create.”
  - Centers – entities that contribute to the wholeness of a design; “a distinct physical system which occupies a certain volume in space, has a special marked coherence”

The Unfolding Process

- Wholeness and Centers
  - Example: Pond from *The Phenomenon of Life*, *Nature of Order*
  - Wholeness
  - Fuzzy boundaries

Photo from *Nature of Order*

The Unfolding Process

- Nature of Centers
  - Centers themselves have life.
  - Centers help one another; the existence and life of one center can intensify the life of another.
  - Centers are made of centers (recursion).
  - A structure gets its life according to the density and intensity of the centers which have been formed in it.

The Unfolding Process

- 15 Properties
  - Based on Alexander's research into natural and classical design
  - Interdependent, not independent
  - Used to understand and strengthen centers

1. Levels of Scale
2. Strong Centers
3. Boundaries
4. Alternating Repetition
5. Positive Space
6. Good Shape
7. Local Symmetries
8. Deep Interlock and Ambiguity
9. Contrast
10. Gradients
11. Roughness
12. Echoes
13. The Void
14. Simplicity and Inner Calm
15. Not-Separateness

The Unfolding Process

- The Unfolding Process
  - Third party (observer) perspective of design evolution
  - Step-by-step adaptation
  - 15 Properties become 15 Transformations
  - Example: Mouse forelimb development

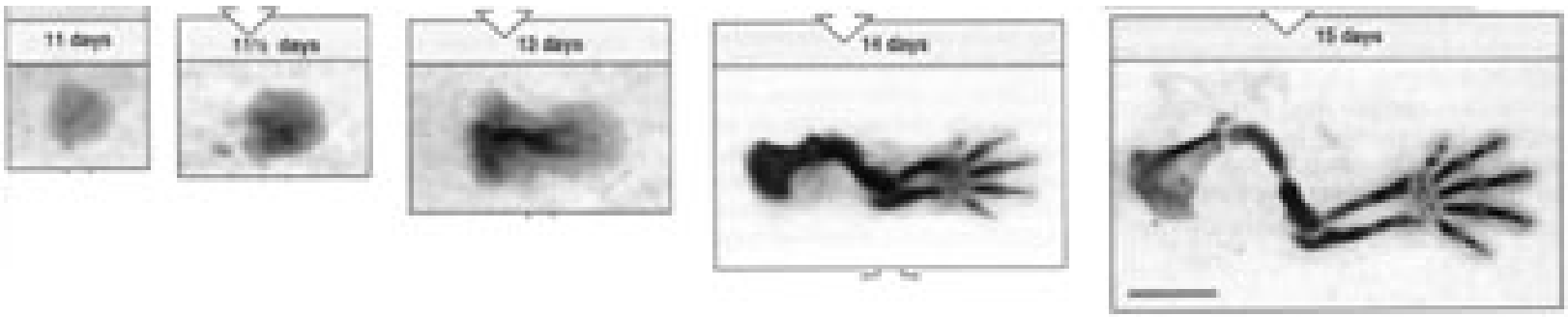


Photo from *Nature of Order*

Image Theory and Differentiation

- Alexander's Approach to Topsight and Insight
  - View of the design's wholeness = topsight
  - View of a particular center in the design = insight
- The Differentiation Process
  - First party (actor) perspective of design evolution
  - 4 Necessary Conditions:
    - Awareness of the whole
    - Step-by-step adaptation
    - Unpredictability
    - Feedback

Image Theory and Differentiation

- The Differentiation Process
  1. *At any given moment in a process, we have a certain partially evolved state of a structure. This state is described by the wholeness: the system of centers, and their relative nesting and degrees of life.*
  2. *We pay attention as profoundly as possible to this wholeness - its global, large-scale order, both actual and latent.*
  3. *We try to identify the sense in which this structure is weakest as a whole, weakest in its coherence as a whole, most deeply lacking in feeling.*

Image Theory and Differentiation

- The Differentiation Process (continued)

4. *We look for the latent centers in the whole. These are not those centers which are robust and exist strongly already; rather, they are centers which are dimly present in a weak form, but which seem to us to contribute to or cause the absence of life in the whole.*
5. *We then choose one of these latent centers to work on. It may be a large center, or middle-sized, or small.*
6. *We use one or more of the fifteen structure-preserving transformations, singly or in combination, to differentiate and strengthen the structure in its wholeness.*

Image Theory and Differentiation

- The Differentiation Process (continued)

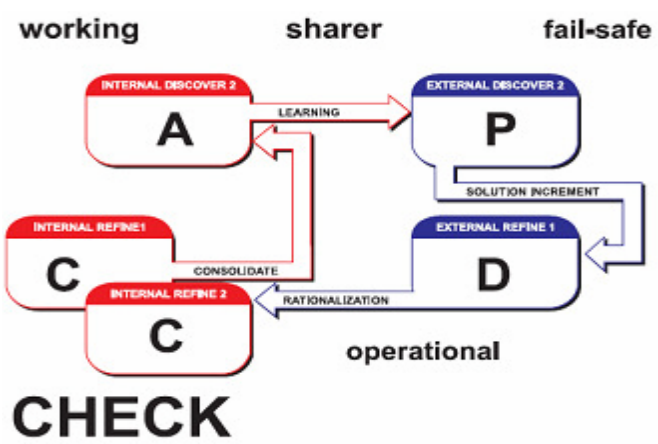
7. *As a result of the differentiation which occurs, new centers are born. The extent of the fifteen properties which accompany creation of new centers will also take place.*
8. *In particular we shall have increase the strength of certain larger centers; we shall also have increased the strength of parallel centers; and we shall also have increased the strength of smaller centers. As a whole, the structure will now, as a result of this differentiation, be stronger and have more coherence and definition as a living structure.*

Image Theory and Differentiation

- The Differentiation Process (continued)
  9. *We test to make sure that this is actually so, and that the presumed increase of life has actually taken place.*
  10. *We also test that what we have done is the simplest differentiation possible, to accomplish this goal in respect of the center that is under development.*
  11. *When complete, we go back to the beginning of the cycle, and apply the same process over.*

Knowledge Insight Model (KIM)

- Four Roles (or Patterns) Emerge:
  - Framer: responsible of understanding the problem and designing an overall architecture (or framework) that will solve the problem.
  - Maker: responsible for creating an innovative solution to the problem using the given framework
  - Finder: responsible for finding resources to supplement the Maker's efforts
  - Sharer: responsible for ensuring that the Framer, Maker, and Finder work together by sharing information


working
sharer
fail-safe
INTERNAL DISCOVER 2
A
LEARNING
EXTERNAL DISCOVER 2
P
SOLUTION INCREMENT
INTERNAL REFINE1
C
CONSOLIDATE
EXTERNAL REFINE 1
D
INTERNAL REFINE 2
C
RATIONALIZATION
operational
CHECK

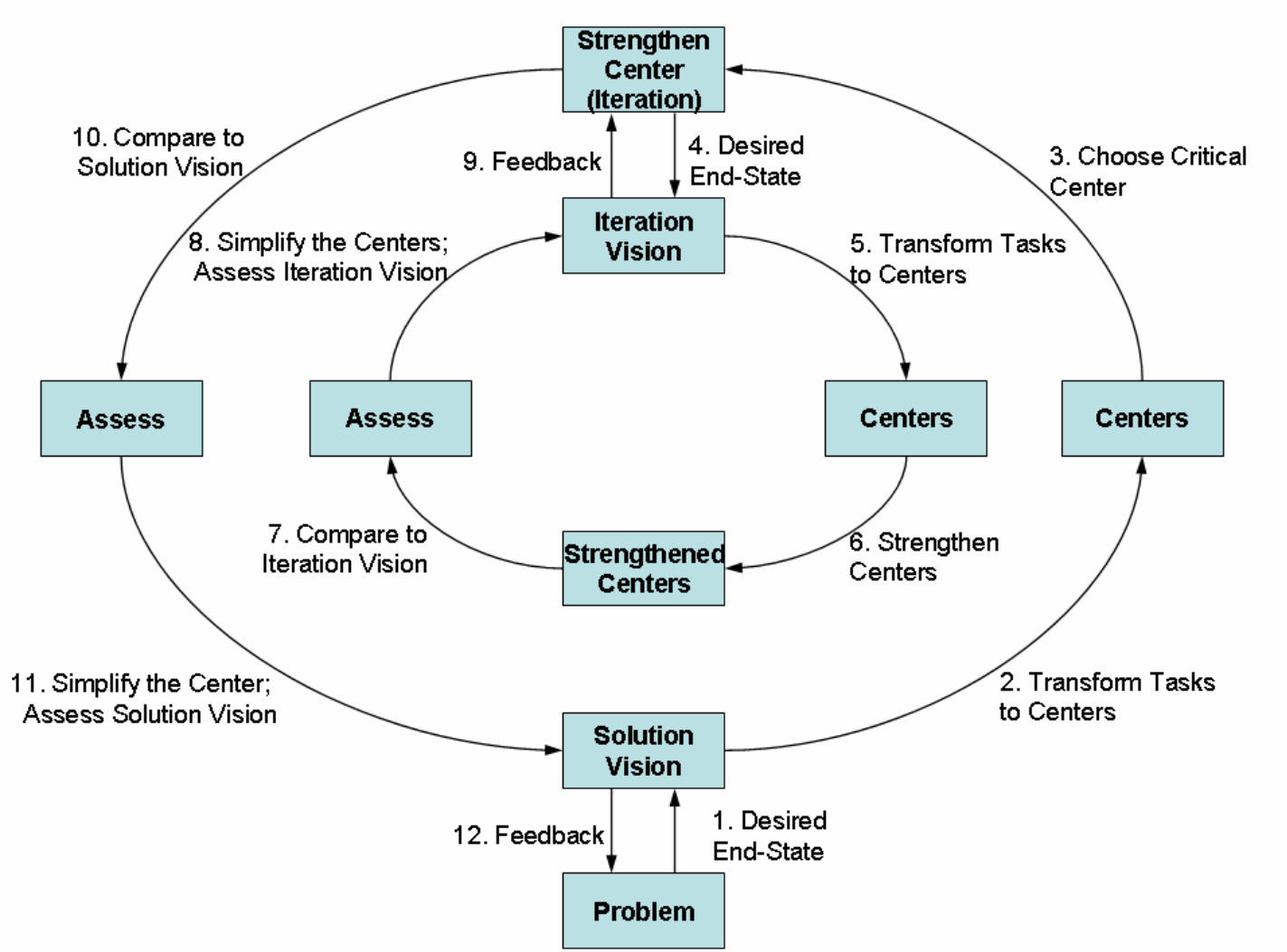
Knowledge Insight Model (KIM)

- KIM and Topsight versus Insight
  - The Framer uses Topsight
  - The Maker and the Finder use Insight
  - The Sharer must balance Topsight and Insight
- The Sharer's Role (or Inner Mechanism) is the most critical to solution's success
- The key must be the development of a knowledge sharing mechanism

Knowledge Sharing Mechanism (KSM)

- Utilizes the power of images
- Balances topsight and insight
- Synthesis of images and the Differentiation Process

Knowledge Sharing Mechanism (KSM)



Knowledge Sharing Mechanism (KSM)

1. Identify the Problem and the Problem's environment.
2. Develop a Solution Vision to solve the problem. The Solution Vision consists of the following: a desired end-state, critical tasks, and a purpose.
3. Begin designing the Solution by transforming each critical task into center
4. Begin a series of Iterations. At the beginning of each Iteration, identify the center which is the most critical at that moment.

Knowledge Sharing Mechanism (KSM)

5. Develop an Iteration Vision to improve/strengthen the chosen center. The Iteration Vision also consists of a desire end-state, critical tasks, and a purpose. It is imperative that the Iteration Vision supports the overall Solution Vision.
6. Improve/strengthen the chosen center.
7. At the end of the Iteration, assess whether the Iteration Vision has been fulfilled with the improvement of the center. Also assess whether the Iteration Vision is still valid and still supports the Solution Vision.
8. Repeat the Iteration process. Throughout the process, assess the Solution Vision to determine if it is still valid or does it need to be modified.

Analysis of KSM

- Command and Control Analysis Metrics
  - **Robustness**: the ability to maintain effectiveness across a range of tasks, situations, and conditions.
  - **Resilience**: the ability to recover from or adjust to misfortune, damage, or a destabilizing perturbation in the environment.
  - **Responsiveness**: the ability to react to a change in the environment in a timely manner.
  - **Flexibility**: the ability to employ multiple ways to succeed and the capacity to move seamlessly between them.
  - **Innovation**: the ability to do new things and the ability to do old things in new ways
  - **Adaptation**: the ability to change work processes and the ability to change the organization.

Analysis of KSM

- KSM addresses:
  - **Robustness** by focusing on problem solving
  - **Resilience** through feedback mechanisms and simplifying
  - **Responsiveness** through continuous assessment and evolution
  - **Flexibility** by use of vision statements
  - **Innovation** through use of centers
  - **Adaptation** with its inherent step-by-step adaptation

Applying KSM to C2

- Integration of KSM into MDMP
  - MDMP consist of 7 steps:
    1. Receipt of Mission
    2. Mission Analysis
    3. Course of Action Development
    4. Course of Action Analysis
    5. Course of Action Comparison
    6. Course of Action Approval
    7. Orders Production
  - KSM applied to Mission Analysis step

Applying KSM to C2

- Mission Analysis
  1. Analyze the higher HQ's order
  2. Perform Initial Intelligence Preparation of the Battlefield
  3. Identify Specified, Implied, and Critical Tasks
- Integration of KSM
  - Visualize higher HQs' Solution Visions and develop unit's Solution Vision
  - Use IPB to understand the problem environment
  - Transform Critical Tasks into Centers

Applying KSM to C2

- Mission Analysis
  4. Review available assets
  5. Determine constraints
  6. Identify critical facts and assumptions
  7. Perform risk analysis
  8. Determine initial CCIR and EEFI
  9. Determine initial ISR plan
  10. Update the timeline
  11. Write the restated mission
- Integration of KSM
  - Perform successive Iteration Cycles developing each Critical Center of the Solution Vision
  - Compare progress to Iteration and Solution Visions
  - Brief the developed Solution Vision to the commander

Conclusion

- Software Engineering and Command and Control environments will grow more complex
- Successful solutions must accommodate change and unpredictability
- KSM provides a framework to accomplish these tasks using a synthesis of the Differentiation Process and image theory

Questions?