Software Architecture

Software Product Line

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Software development

- Develop from scratch
- Develop via reuse
  - Methods and functions
  - Classes and libraries
  - Component
  - Subsystem

software product line

- A software product line organization builds and (re)uses assets, but the assets are all targeted at products within the well-defined scope.
- We will reuse anything (code, documentation, tests,…) as long as it is useful in building the products within the scope of the product line.
- Our goal is not reuse, our goal is to produce products quickly and economically.

software product line

- Some real numbers
  - 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
    - by as much as 98%

Focus on Innovation

- Innovation in a software product line is facilitated by allowing the product manager to quickly dispense with that portion of product implementations covered by the core asset base and focus on innovation.

What makes SPL different?

- There are product management techniques that plan a series of products that share features.
- There are software engineering techniques that share code among products.
- The software product line strategy is the first to integrate the two so that shared features are implemented by shared code in a set of products and in an organization structured to make product production effective and efficient.

Product Line Definition

- 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 product line technique builds different models of a product using common assets

Product Line Definition

- A frequent misconception is that the core assets, the reusable pieces, are the product line. As you can see from the definition, the product line comprises the products.
- Product line is a set of products that address a particular objective
- Using product line to build a product is economic and efficient. Most work is about integration instead of creation.

Product Line Definition

- Example: The components of Boeing 757 and 767 are 60% in common
- Example: The components in different models of M. Benz E class may be over 70% in common.

Product Line Definition

- common set of core assets
  - A "core" asset is anything used to produce multiple products
    - Source code
    - Software architecture
    - Test infrastructure, test cases, and test data
    - Production plans
    - ….

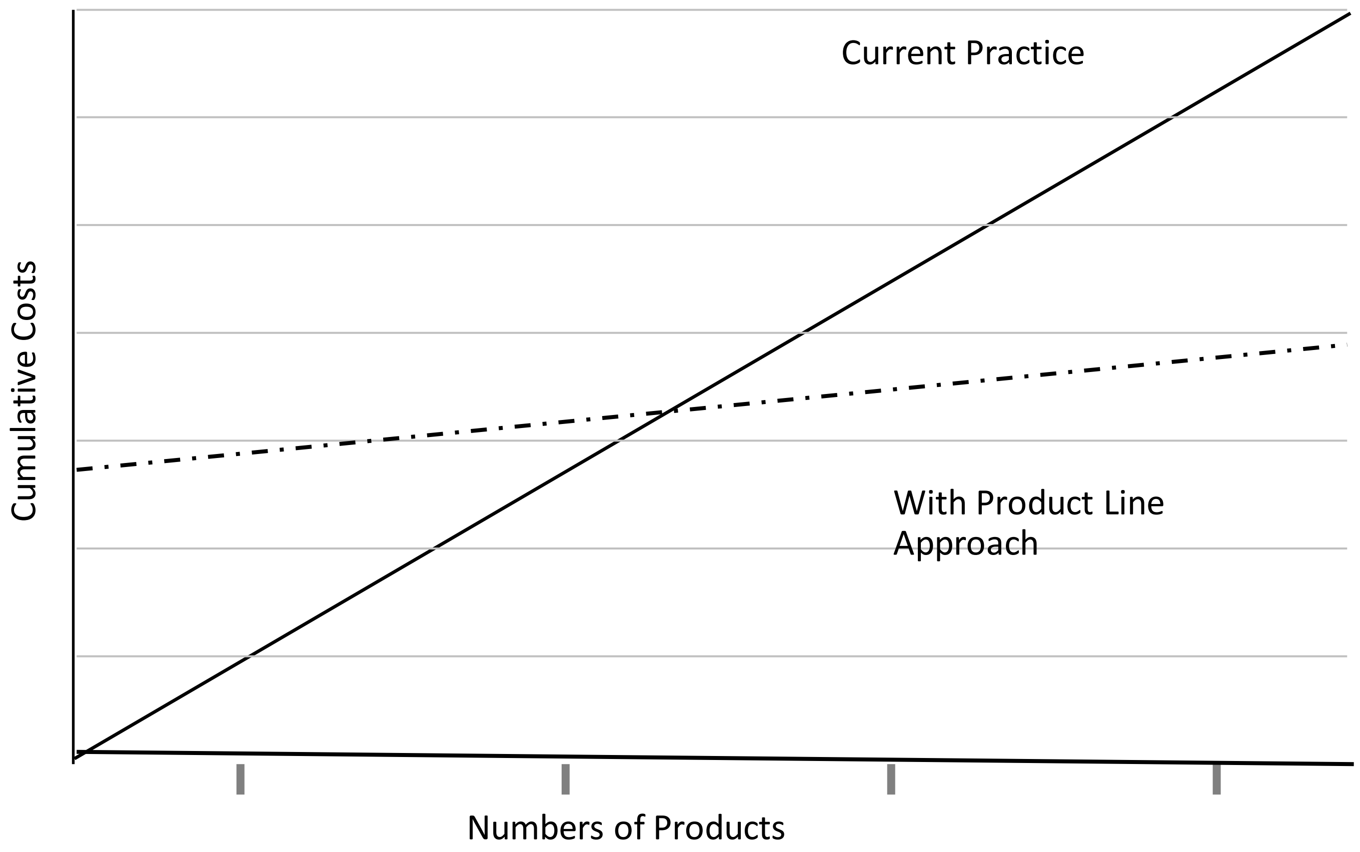
Product Line Definition

- The assets are designed to handle the range of variability defined in the product line scope
- Each asset is accompanied by an attached process, which explains how to use the asset in building a product.

The payoff

- Initiating a software product line strategy requires some amount of up-front investment although it can be minimal.
- If the commonality is sufficiently high, payback can happen after a relatively small number of products.
- Many organizations have reached the payoff point

The payoff


Current Practice
With Product Line Approach
Cumulative Costs
Numbers of Products

Philips Medical

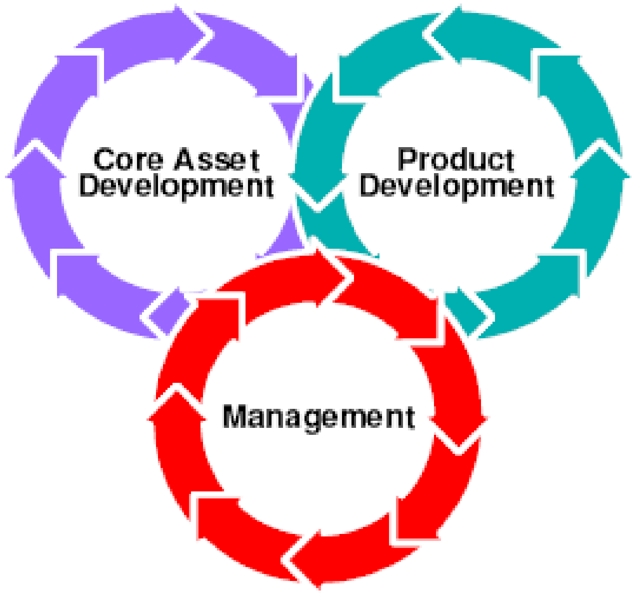
- Goals: Improved time to market and consistent and integrated behavior of applications.
- Achieved
  - 2-4 times effort reduction.
  - Reduction to less than 50% time-to-market.
  - Product defect density to 50% of original rate.
  - Ease of feature propagation from one product to others.
  - Common look-and-feel.
  - Better product planning & use of roadmaps.

Philips Medical

- The primary asset is the product line architecture
- Architecture supports distributed development that will still work seamlessly when integrated
- Philips has developed their core asset base through an innovative approach to open source referred to as “inner source”
- Different business units contribute to the development of the core assets

How’s it done?

- Essential activities
  - Core asset development
  - Product development
  - Management



Core asset development

- What can we profitably reuse?
  - How many products will use it?
  - How much extra will it cost to make it reusable?
- We reuse ANYTHING that makes sense (money)
  - Source code – obviously – but non-software assets also
  - For example, we decompose a test suite into individual test cases, then compose as needed by a product

Core asset development

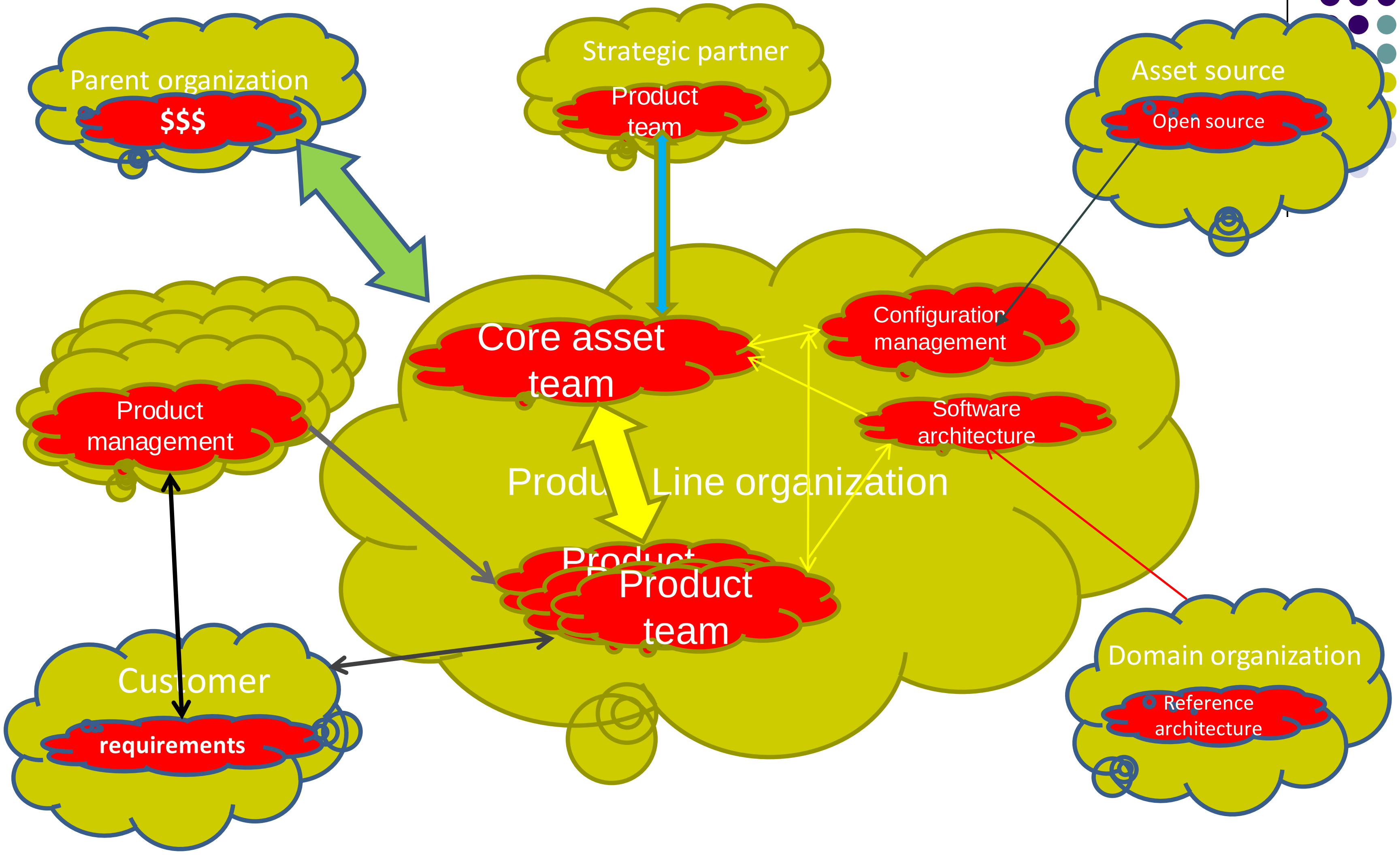
- A team is devoted to providing these assets
- This team has a vision that encompasses all products that would use its assets.
- An "attached process" accompanies each core asset to facilitate reuse of the asset

Product development

- Product development is combining core assets with product-specific artifacts to produce products.
- Product development moves faster than in traditional development because of the assets and the small percentage of product-specific artifacts.
- A product team may continue to own the product it has built or it may hand it off to a maintenance team.

Management

- A central authority, such as a product line manager, oversees the organization which may cut across multiple business unit boundaries
- Coordinates the production of core assets and the assembly of products.
- Ensures that resources are available at the right time to optimize operation of the production capability.



Software product line ecosystem

Software product line

- a product line consists of:
  - multiple systems, which have the same architecture and share common core assets
  - variability among systems
- To produce a product from a product line, the product line should be instantiated through the following two steps:
  - Selection: unneeded functionality (i.e, assets) is stripped, needed assets are selected, variability are solved

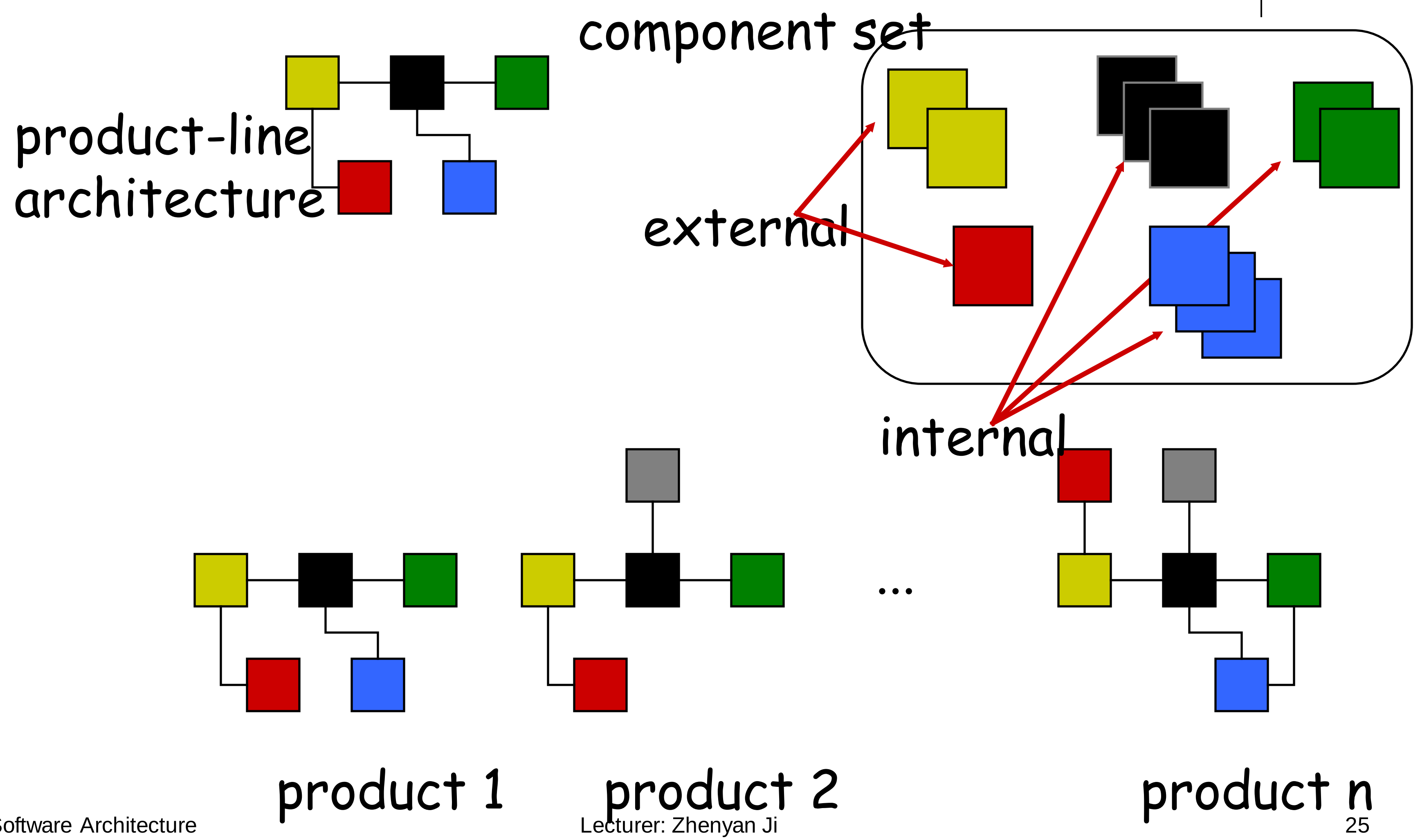
Software product line

- Extension: addition assets are added for the remaining variation points (possibly created from scratch)

Software product line

- Selection is an essential step in producing a product from a product line. The problem is how to select assets from a product line?
- Possible solution: based on keywords, attributes, behaviors, and so on.
- Currently, the most popular approach is based on features.

Software Product Lines



Key ingredients

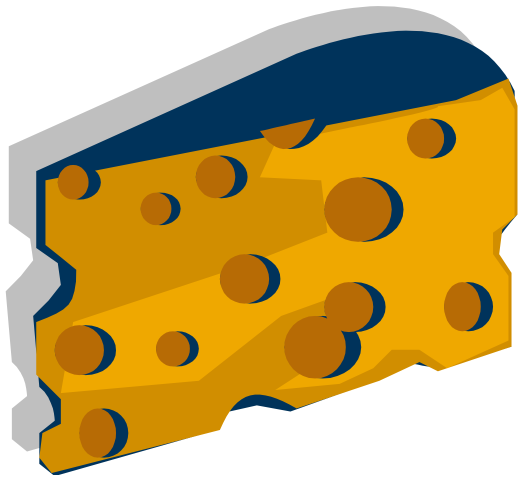
- Business case
- Software architecture
- Variability management

Software architecture

- Perhaps the key core asset
- Captures early decisions about solving the problem
- Communication vehicle among the stakeholders
- Explicitly addresses the quality attributes
  - Reliability
  - Security
  - Dependability

Product line architecture

- The product line architecture is the architecture for a family of systems
- Is more abstract, not every thing is completely defined
- There are holes in its specification, but the architecture constrains how the holes can be filled

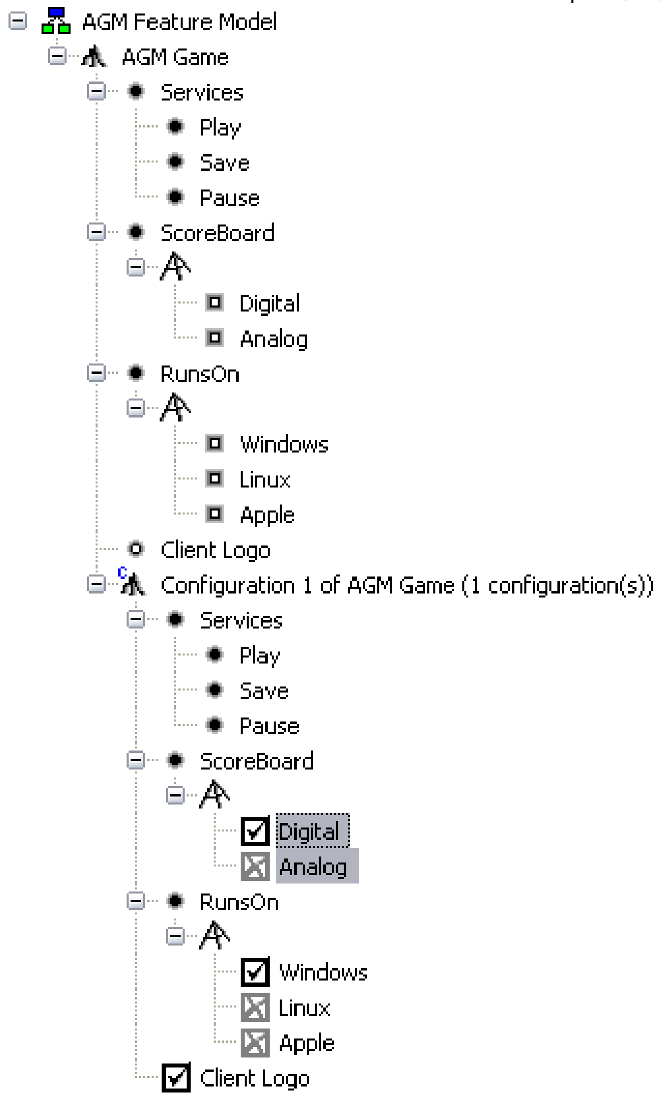


Variation

- Products vary from one another in specific ways - the allowable contents of the holes in the architecture.
- Strategic variations at the business unit level.
- Tactical variations at the technical manager's level
- Variation points at the implementation level.

Commonality/Variability Analysis

- What do the products in the product line have in common?
- How are they different?
- A configuration is a selection of inclusive and exclusive OR feature choices to completely define a single member of the product line.



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AGM Feature Model
  AGM Game
    Services
      Play
      Save
      Pause
    ScoreBoard
      Digital
      Analog
    RunsOn
      Windows
      Linux
      Apple
    Client Logo
  Configuration 1 of AGM Game (1 configuration(s))
    Services
      Play
      Save
      Pause
    ScoreBoard
      ☑ Digital
      ☒ Analog
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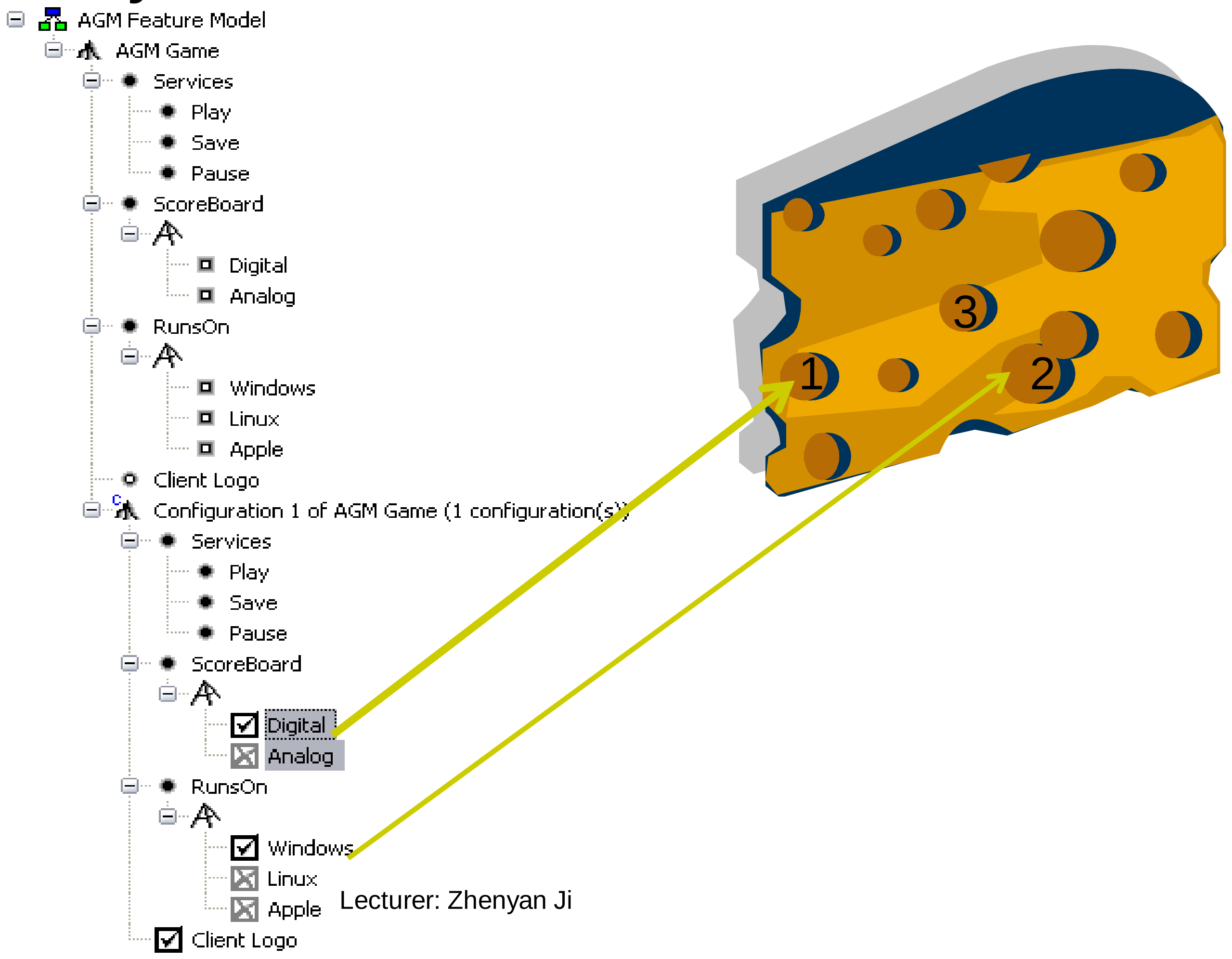
```

Product architecture

- Each hole is plugged by a specific variant determined by the features selected.



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Example (software systems)

- For a bank system product line, you can select the features: deposit, withdraw, loan, remit, foreign currency exchange, and so on. According to the features you selected, a specific bank system can be produced for you. Variability should be solved sometimes, such as what kinds of foreign currency exchange are allowed.

Software product line vs. individual systems

- When a core asset is changed, the change reflects to every system within a product line.
- Product line can be evolved (e.g., a product line may be ported to the Internet). When evolving a product line, all the systems within the product line are evolved
- Individual systems cannot obtain the above benefit.

Software product line vs. individual systems

- If a common component is changed (or added), every system in the individual systems should be changed (extended).
- The work is cumbersome if there are many (e.g., 1000) individual systems.