Program Families

Operating-System Engineering

Programmer’s Practice

We were behind schedule and wanted to deliver an early release with only a proper subset of intended capabilities, but found that this subset would not work until everything worked.\[5\]

We wanted to add simple capability, but to do so would have meant rewriting all or most of the current code.\[5\]

We wanted to simplify and speed up the system by removing the unneeded capability, but to take advantage of this simplification we should have had to rewrite major sections of the code.\[5\]
Software as Product Family

• understanding a program as a single product . . . 

\[
\text{is } \begin{cases} 
\text{good} \\ 
\text{bad} 
\end{cases} \text{ practice from the perspective of } \begin{cases} 
\text{marketing} \\ 
\text{development} 
\end{cases}
\]

• product-line development helps to let do even marketing a better job
  – aim at looking for already existing solutions
  – provide an infrastructure of reusable (software) components
  – don’t re-invent wheels, waste man power, and extent the time to market

• single-product thinking goes back to the “Stone Age” of programming

Product-Line Development

• what was (is) true for “hardware” over a long period is also true for software
  – i.e., hardware such as e.g. car, watch, house, camera, handy and so on
  – i.e., hardware in the sense of an industrial good

• software-product development is an evolutionary process
  – a software product may exist for years, or even decades, at the market
  – typical examples are operating systems: UNIX, e.g., exists since 1970 \(^1\)

• software manufacturing (e.g. operating systems) is an engineering discipline

\(^1\)But this doesn’t mean that UNIX has been a product-line development from the very beginning. Refer to [6].
Product Line $\implies$ Program Family

- a product line is made of a number of individual products:
  - the Volvo 40, 60, 70, and 80, with its V and S models and variations
  - the Leica-M system with its M3, M2, M1, M4, M5, and M6 cameras

- all products of the same line share the same (sub-) set of properties:
  - SIPS and WHIPS is available for the V/S 40, 60, 70, and 80 models, resp.
  - M-lenses are upward compatible from the M3 to the M6 (i.e. 1954 – today)

- a program family is a **software-product line** with programs being the products

Program Family $\implies$ Function Reuse

We consider a set of programs to be a program family if they have so much in common that it pays to study their **common aspects** before looking at the aspects that differentiate them. [5]

We want to **exploit** the commonalities, **share** code, and **reduce** maintenance costs. [5]
Function Reuse $\iff$ Separation of Concerns [2]

- for a function to be reusable, it needs to be “componentized"
  - concentrate on the function’s essentials
  - hide the function’s implementation details as far as possible
  - design a complete and, yet, easy to employ function interface
  - provide a full specification and extensive documentation of the design

- differentiate functional requirements from non-functional requirements
  - free a function’s implementation from any non-functional property
  - particularly, don’t hard-code assumptions about the function’s use pattern

- remind the experiences made over time and reflect the lessons learned

What you demand is what you get — WYDIWYG

Some users may require only a subset of the services of features that other users need. These “less demanding” users may demand that they are not be forced to pay for the resources consumed by the unneeded features. [5]
Family-Oriented Design

**minimal subset of system functions**

- captures common functions that are useful to build specialized systems
- provides mechanisms in the form of fundamental building blocks
- is made of a distinct (i.e., small) number of reusable assets

**minimal system extensions**

- reuse and specialize or customize the fundamental system functions
- encapsulate the strategic and application-specific design decisions
- are stepwise developed bottom-up, directed in a top-down manner

Incremental System Design

- program families tend to exhibit a distinguished, deep hierarchical structure
  - the design process is somewhat challenging and proceeds in “tiny” steps
  ⇒ “decisions which restrict the family are postponed as far as possible.” [3]
  - the result is a multi-level hierarchy of a large number of thin abstractions
- proceeding iterative and bottom-up, from generalization to specialization
Example of a Family of Operating Systems — FAMOS [3]

- the sample shows three family members:
  - a process-control system
  - a time-sharing system
  - a batch system

- ... exploiting a set of commonalities:
  - synchronization
  - process management
  - address space

- ... sharing the same design decisions

Software Framework

Rather than write programs that perform the transformation from input to output data, we design software machine extensions that will be useful in writing many such programs. [5]
Summary

- a major concern is what ideas to exclude from the design [Liskov, 1981]
- keep things as simple as possible [Lampson, 1983]
- the challenge lies in doing it 'right', and 'right' often means staying simple [Svobodova, 1985]
- simple systems work surprisingly well [Birrell, 1986]
- simple things nearly always work, and simple thinks are extensible [Needham, 1986]

Bibliography