NPRG075

Learning from architecture and design

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Lectures: Tuesday 12:20, S6
https://d3s.mff.cuni.cz/teaching/nprg075

Design and architecture

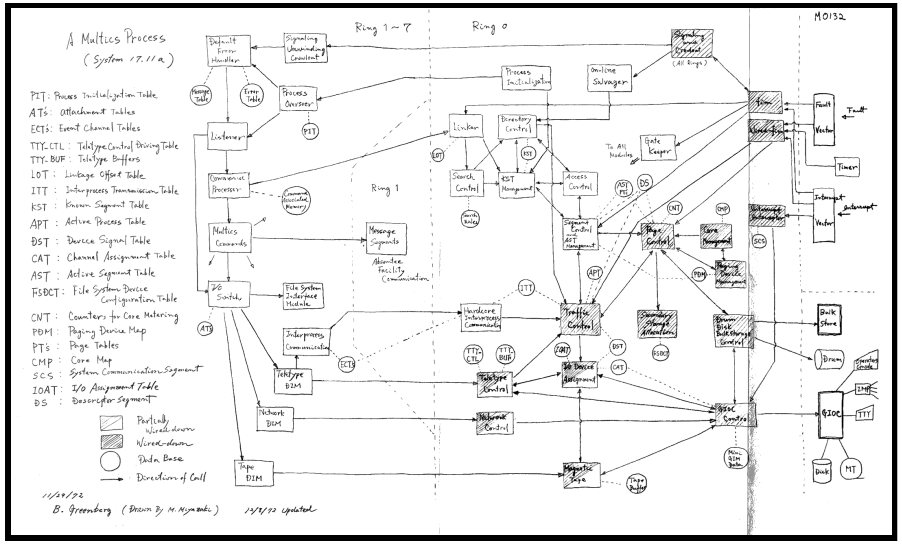
Solving complex problems

Architecture and urban planning

Understanding and solving complex problems

Organizing large number of diverse entities

Useful concepts and methodologies?



Software architecture

How to organize systems?

How can we study what organization makes sense?

How languages and tools shape organization?

How systems grow as requirements change?

Urban planning

Jacobs on cities

Problems of simplicity
Fully analyzable

Unorganized complexity
Statistically analyzable

Organized complexity
Non-reducible

Parnas on software

Analogy systems
Continuous models

Repetitive digital
Reduce via abstraction

Non-repetitive digital
Non-reducible

Design problems

Design problems are ill-defined

- Full information never available
- Cannot be exhaustively analyzed
- No correct solution may exist

Solving design problems

- Conjectured solution reframes the problem
- Designers impose "primary generator"
- Change problem-as-given in light of solution

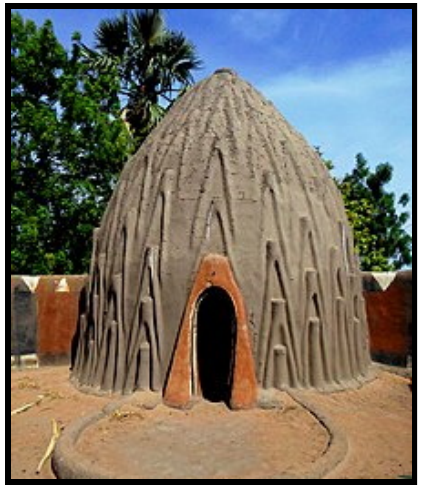
Design patterns

Learning from architecture

Achieving fit

Vernacular

Adaptation over generations

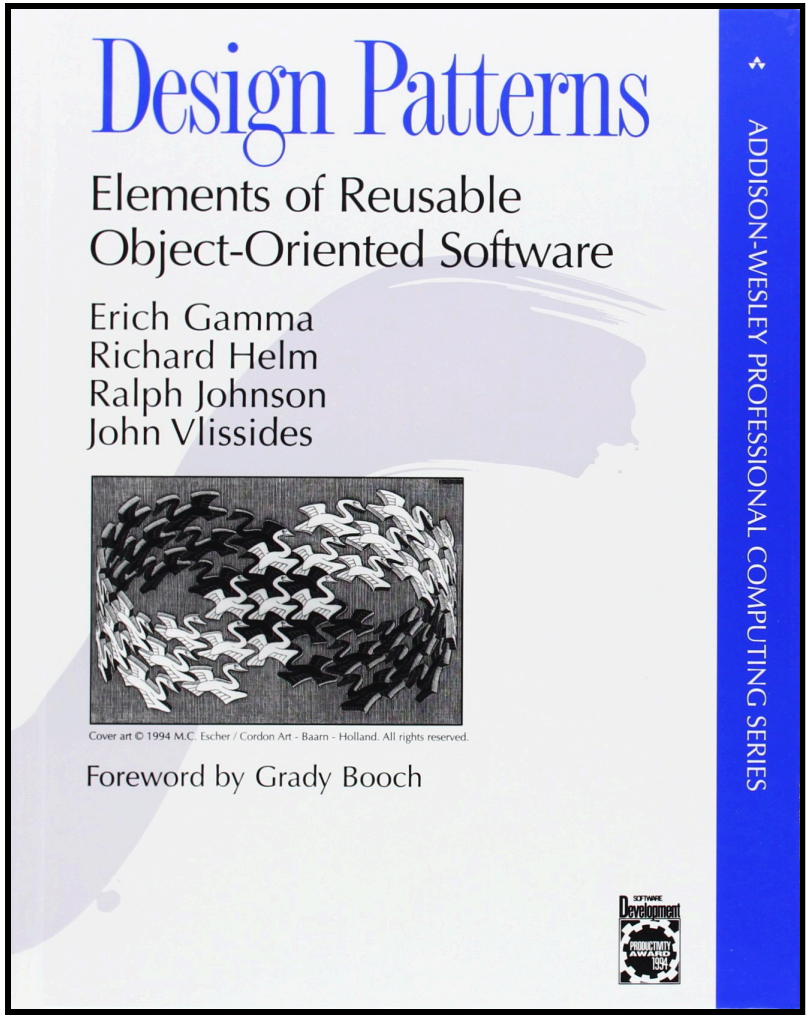


Modernist

Problem analysis and fresh design

Post-modern

Prefers cleverness, humour over fit!



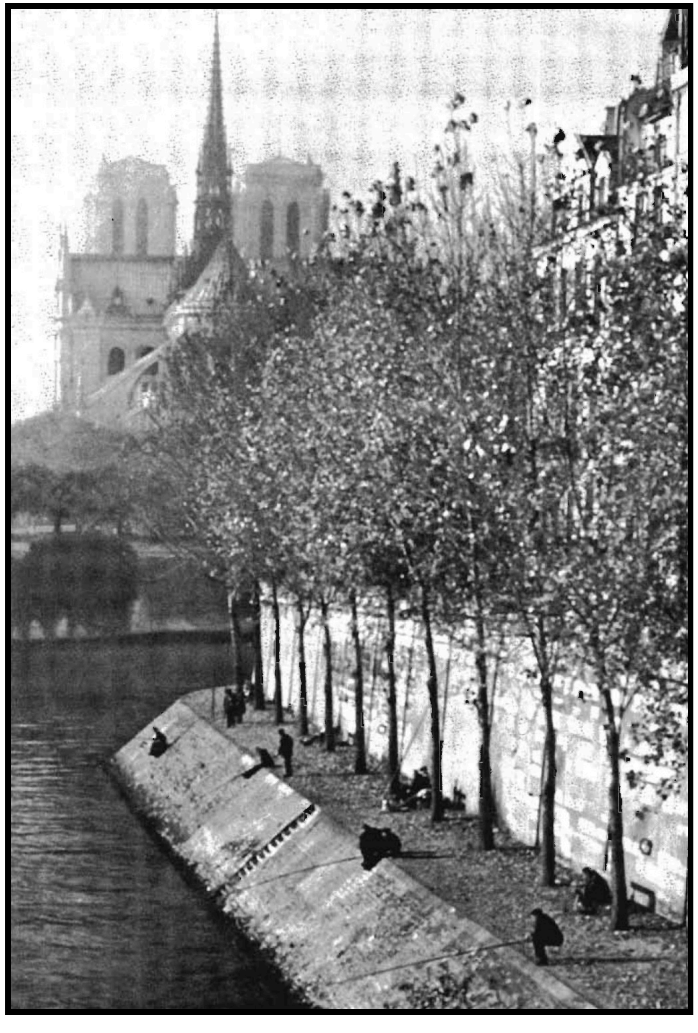
Design patterns

Based on Christopher Alexander's work on architecture

Useful but criticized

Missing the point of Alexander's work

Workarounds for coding in a poor language



Quality without name

A system has it when it is true to its inner forces, when it is free from contradictions

Each "living" pattern resolves a system of forces. When all forces are resolved, the quality appears.

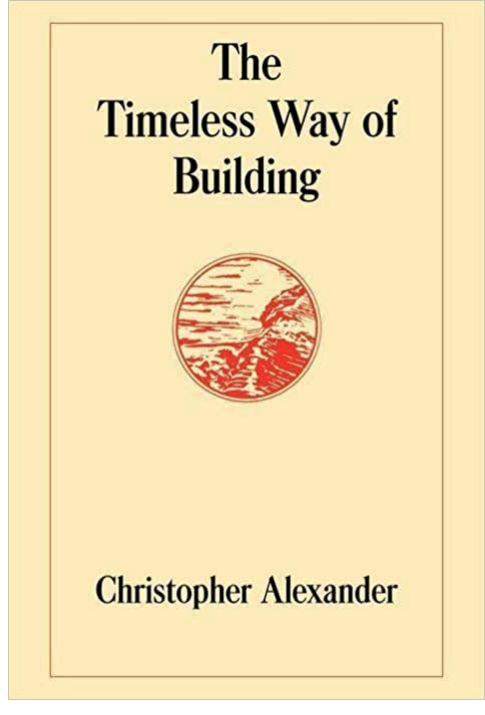
Why is it hard?

Vernacular method

- Shared language lost from community
- Complexity of problems has grown
- Community cannot build a skyscraper

Modernist method

- Cannot perfectly analyze problem
- Always misses some important detail
- Keeps reinventing imperfect forms



Quality

How is this about programming?

 Think about programmer thinking and coding

 Programming systems, not languages

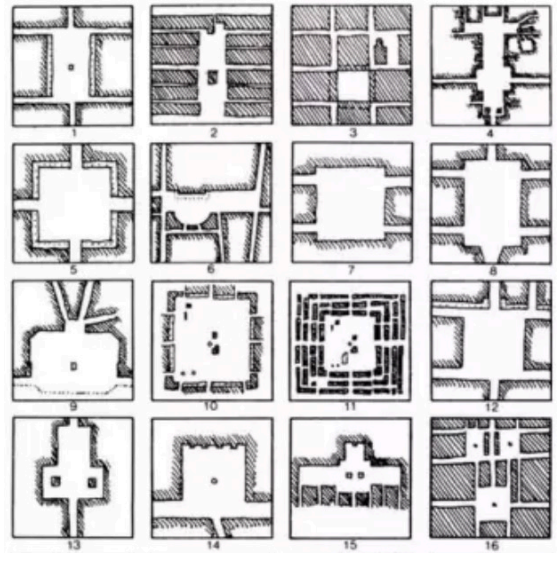
 Need to resolve complex systems of forces

 Patterns to capture approaches that work

Achieving fit

Design pattern

- Context, problem, forces, solution
- Resolves interconnected forces
- Works as a solution template



Pattern language

- Ordered sequence of patterns
- Can be followed step-by-step
- Ideally shared and agreed on

Degrees of publicness

Context: Where people want to live is different

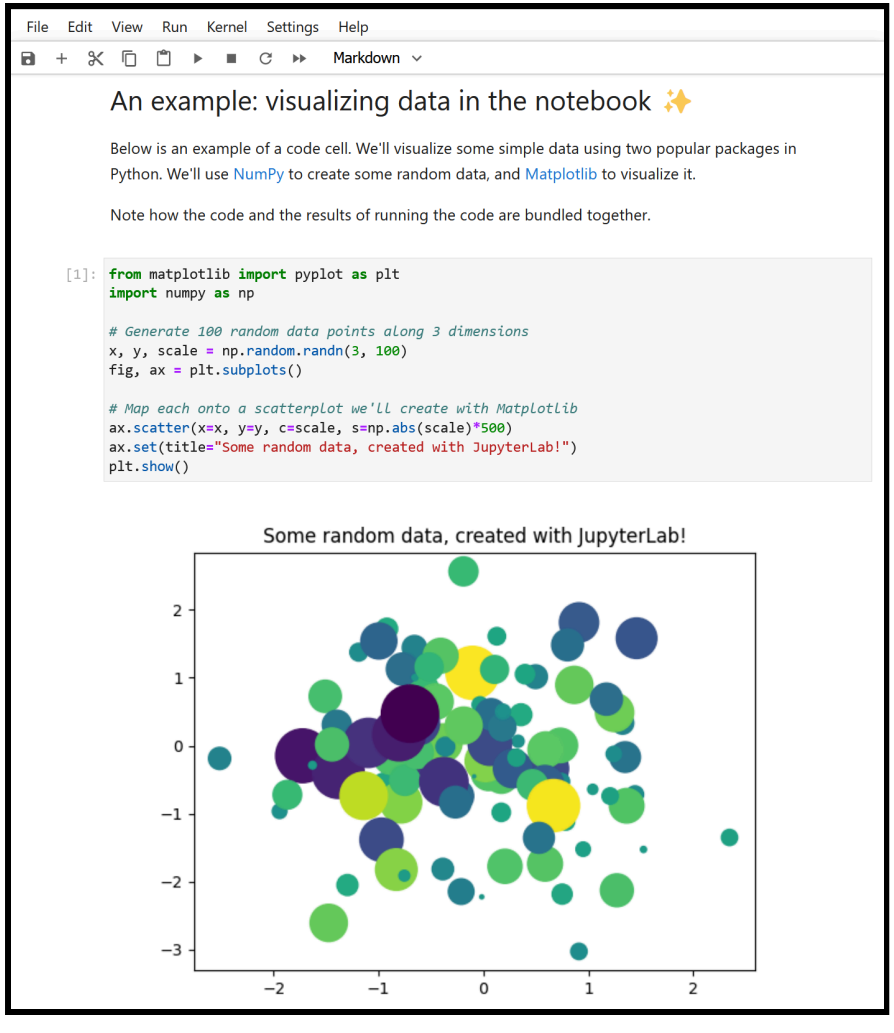
Forces: Some want to live where the action is, some in more isolation

Problem: How to organize a cluster of homes?

Solution: Distinguish private homes, public homes and in-between

Notebook systems

Designing a complex system



Notebook systems

Literate programming environment - code, outputs, comments

Used for exploration, scientific tasks, data science, learning

How to design exploration environment?

Demo

Using Python in a notebook system

Case study: Notebooks

Notebooks for data science

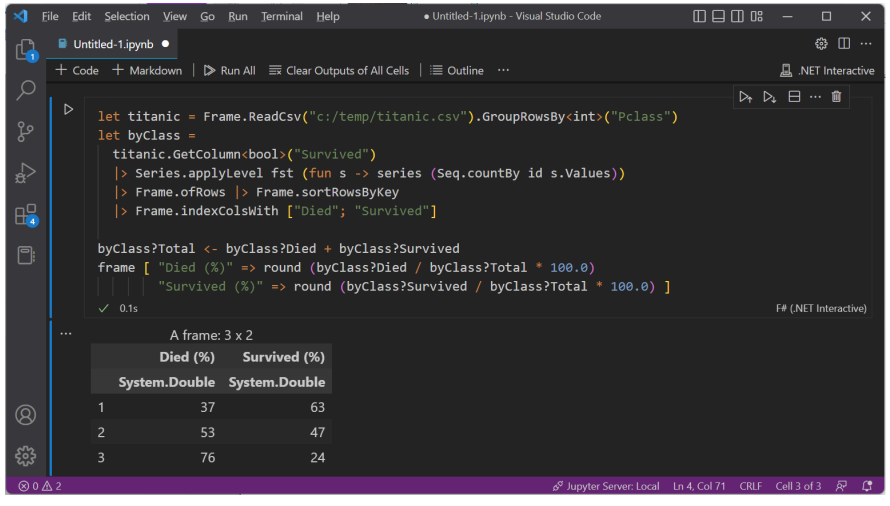
- Use by FT journalists for article
- Start with "Eurostat exports data"
- tinyurl.com/nprg075-ft

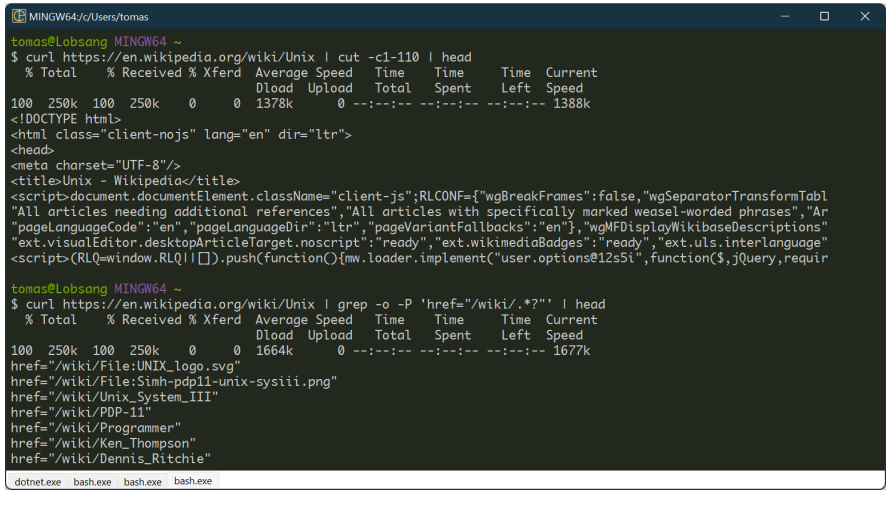
Design questions

- What are the specific forces?
- How are they reflected in the notebooks?
- Which are poorly resolved?

Pattern languages

Designing exploration tools





Exploratory programming workspaces

Environment that lets you figure something out interactively..

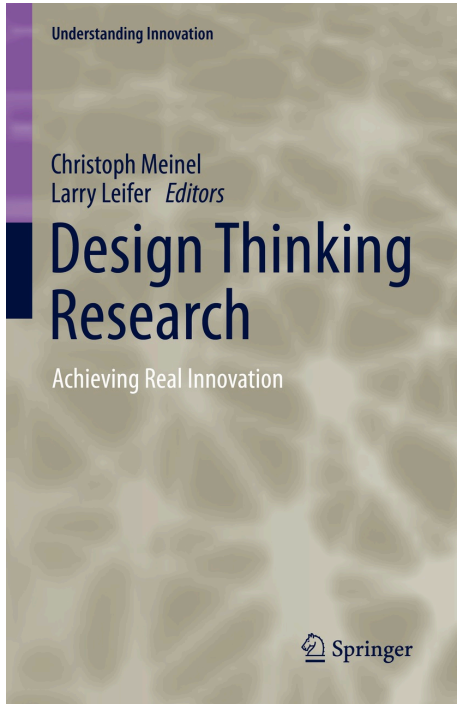
Data science, but also general programming

Are there common patterns of working?

Taeumel et al. (2022)

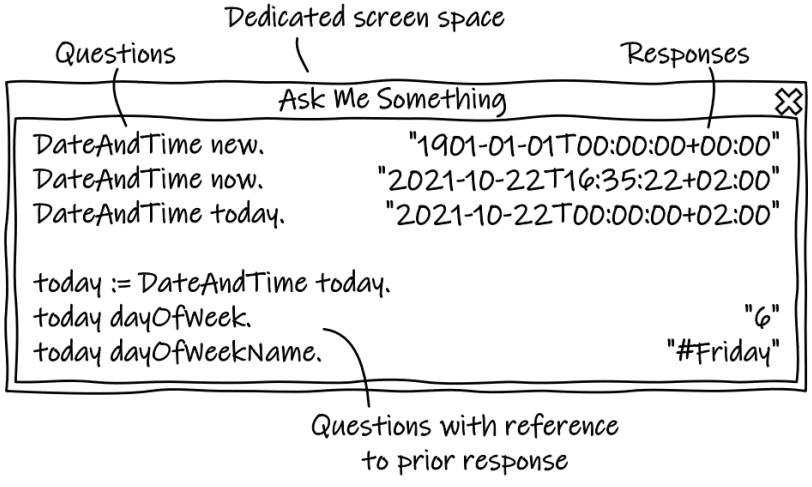
A Pattern Language of an Exploratory Programming Workspace

- Patterns in exploratory tools
- Smalltalk, notebooks, UNIX
- System design and ways of using



Conversation in context

- Seven patterns covering three aspects
- Questions, context, responses
- Capture needs, forces, structure, trade-offs, etc.



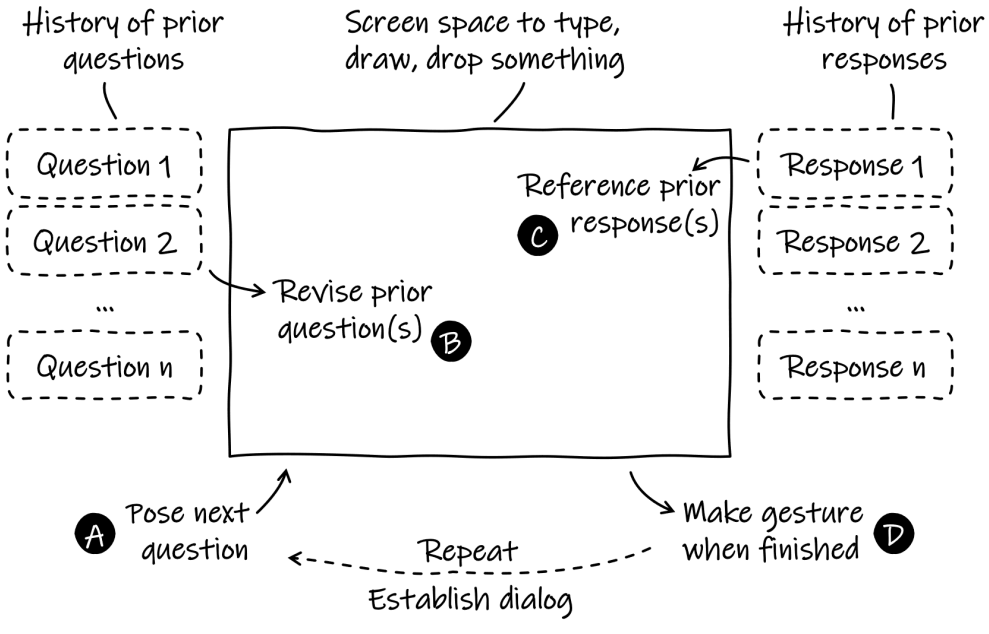
Programmer, environment, interaction context

"It is all about you working on a project in an environment while continually switching between different interaction contexts"

Conversation in context

Forces resolved by the pattern

- Want to ask question about something
- Finding the right place to ask
- Finding the right words to use
- Understanding complex technical answer



Conversation in context

Solution structure

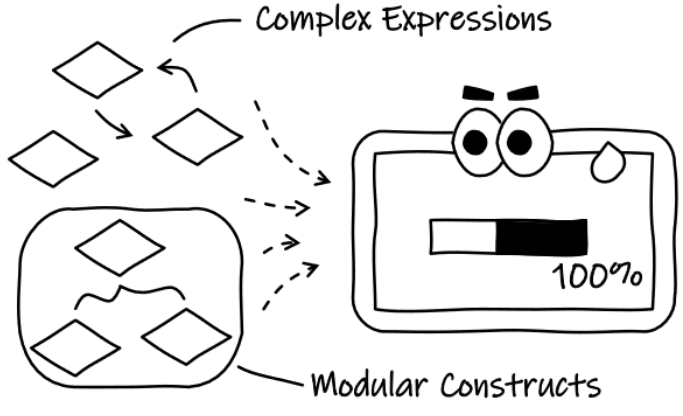
Iterative question and answer interaction with persistent context

Support for revising questions asking follow-up questions

Further patterns

Elaborate inquiry

- Difficult to ask complex questions
- Use stepwise composition
- Refer to previous answers



Proxy transport

- Need to access external information
- May be big or use an odd format
- Embed into local context with lazy loading

Further patterns

Context, forces, solution

- **Coach your environment** by adding information
- **Concepts in shards** need to be linked
- **Simple response** to be found iteratively
- **Pause and explore** to better understand

Pattern languages

Designing pattern languages

Where patterns come from?

Pattern languages for creating pattern languages

No single systematic method that would always work

Pattern writing

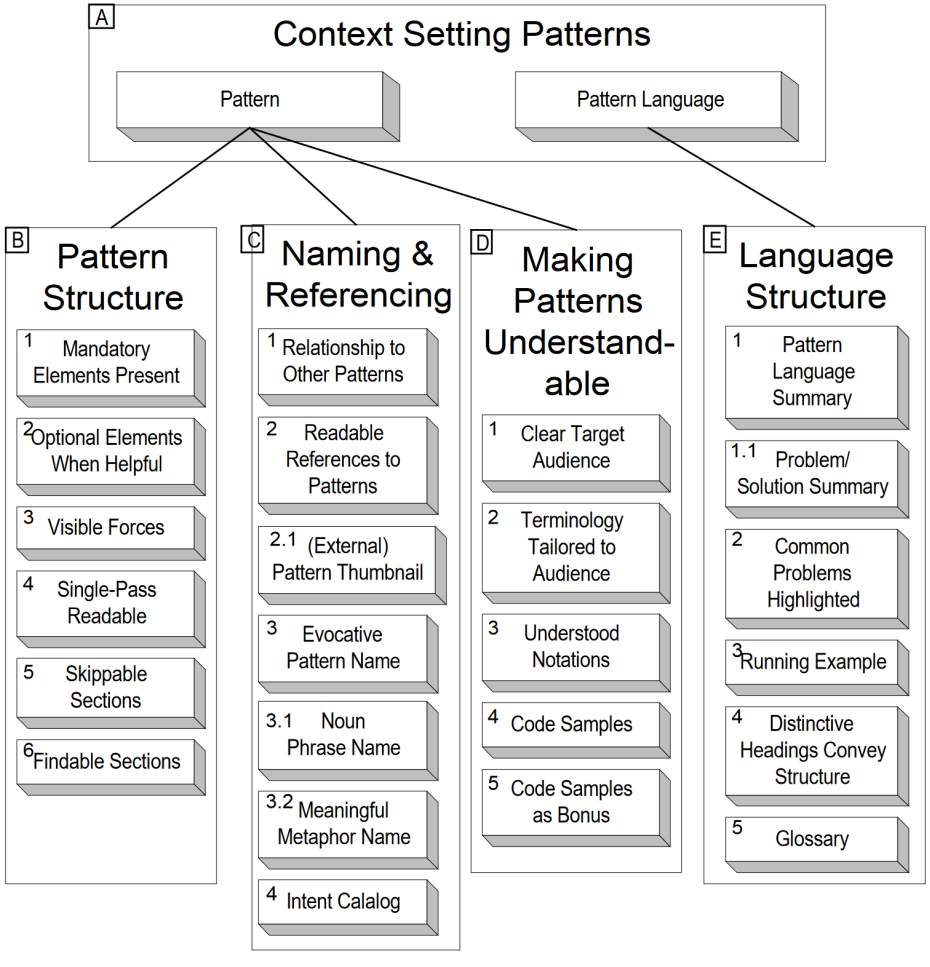
Where patterns come from

 Shared and evolved in a community

 Repeated solutions in past software systems

 Personal experience with a problem

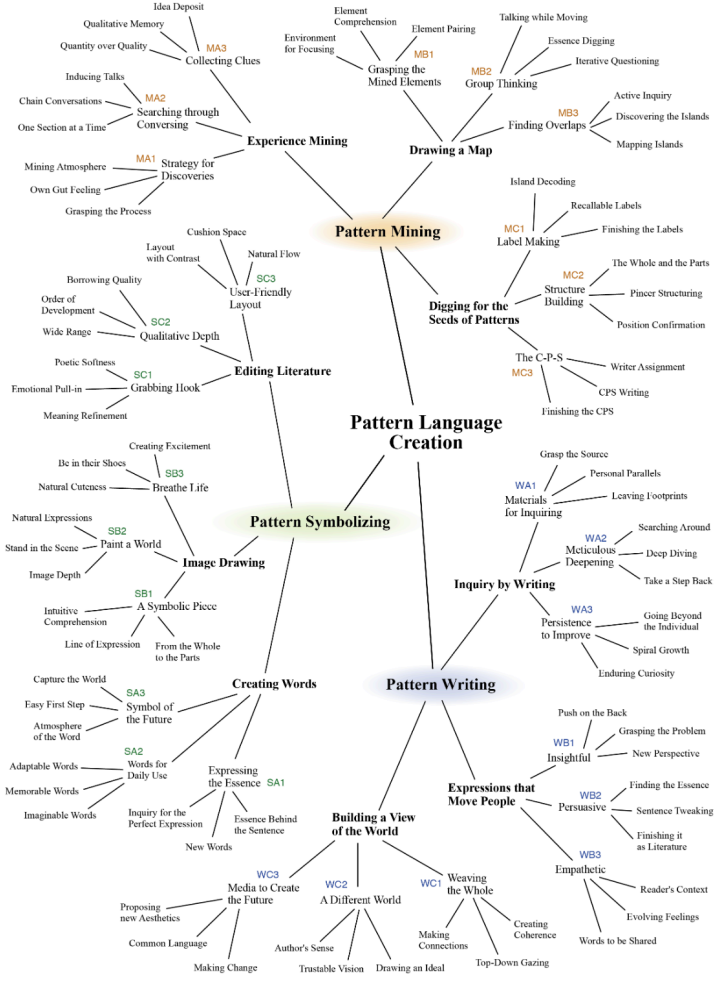
 Focused group collaboration (origins of wiki!)



A pattern language for pattern writing

(Meszaros+Doble, '97)

How to structure, write and present patterns & pattern languages



A pattern language for creating pattern languages

(Iba+Isaku, 2016)

Hints on pattern mining

Collect experiences
Map and find overlaps
Structure in clusters

Practical tips

How to write a pattern language

 Patterns are about resolving forces

 Patterns should have fixed format

 Context, forces, structure, related patterns

 System structure or human interaction with it

Concepts and methods

Learning from architecture

Learning from unaverage clues

(Jacobs, 1961)

Cannot reduce city to a single statistic

Look for informative singleton clues!

Demo

Commodore 64 BASIC

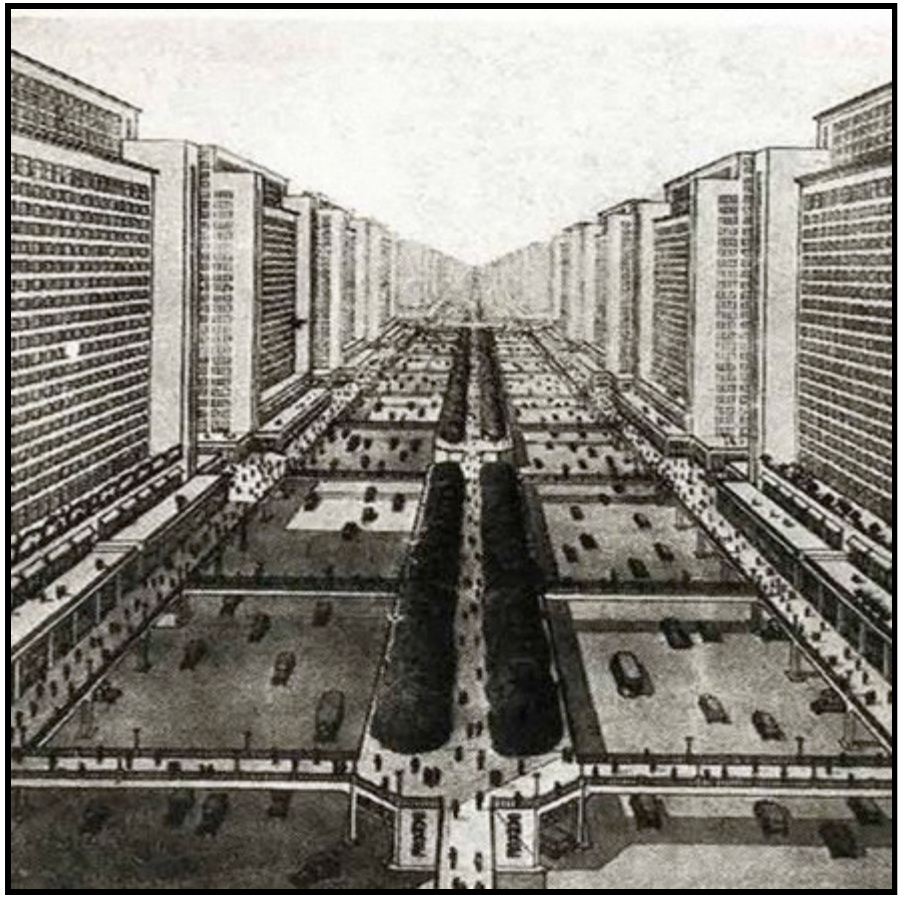
10 PRINT CHR$(205.5+RND(1)); : GOTO 10

Technical aspects

- Edit & run in one terminal
- Line numbers for navigation
- Simple with **POKE** for hackers

Social aspects

- Path from a user to a programmer
- Commodore 64 boots into BASIC!
- Learn by copying from magazines



What works despite the theory

(Jacobs, 1961)

Elegant theories
that are convincing
but do not work

Document what
actually works
in practice instead!

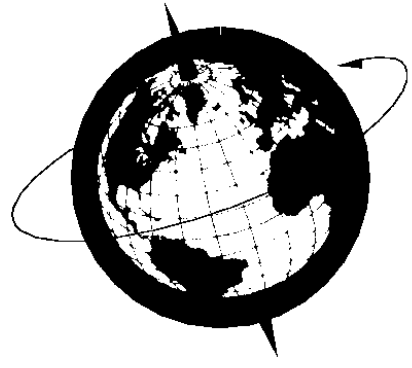
Information hiding

Good software engineering

- Divide systems into modules
- Hide implementation details
- Expose only what is needed

Why should this work?

- Basic principle of OOP!
- Can freely change internals
- Modules developed independently



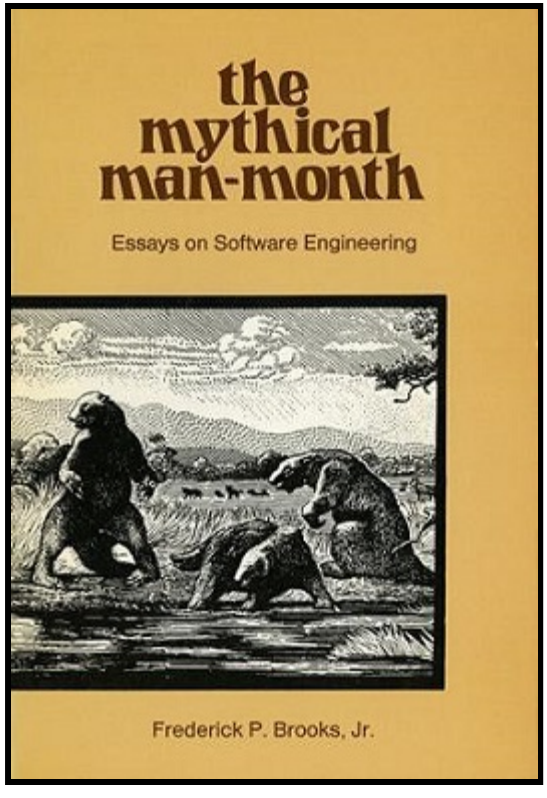
Information hiding

Brief history

- Decomposing systems (1972)
- IBM OS/360 development (1975)
- Brooks' reflections (1995)
- Cathedral and the bazaar (1999)

Critique and alternatives

- Design is hard to anticipate
- Cumbersome & inefficient uses
- MIDI SysEx and UNIX DWARF work!



Conceptual coherence

(Brooks, 1975)

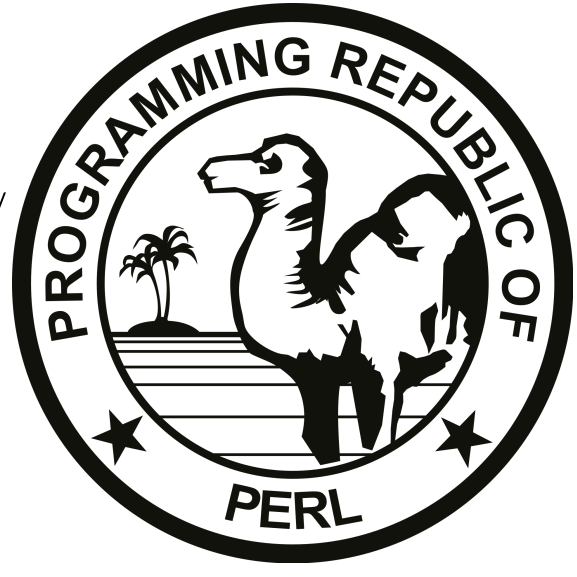
A clean, elegant programming product must present to each of its users a coherent mental model of the application.

Conceptual integrity is the most important factor in ease of use.

Post-modern programming

No grand narrative

I set out to deconstruct all the computer languages and recombine them. I lovingly reused features from many languages.



Why this works

- Worse is better
- Postmodernists prefer AND, modernists OR
- Possible to write messy & clean programs

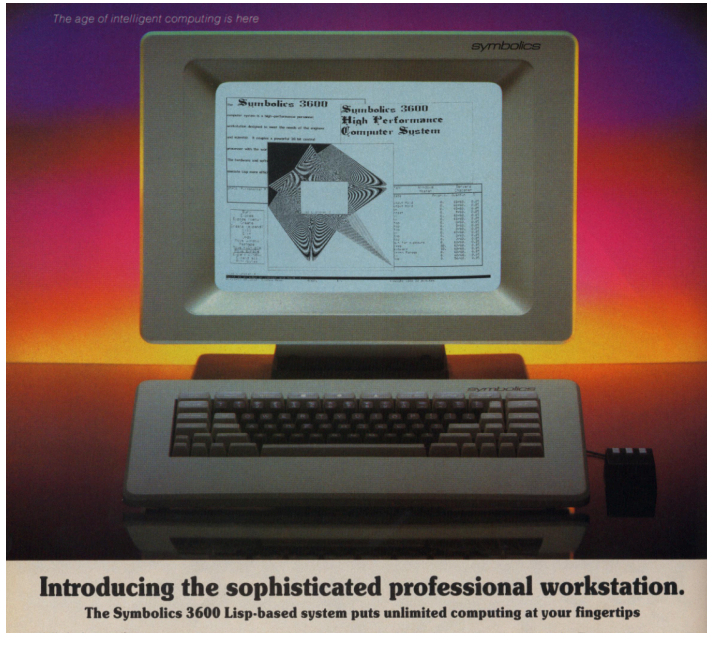
Worse is better

The right thing

- Common LISP, ITS system
- No incorrectness / inconsistency
- Completeness, then simplicity

Worse is better

- UNIX and C language
- Simple is better than correct, consistent & complete



Concepts and methods

Unexplored inspirations

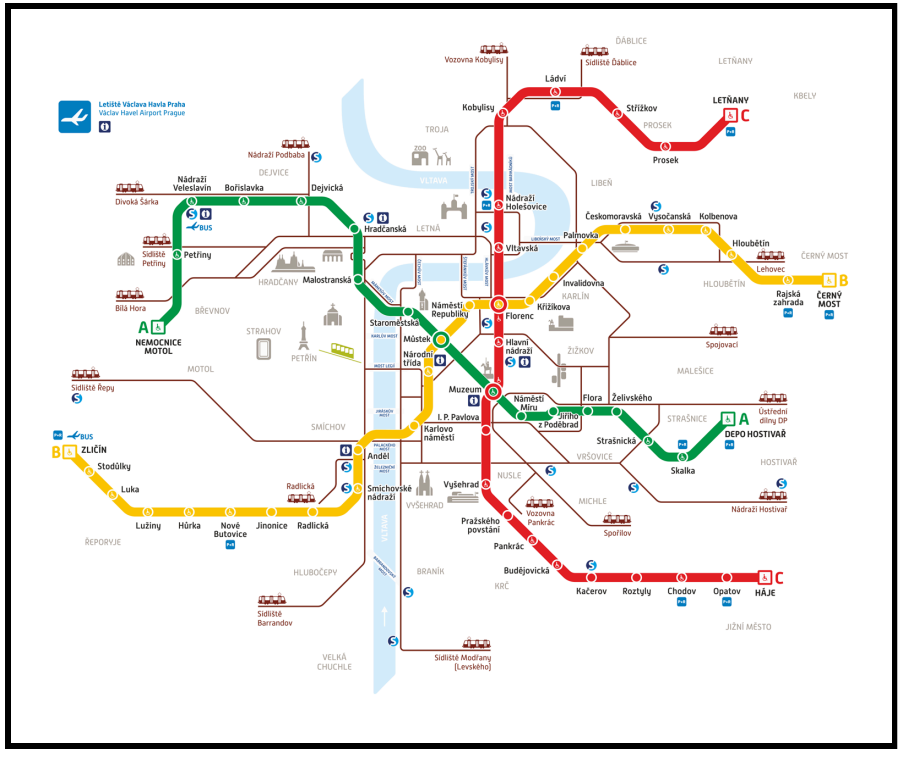


Image of a city

How do we navigate around cities?

And codebases?

Districts, landmarks and pathways

Good design supports navigability and legibility

Materials

Building materials that look bad before they go bad

Software tends to break abruptly without any warning...

Is there an alternative?

Vernacular architecture

Achieves a good fit without the continuous reinvention of forms

Can we build software without reinventing forms? Spreadsheets? Configuration?

Conclusions

Learning from architecture

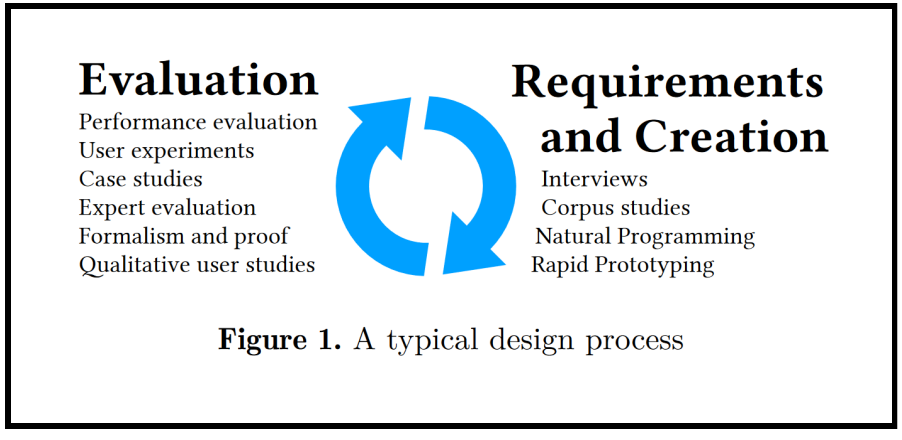


Figure 1. A typical design process

Architecture and design in context

Conceptual design rather than empirical science

Powerful methodologies for idea generation

Appropriateness is harder to evaluate - wait and see!

Reading

No information hiding?

- Varv: Reprogrammable Interactive Sofware as a Declarative Data Structure
- Available at: http://vis.csail.mit.edu/pubs/varv.pdf

What to read and how

- Declarative, extensible programming!
- Get a sense of how it works (Section 2)
- Look at evaluation (Section 5)

Conclusions

Learning from architecture and design

- Methods & concepts for complex systems
- Architecture, urban planning and design
- Design patterns & pattern languages

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Just for fun...

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