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Complexity

COMP61511 (Fall 2017)
Software Engineering Concepts
in Practice

Week 4

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(bug reports welcome!)

Complexity Challenge

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"But when projects *do fail* for reasons that are primarily technical, *the reason is often uncontrolled complexity*....

When a project reaches the point at which no one completely understands the impact that code changes in one area will have on other areas, progress grinds to a halt."

Complexity Challenge

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- "Software's Primary Technical Imperative has to be managing complexity."
  - McConnell, 5.2
- Architecture is key to managing complexity
  - Architecture provides a guide
  - Good architecture controls interaction
    - which allows considering subsystems *independently*

Dealing with complexity

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- We can't comprehend the entire system in detail, so we use information hiding via
  - *Modularisation*
  - *Abstraction*
- ...to be able to effectively deal with complexity

Modularity and abstraction are major aids to understanding

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- Using modularisation and abstraction, we have the intellectual leverage to understand and (informally) reason about systems
- We can apply these concepts at different levels to aid our understanding of a system
- In turn understanding enables us to
  - Go about constructing systems
  - Maintain them
  - Extend them

Levels of Design

- *Modularity*
  - Confines the details
    - So they don't matter "from outside"
  - Facilitates abstraction
- As we move up levels
  - We lose detail, and
  - Expand scope of what we can understand
  - Good design and construction means that the details can be safely ignored at higher levels

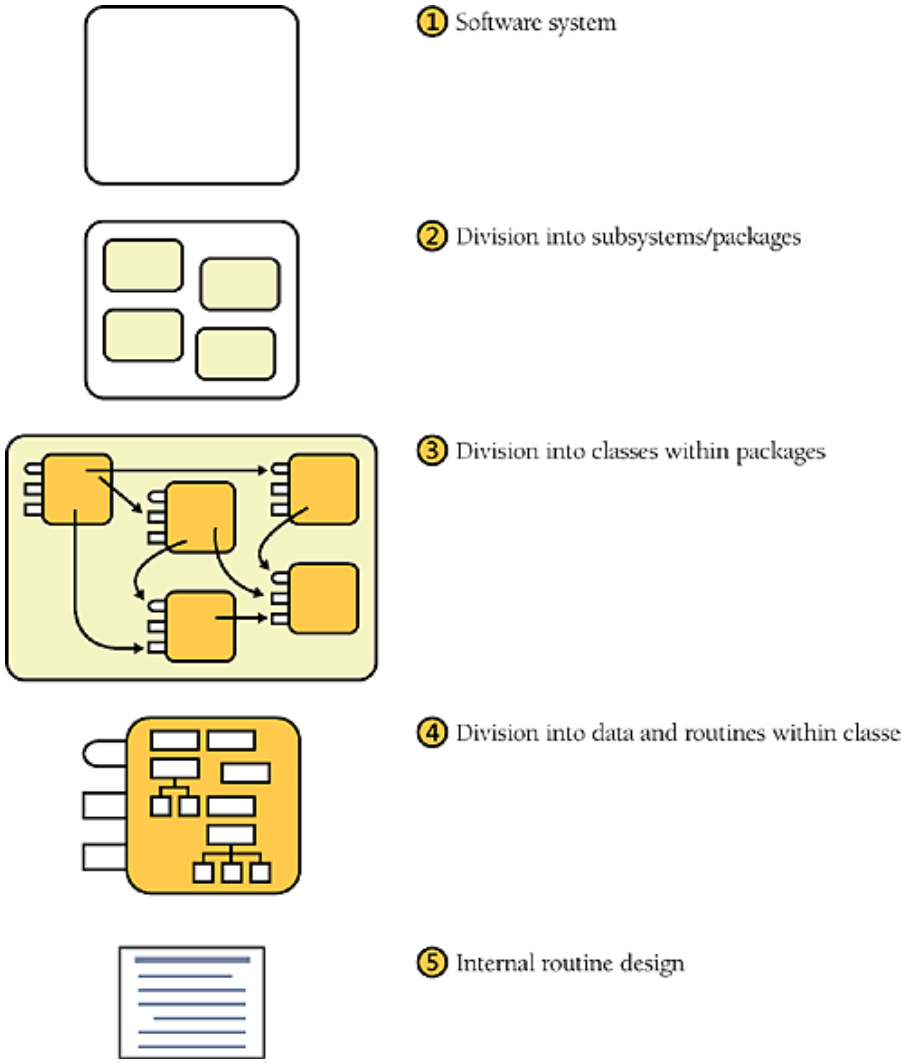
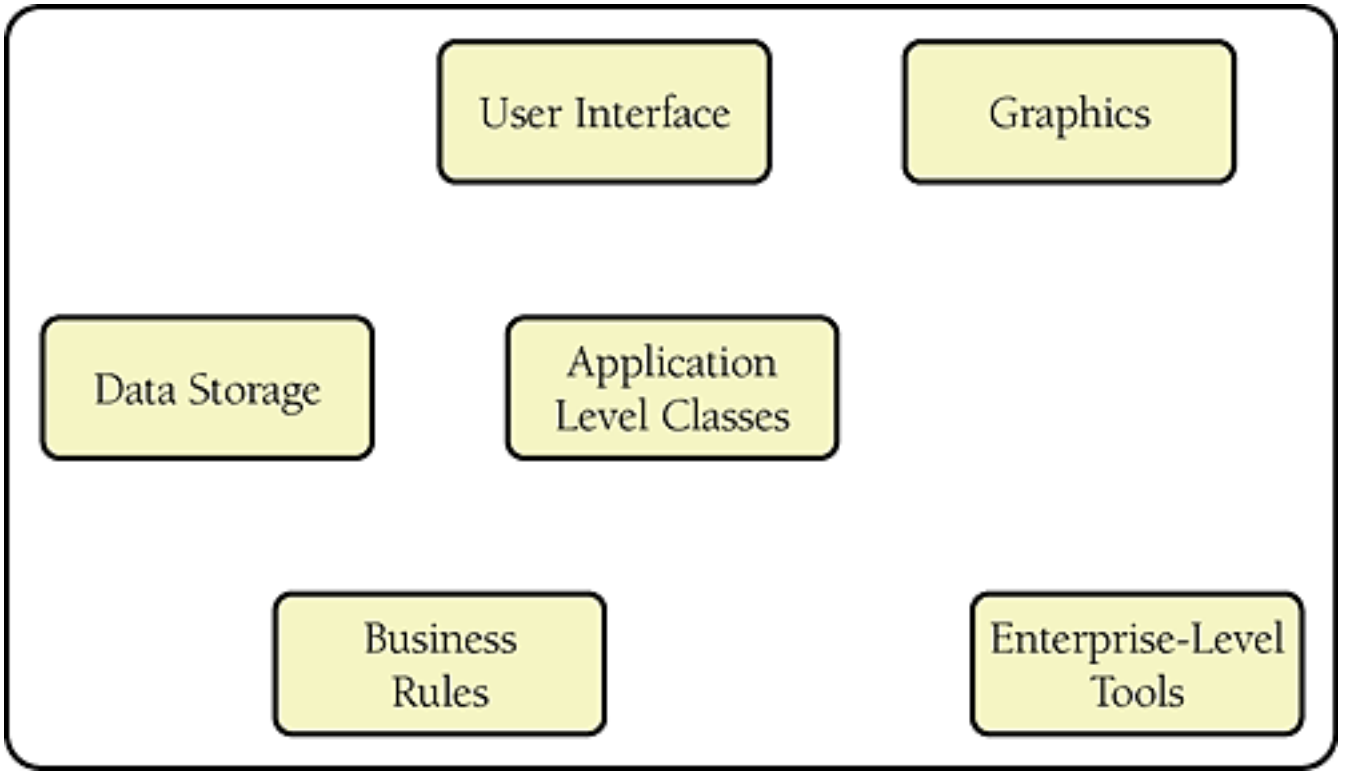


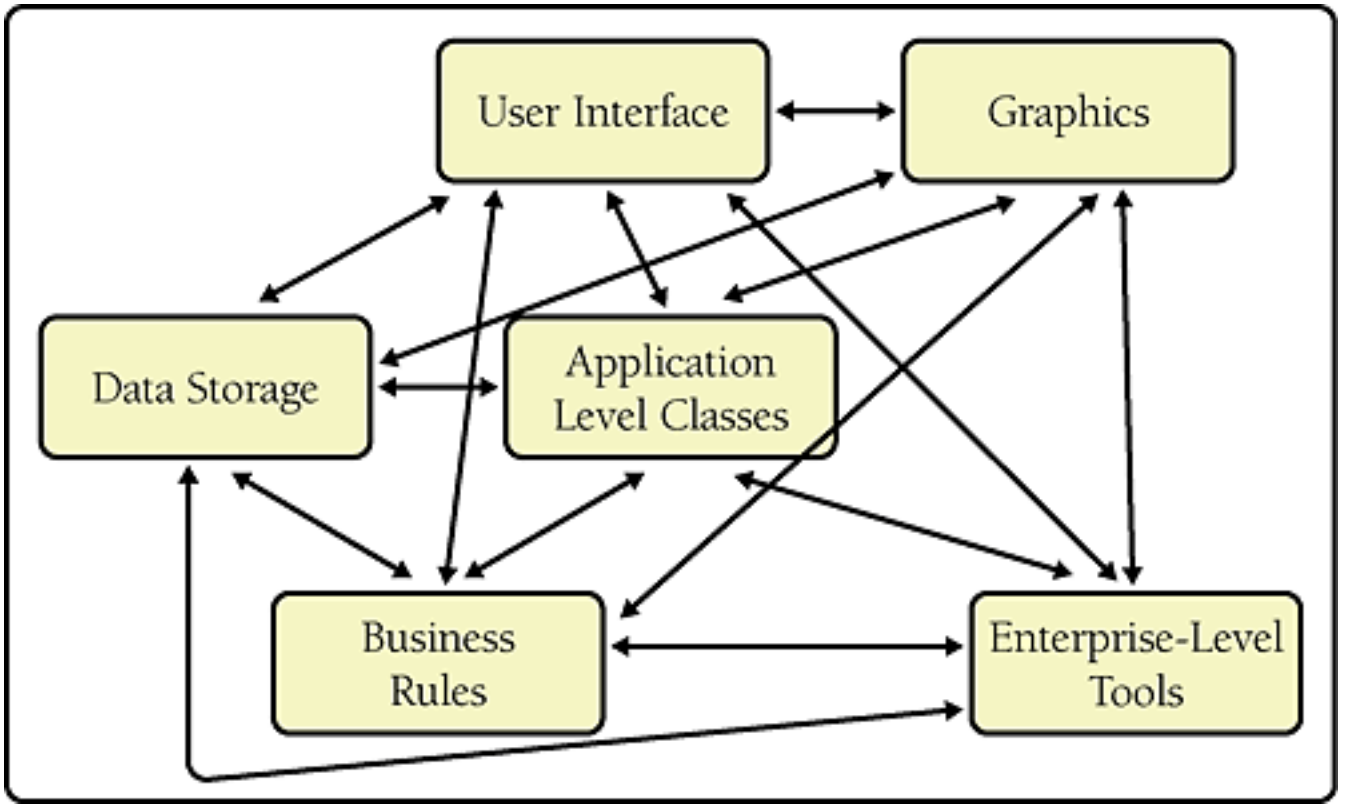
Diagram source: McConell

Example: Components



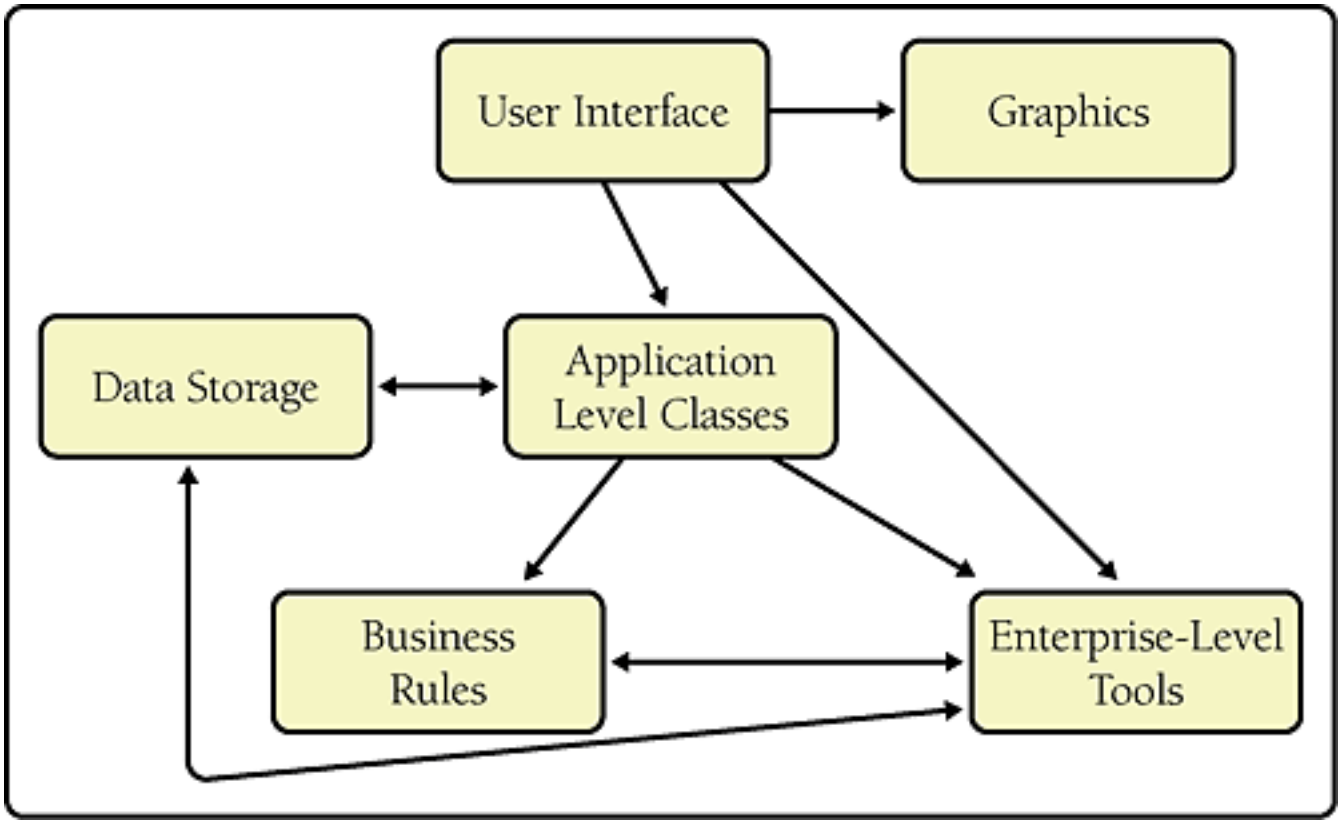
McConnell, 5.2: Figure 5-3. An example of a system with six subsystems

Example: Complexity via unconstrained communications



McConnell, 5.2: Figure 5-4. An example of what happens with no restrictions on intersubsystem communications

Example: Low coupling is better



McConnell, 5.2: Figure 5-5. With a few communication rules, you can simplify subsystem interactions significantly

Different Levels of Modularity

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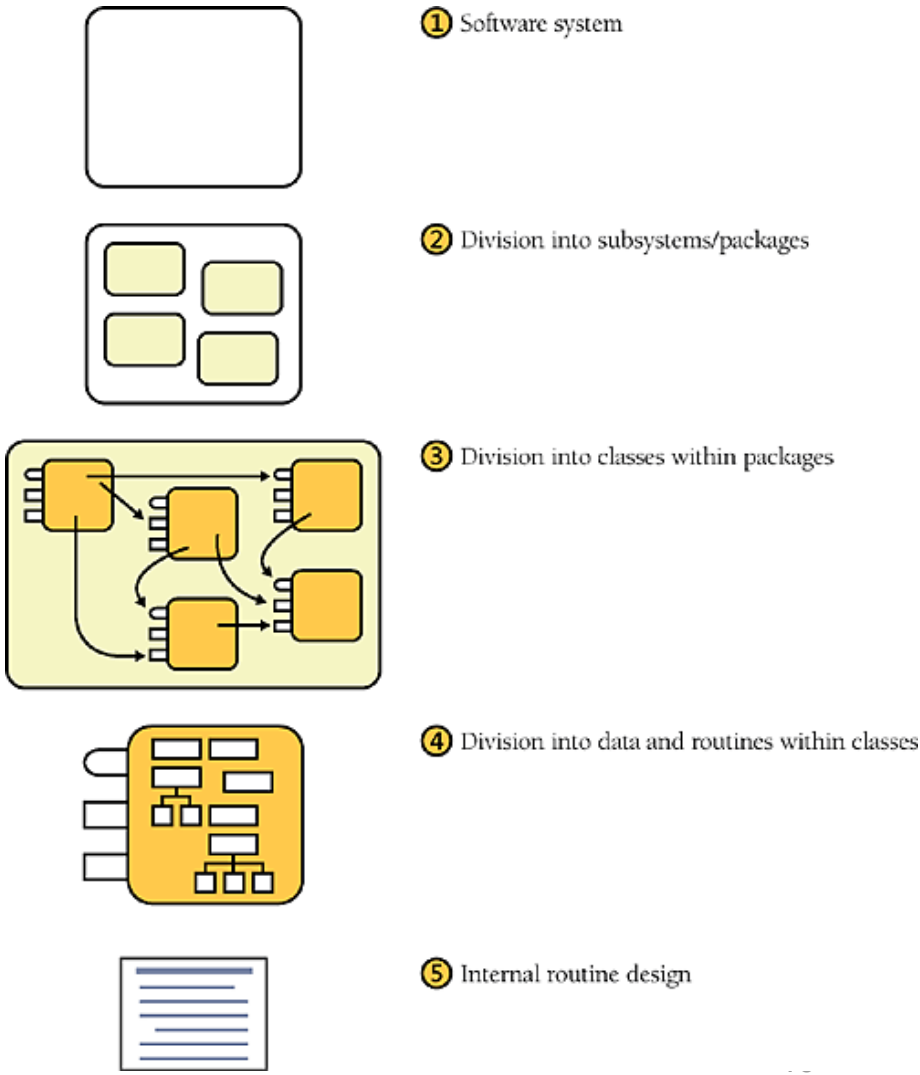
- Notice modularity, encapsulation and interfaces at different levels
  - Subsystem
  - Package
  - Object



Different Levels of Modularity

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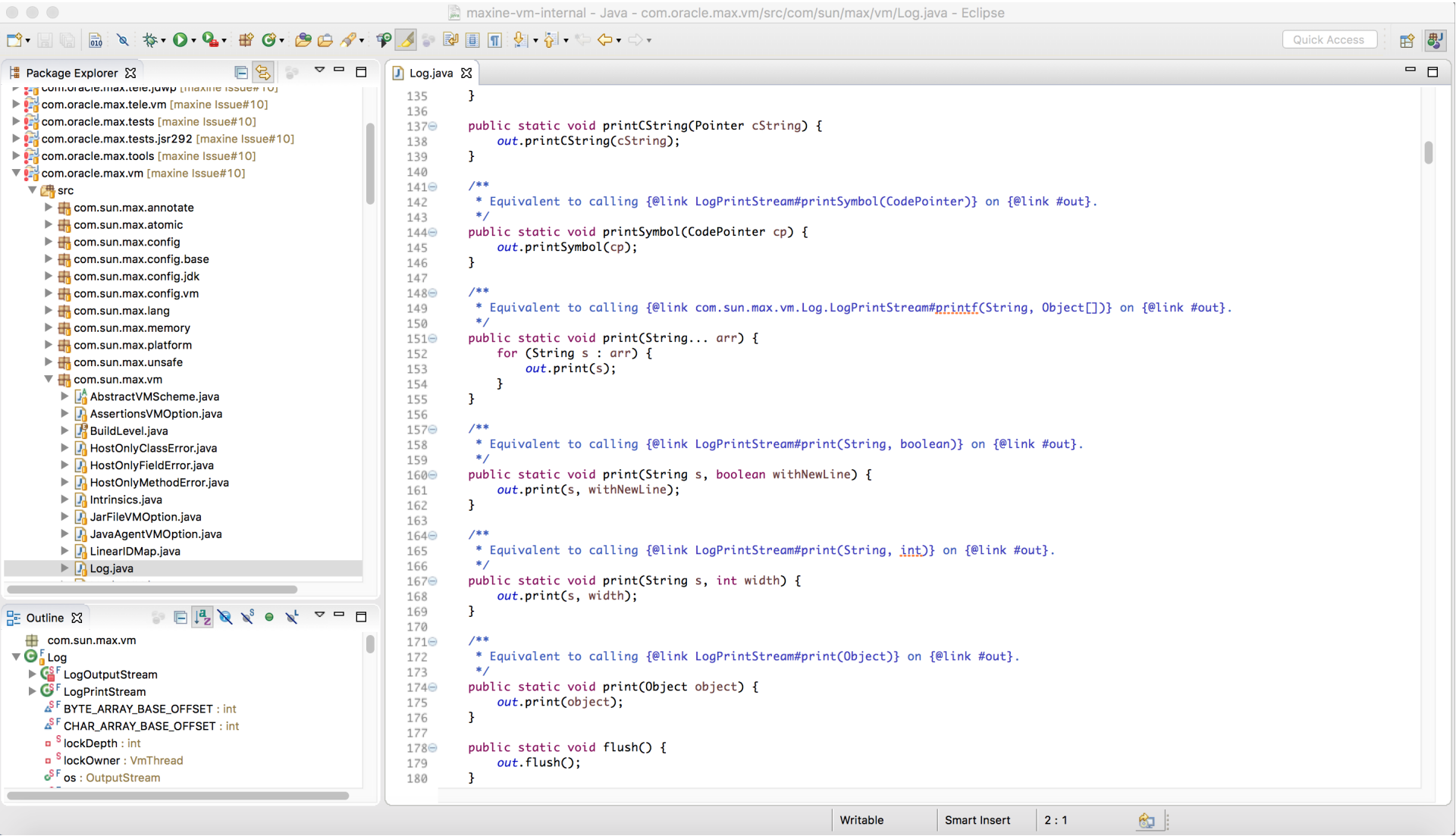

Different Levels of Modularity

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- LOC: 891K (Java, C, Python, Assembly, Make etc.)
- Files: 3957
- Classes: 9788
- Packages: ~100 packages
- Projects: ~30

Different Levels of Modularity

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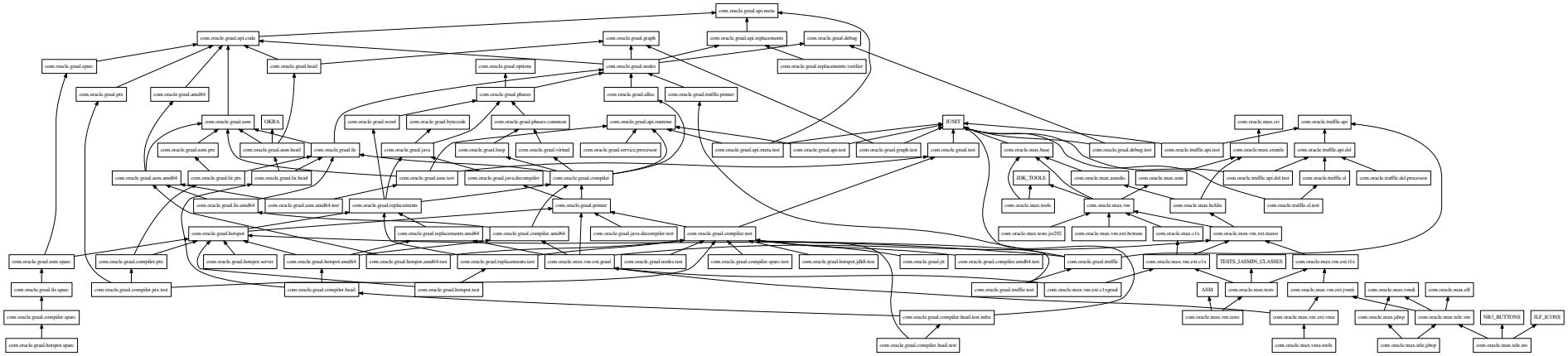

Different Levels of Modularity

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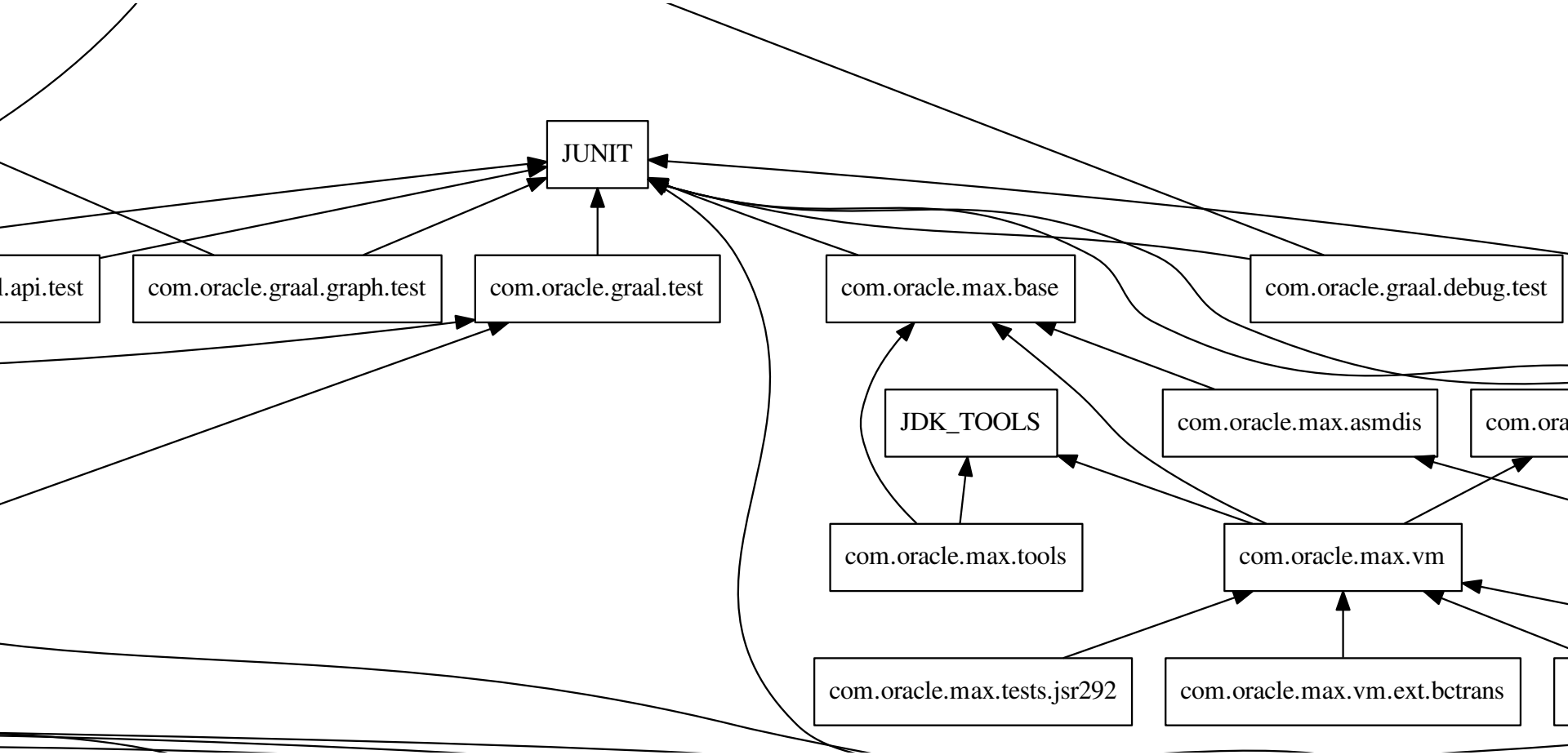

The activity of design and when we do it

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- Design is an activity in many fields
  - e.g.: Architecture (for buildings), computer architecture to code and test construction
- Characteristics of software design
  - Knowledge in three kinds of domain: Application, technical domain and design domains
  - Requires motivated choices and tradeoffs
  - Knows what to take account of, and what to ignore
  - Multi-faceted and sometimes multi-level

Design is a Wicked Problem

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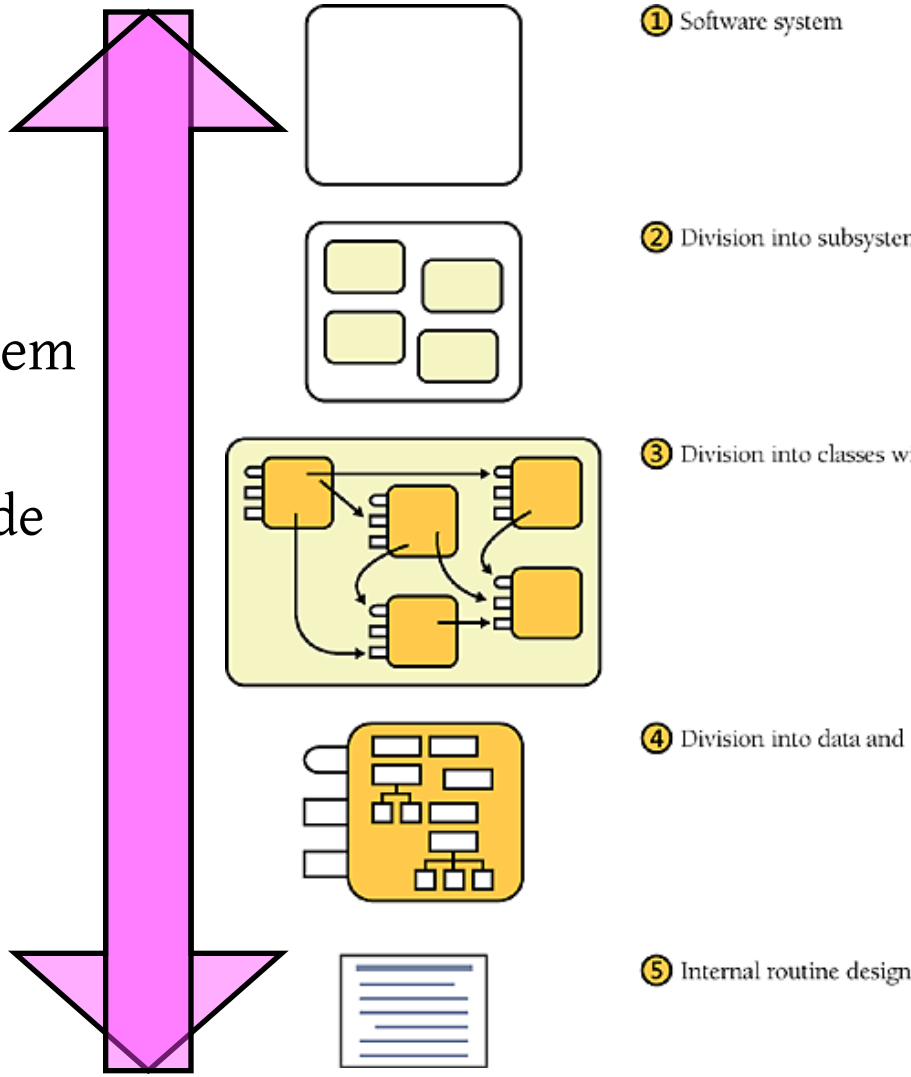
> *Horst Rittel and Melvin Webber defined a "wicked" problem as one that could be clearly defined only by solving it, or by solving part of it (1973).* McConnell, 5.1

- Change is a reality
  - Requirements and problem definitions change
    - Exogenously | the external world changes
      - e.g. a regulation is passed during development
    - Endogenously | triggered by the evolving system
      - e.g. people learn that they misunderstood the problem
- Software development must cope
  - Methodologically | e.g. agile methods respond well to change
  - Architecturally | e.g. modularity lets us replace modules
  - Constructionally| e.g. robust test suites support change

Direction of Design

System Software Architecture

- Top down
  - Start with the general problem
  - Break it into manageable parts
    - Each part becomes a new problem
      - Decompose further
      - Bottom out with concrete code
- Bottom up
  - Start with a specific capability
    - Implement it
    - Repeat until confident enough
      - to think about higher level pieces



Software construction

Opportunistic focus

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- Top down and bottom up aren't exclusive
  - "Thinking from the top"
    - Focuses our attention on the whole system
  - "Thinking from the bottom"
    - Focuses our attention on concrete issues
  - Being able to choose where you focus your attention opportunistically is a great help
  - For example working at the top level, you may wonder will this really work, so you consider realisation at a lower level of detail
    - Will have to rework the top level if it doesn't work at a greater level of detail

Exploring the Design Space

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- Wickedness suggests
  - we need to *do* stuff early
  - *build* experimental solutions
- Three common forms
  - Spikes
  - Prototypes
  - Walking skeletons

Spikes

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- Very small program to explore an issue
  - Scope of the problem is small
- Often intended to determine specific risk
  - Is this technology workable?
- No expectation of keeping

Prototype

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- Can have some small or large scope
- Intended to demonstrate something, rather than 'just' find out about technology (a spike)
- Mock ups through working code
- Can be "on paper"!
- Prototypes get thrown away
  - Or are intended to!

Walking Skeleton

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- Small version of "complete" system
  - "tiny implementation of the system that performs a small end-to-end function. It need not use the final architecture, but it should link together the main architectural components. The architecture and the functionality can then evolve in parallel." - *Alistair Cockburn*

- Walking skeletons are meant to evolve into the software system
- Consider miniwc.py!