Developing large-scale Applications in Python

Lessons learned from 10 years of Python Application Design

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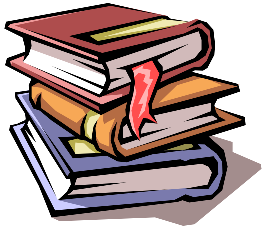
Speaker Introduction: Marc-André Lemburg

- CEO eGenix.com and Consultant
  - More than 20 years software experience
  - Diploma in Mathematics
  - Expert in Python, OOP, Web Technologies and Unicode
  - Python Core Developer
  - Python Software Foundation Board Member (2002-04)
  - Contact: mal@egenix.com
- eGenix.com Software GmbH, Germany
  - Founded in 2000
  - Core business:
    - Consulting: helping companies write successful Python software
    - Product design: professional quality Python/Zope developer tools (mxODBC, mxDateTime, mxTextTools, etc.)
  - International customer base



Introduction

1. Introduction
2. Application Design
3. At work...
4. Discussion

Python2EE: Large-scale applications

- What is considered “large-scale” in Python ?
  - Server application: >30 thousand lines of Python code
  - Client application: >10 thousand lines of Python code

  - Third-Party code: >10 thousand lines of code
  - Typically a mix of Python code and C extensions

- Examples:
  - Zope / Plone
  - eGenix Application Server
  - eGenix projects: e.g. Web Service Application Server, XML Database, ASP Trading System

Snake bites: Why write large-scale applications in Python ?

- Highly efficient
  - small teams can scale up against large companies
  - very competitive turn-around times
  - small investments can result in high gains
- Very flexible
  - allows rapid design, refactoring and rollout
  - highly adaptive to new requirements and environments
  - no lock-in
- Time-to-market
  - develop in weeks rather than months

Application Design

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Path to success: Application Design

- Python makes it very easy to write complex applications with very little code
  - It's easy to create bad designs fast
  - Rewriting code is fast as well
- Application design becomes the most important factor in Python projects
- Here's a cookbook approach to the problem…

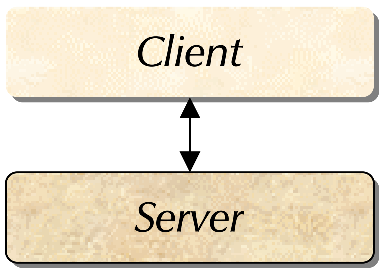
Breaking it down: The Design Concept

- Zen approach to application design
  - Keep things as simple as possible, but not simpler (KISS).
  - There's beauty in design.
  - Before doing things twice, think twice.
  - If things start to pile up, management is needed.
  - If management doesn't help, decomposition is needed.

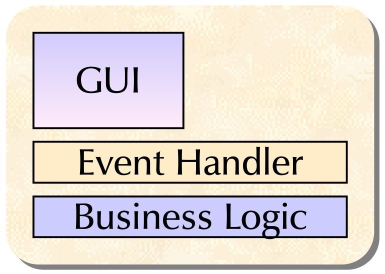
- Structured approach to application design
  - Divide et Impera (divide and conquer)
  - Lots and lots of experience ☺

First step: Choose a suitable *application model*

- Client-Server
  - Client application / Server application
  - Web client / Server application



- Multi-threaded stand-alone
  - Stand-alone GUI application

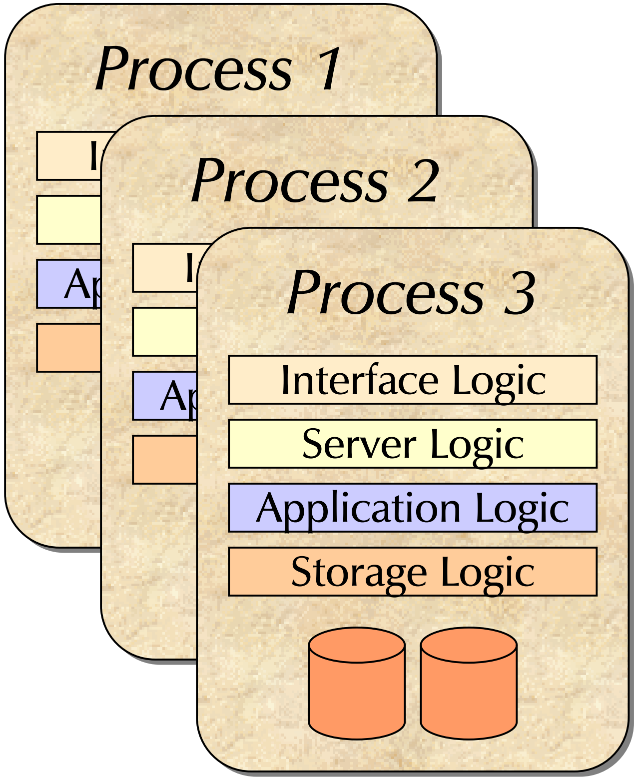


- Single process
  - Command-line application
  - Batch job application

- etc.

Bytes in action: Identify the *processing model*

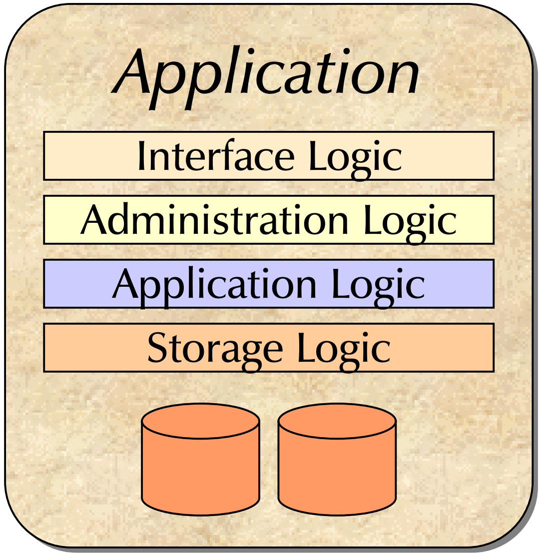
- Identify the processing scheme:
  - Single process
  - Multiple processes
  - Multiple threads
  - Asynchronous processing
  - A mix of the above



- Identify the process/thread boundaries:
  - Which components (need to) share the same object space ?
  - Where is state kept ?
  - What defines an application instance ?

Looking closer: Application layers

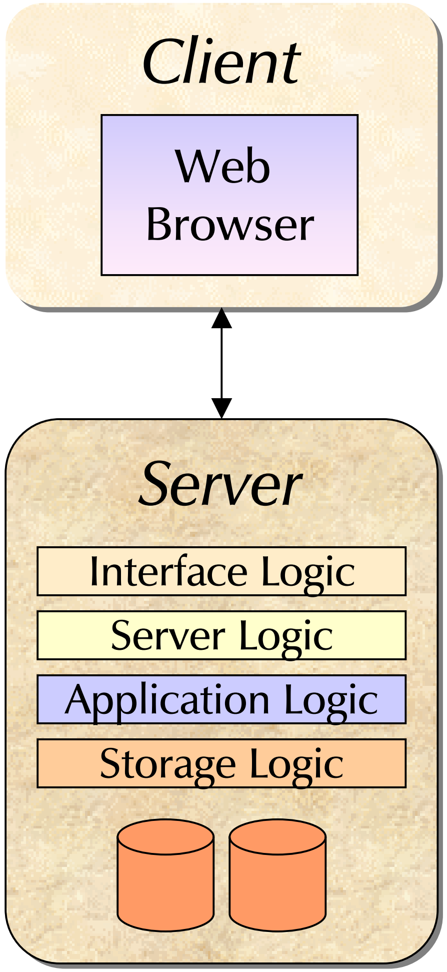
- Every application can be divided into layers of functionality defined by the flow of data through the application
  - Top layer: interface to the outside world
  - Intermediate layers: administration and processing
  - Bottom layer: data storage



- Layers are usually easy to identify given the application model
  - … but often hard to design

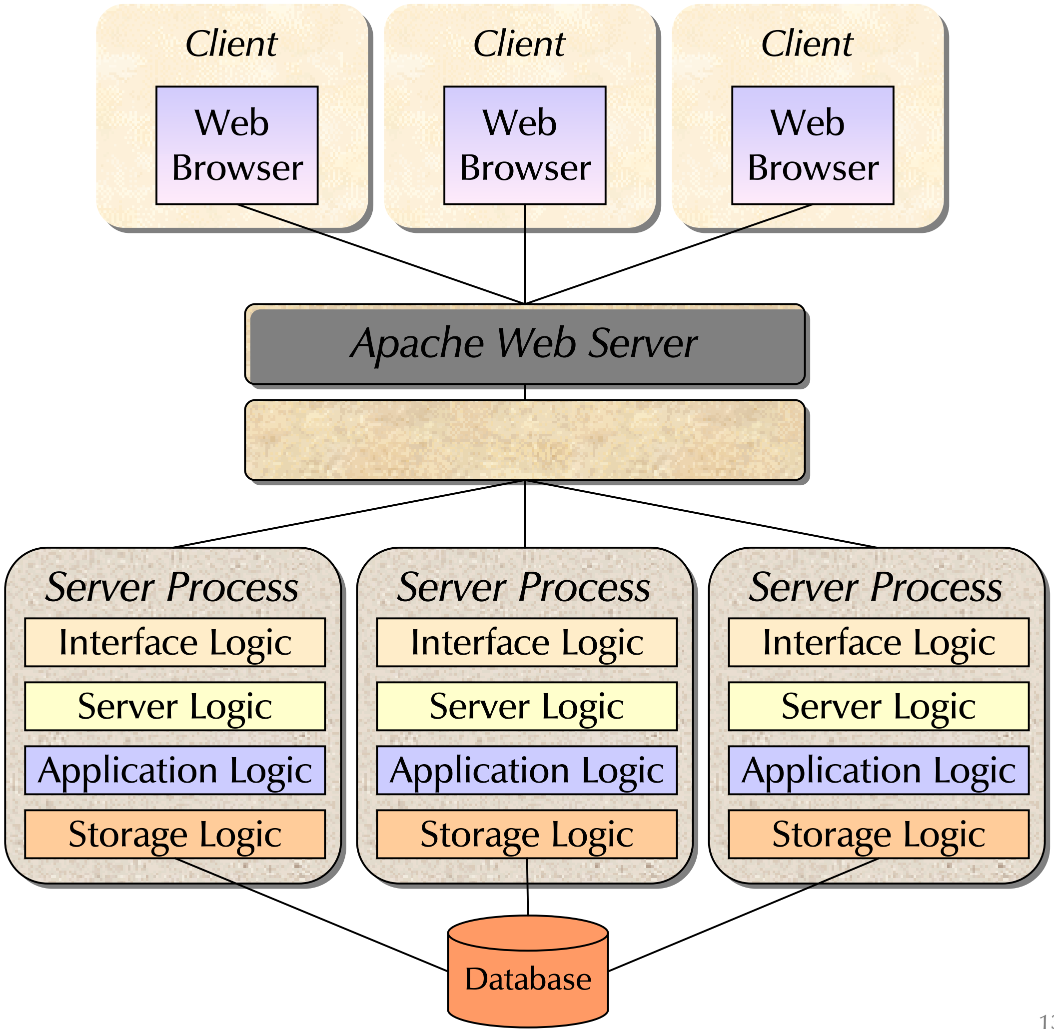
Vertical design: Find the right application *layer model*

- GUI / Application Logic / Storage Logic
- Network / Apache / SCGI / Server Logic / Application Logic / Storage Logic
- File I/O / Application Logic / Storage Logic
- Custom model



Example: Web Client + Server Application

- Setup:
  - Client is a standard web-browser
  - Server needs to take a lot of load and will have to do all the calculation work
  - Server needs to be fail-safe
- Solution:
  - Multiple process model
  - Application server layers



The next step: Breaking layers into smaller pieces

- Layers provide a data driven separation of functionality
- Problem:
  - The level of complexity is usually too high to implement these in one piece of code
- Solution:
  - build layers using a set of loosely coupled components

Plug & play: *Component design*

- Components should encapsulate higher level concepts within the application, e.g.
  - provide the database interface
  - implement the user management
  - implement the session management
  - provide caching facilities
  - interface to external data sources
  - provide error handling facilities
  - enable logging management
  - etc.

On the loose: Advantages of components

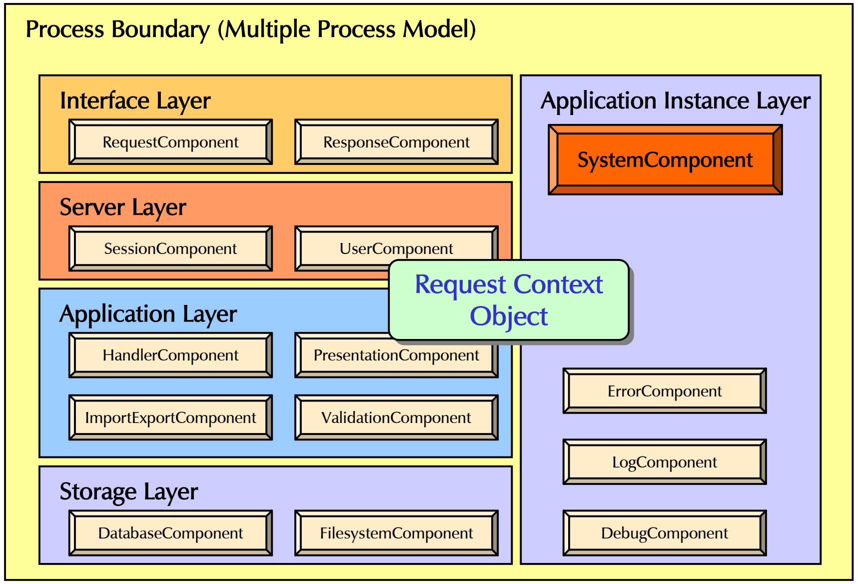
- Components provide independent building blocks for the application
  - They should be easily replaceable to adapt the application to new requirements, e.g.
    - porting the application to a new database backend,
    - using a new authentication mechanism, etc.
    - ➢ If implemented correctly, they will allow switching to different processing model should the need arise
  - Loose coupling of the components makes it possible to
    - refine the overall application design,
    - refactor parts of the layer logic or
    - add new layers
    - ➢ without having to rewrite large parts of the application code

Hitchhiker's guide to: Component implementation

- Each component is represented by a component object
- One system component object (representing the application instance):
  - All component objects are created and managed by the system object
  - Components can access each other through the system object (circular references !)
- Component interfaces must be simple and high-level enough to allow for loose coupling
  - Internal parts of the components are never accessed directly, only via the component interface
- Note: Component objects should never keep state across requests (ideally, they should be thread-safe)

Horizontal design: Split the layers into components

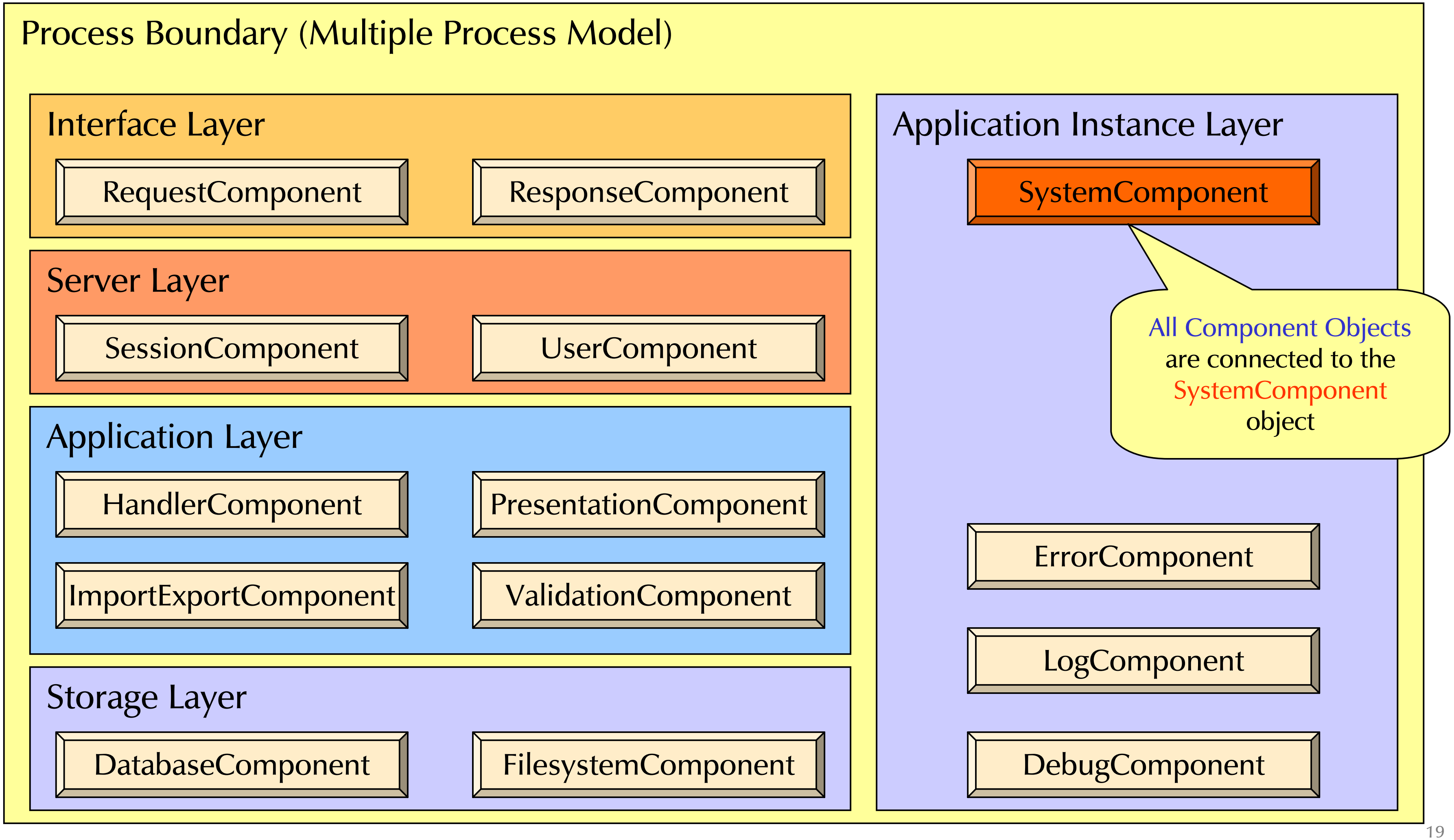
- General approach:
  - One system component that manages the application instance
  - At least one component per layer



- Data management:
  - Global data is only used for configuration purposes
  - Components don't store per-request state !

➢ Per-request global data is stored and passed around via Request Context Objects

The big picture: Layers and components

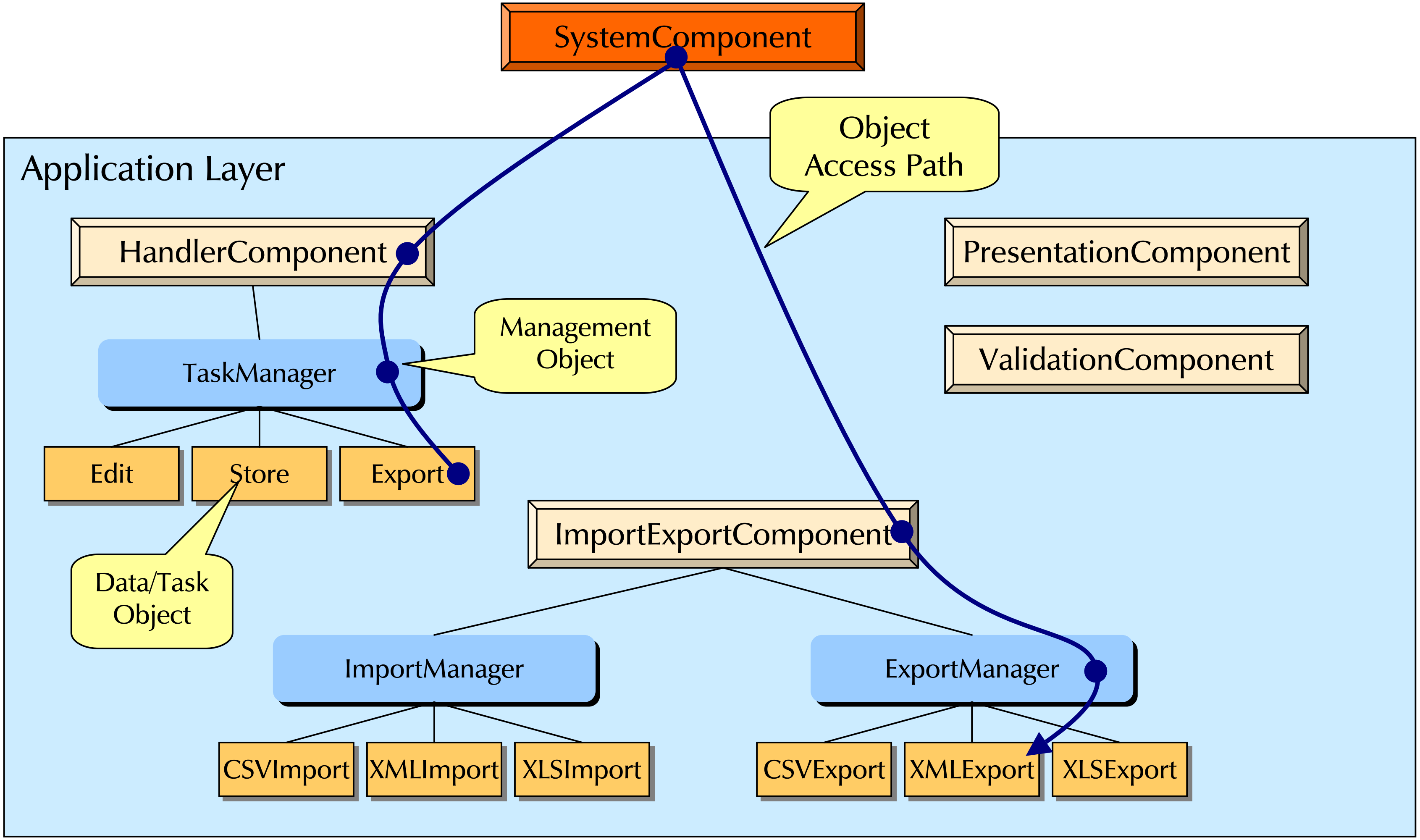


Breaking down complexity: *Management objects*

- Management objects
  - help simplify component object implementations
  - work on or with groups of data/task objects:

  - Data objects
  - Task objects
    - interaction with multiple objects
    - I/O on collections of objects
    - delegating work to other management objects
    - interfacing to component objects
    - etc.
- The distinction between management objects and component objects is not always clear
  - If in doubt, use a component object that delegates work to a management object

Drill-down: Management objects at work…



Managing responsibilities: Who's in charge ?

- Use component objects to represent logical units / concepts within the application
  - without going into too much detail…

- Use management objects to work on collections of data/task objects
  - to simplify component implementations
  - to avoid direct interfacing between the data/task objects

➢ Never mix responsibilities

Reality check: All this sounds familiar…

- Application design is in many ways like structuring a company:
  - Divisions need to be set up (component objects)
  - Responsibilities need to be defined (management vs. data/task objects)
  - Processes need to be defined (component/management object APIs)

- Applications work in many ways like companies:
  - Customer interaction (user interface)
  - Information flow (application interface)
  - Decision process (business logic)
  - Accounting and data keeping (storage interface)

Intermezzo: There's beauty in design

At work...

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Before you start: Structuring your modules

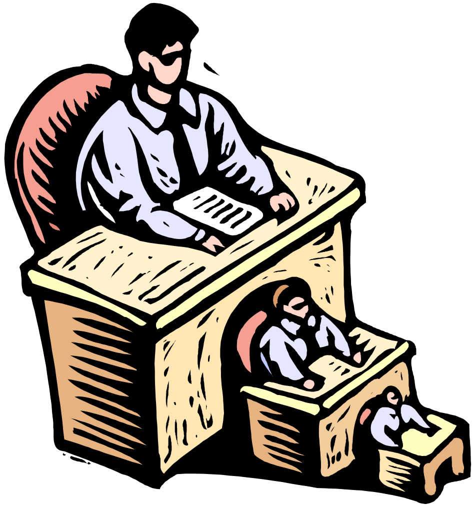
- First some notes on the import statement:
  - Keep import dependencies low;
    avoid “from … import *”
  - Always use absolute import paths
    (defeats pickle problems among other things)
  - Always layout your application modules using Python packages
  - Import loops can be nasty;
    import on demand can sometimes help

Some guidelines: Finding the right package structure

- Use one module per
  - management/component class
  - group of object classes
    managed by the same management class
  - keep modules small;
    if in doubt, split at class boundaries

- Group components and associated management modules in Python packages (directories)

- Use the application model as basis for the package layout



Finding the right mix: Data, classes and methods

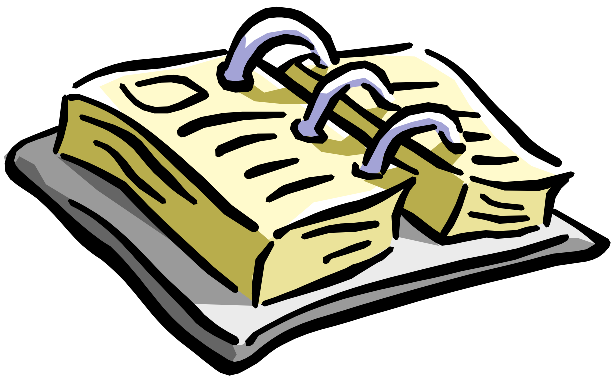
- Use data objects for data encapsulation…
  - instead of simple types (tuples, lists, dictionaries, etc.)
- Use methods even for simple tasks…
  - but don't make them too simple
- Use method groups for more complex tasks
  - e.g. to implement a storage query interface
- Use mix-in classes if method groups can be deployed in more than class context
  - If you need to write the same logic twice, think about creating a mix-in class to encapsulate it, or put it on a base class
  - Avoid using mix-in classes if only one class makes use of them

Make mistakes… and learn from them: Refactoring

- If an implementation gets too complicated, sit down and reconsider the design…
  - often enough a small change in the way objects interact can do wonders
- Be daring when it comes to rewriting larger parts of code !
- It sometimes takes more than just a few changes to get a design right
- It is often faster to implement a good design from scratch, than trying to fix a broken one

Often forgotten: Documentation

- Always document the code that you write !
- Use doc-strings, inline comments and block logical units using empty lines…
  - doc-strings represent your method's contracts with the outside world



- Document the intent of the methods, classes and logical code units…
  - not only their interface
- Use descriptive identifier names…
  - even if they take longer to type

Five minutes that make a difference: Quality Assurance

- Use extreme programming techniques whenever possible:
  - Always read the code top to bottom after you have made changes or added something new to it
  - Try to follow the flow of information in your mind (before actually running the code)
  - Write unit tests for the code and/or test it until everything works as advertised in the doc-strings

- Typos can easily go unnoticed in Python: use the editor's auto-completion function as often as possible
- Use tools like PyChecker to find hidden typos and possibly bugs
- Always test code before committing it to the software repository

Discussion

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Developing large-scale applications in Python

- Questions

  - Has anyone worked on large-scale Python applications ?

  - What tools / features are (still) missing in the tool chain ?

  - Would you be prepared to pay for components or frameworks ?

And finally...

Thank you for your time.

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