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Designing Large-Scale Applications in Python

Lessons learned in more than 10 years of Python Application Design

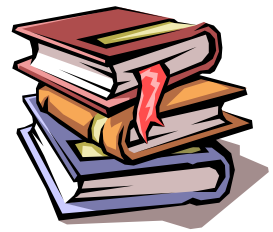
EuroPython Conference 2008
Vilnius, Lithuania

Marc-André Lemburg

EGENIX.COM Software GmbH
Germany

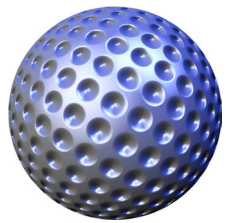
Speaker Introduction: Marc-André Lemburg

- CEO eGenix.com and Consultant
  - More than 20 years software development experience
  - Diploma in Mathematics
  - Expert in Python, Application Design, Web Technologies and Unicode
  - Python Core Developer (since 2000)
  - Python Software Foundation Board Member (2002-2004)
  - 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



Agenda

1. Introduction
2. Application Design
3. Before you start…
4. Discussion



Introduction

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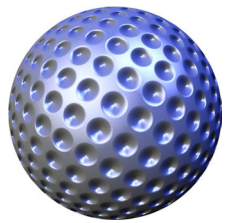

Designing Python Applications

- 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
- This talk presents a general approach to the problem
  - … which is not necessarily specific to Python

Large-scale applications

- What can be considered "large-scale" in Python ?
  - Server application: >100 thousand lines of Python code
  - Client application: >50 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 Engine, XML Database, ASP Trading System

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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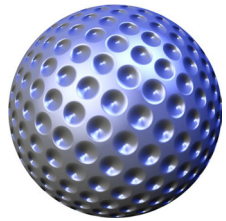

The Design Concept: Structured …

- Structured approach to application design
  - Divide et Impera (divide and conquer)
  - Top-down method:
    1. Application model
    2. Processing model
    3. Layer model
    4. Components
    5. Management objects
    6. Data and Task objects
- Lots of experience also helps…

The Design Concept: … or using “import this”

- Zen of Application Design
  - Keep things as simple as possible, but not simpler (KISS).
  - Before doing things twice, think twice (DRY).
  - If things start to get too complex, management is needed.
  - If management doesn’t help, decomposition is needed.
  - Keep in mind: There’s beauty in design.

Divide et Impera: Step by step approach

- Goal: Break down complexity as far as possible !

- Top-down method:
  1. Application model
  2. Processing model
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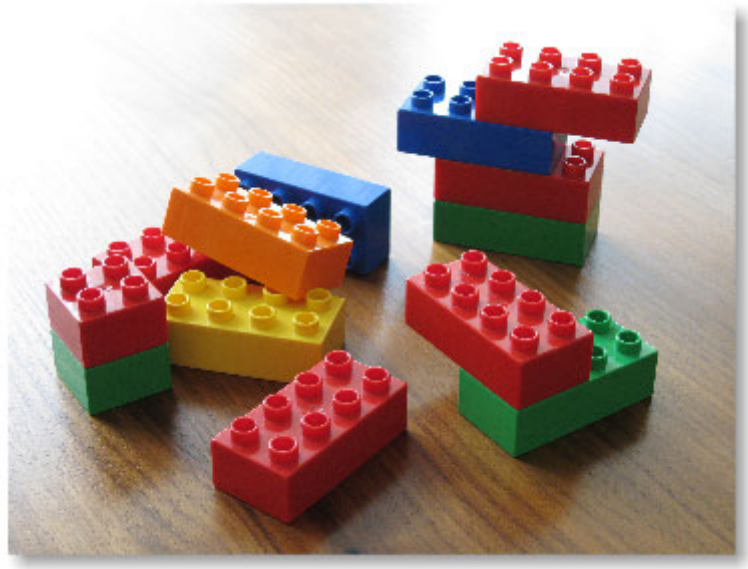

Divide et Impera: Start with the type of application

- Goal: Break down complexity as far as possible !

- Top-down method:
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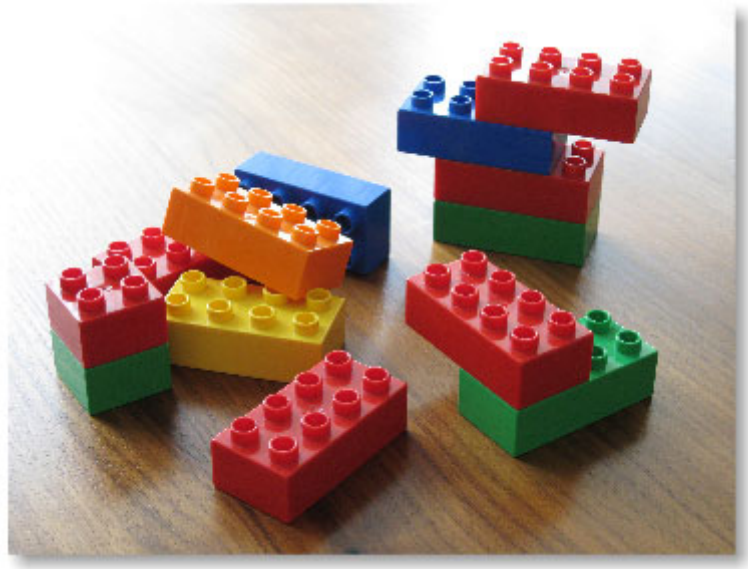
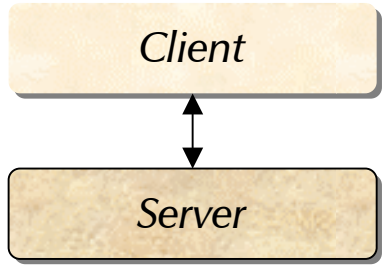
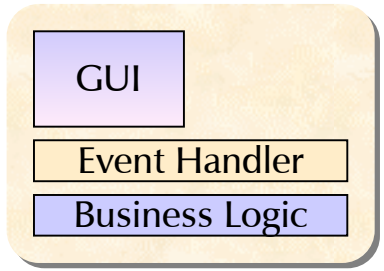


Choose a suitable *application model*

- 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.

Divide et Impera: How should requests be processed ?

- Goal: Break down complexity as far as possible !

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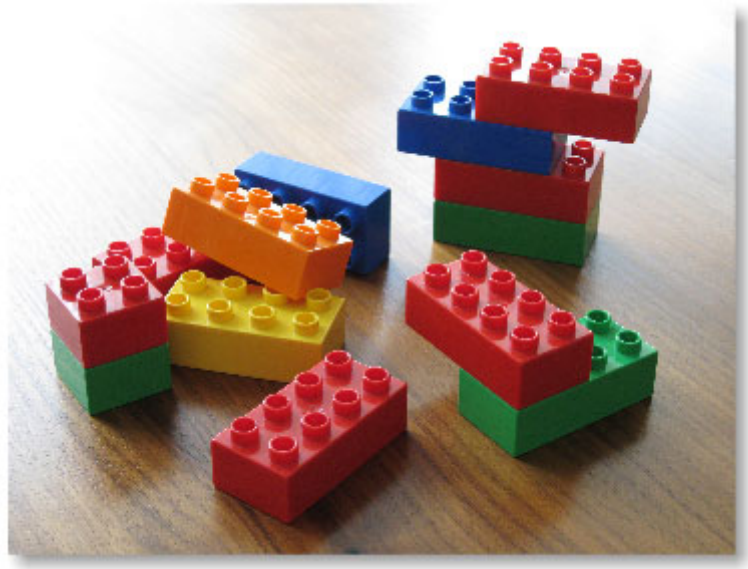
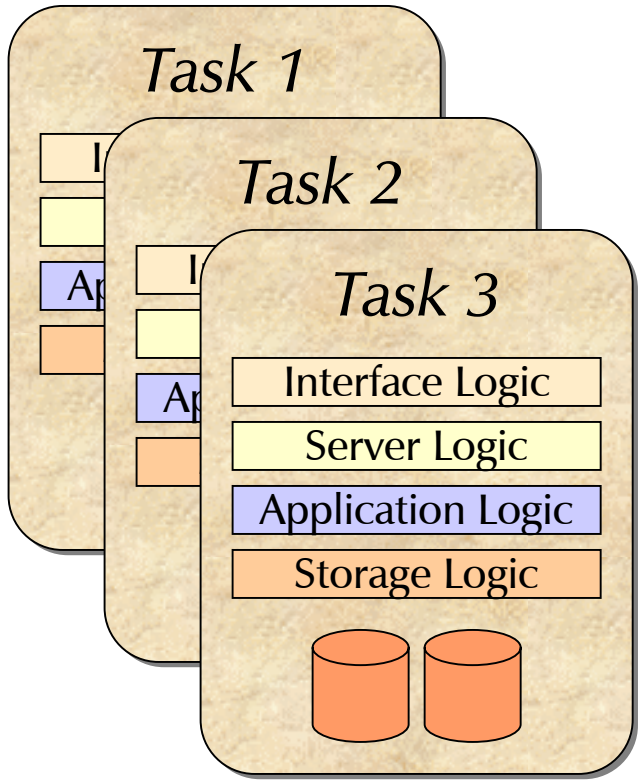


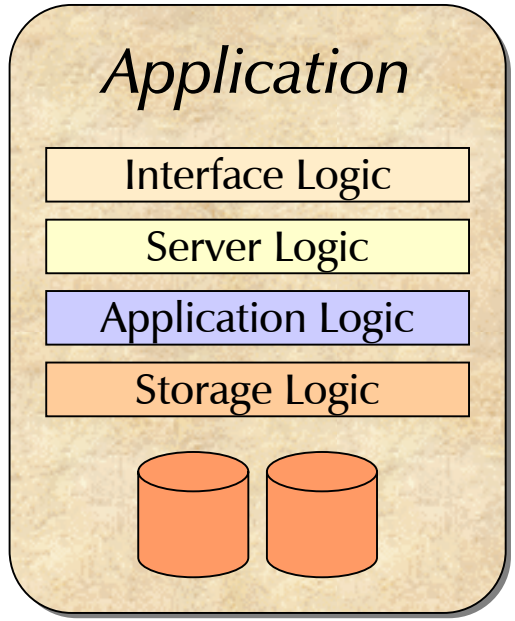
Identify the *processing model*

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



Identify the *processing model*

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



Divide et Impera: Break down by functionality

- Goal: Break down complexity as far as possible !

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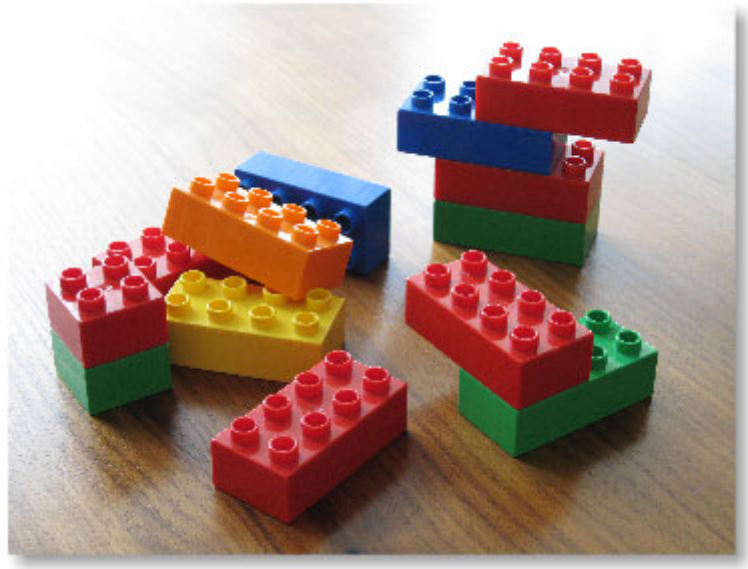
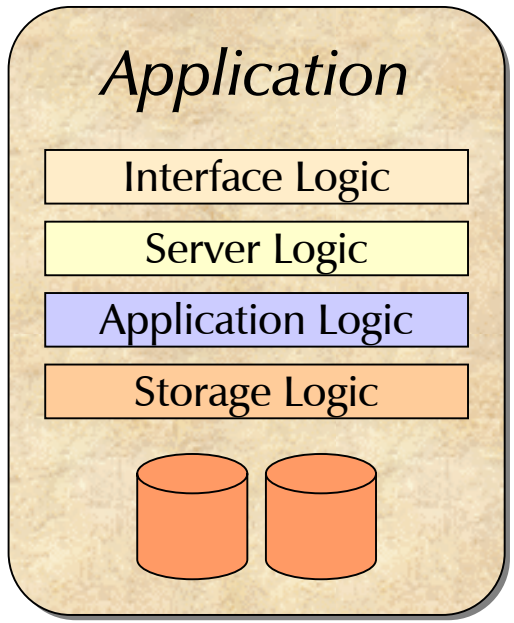


Find the right *layer model*

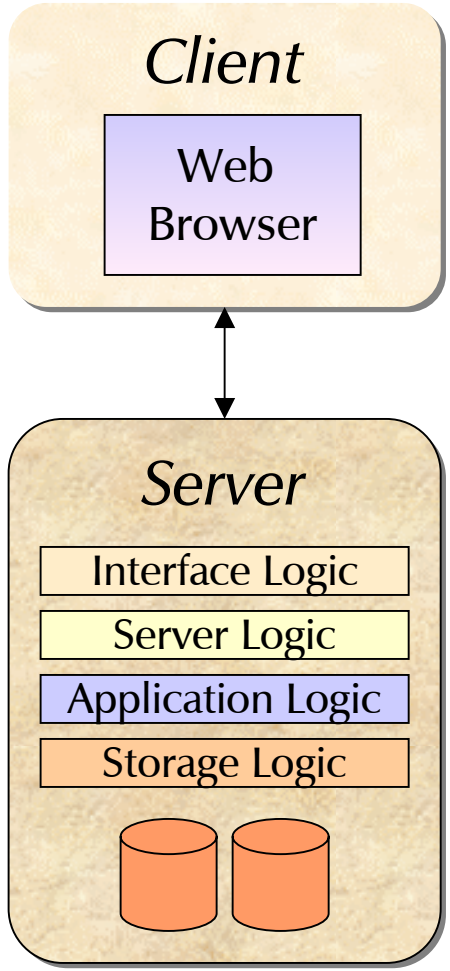
- Every application can be divided into layers of functionality defined by the flow of data through the application

  - Top layer:
    interface to the outside world
  - Intermediate layers:
    administration and processing
  - Bottom layer:
    data storage



Examples of layer models

- Client application:
  GUI / Application Logic / Storage Logic
- Web application:
  Web Browser/ Network / Apache /
  Interface Logic (CGI, SCGI, WSGI) /
  Server Logic / Application Logic /
  Storage Logic
- Batch processing:
  File I/O / Application Logic / Storage Logic
- Custom model



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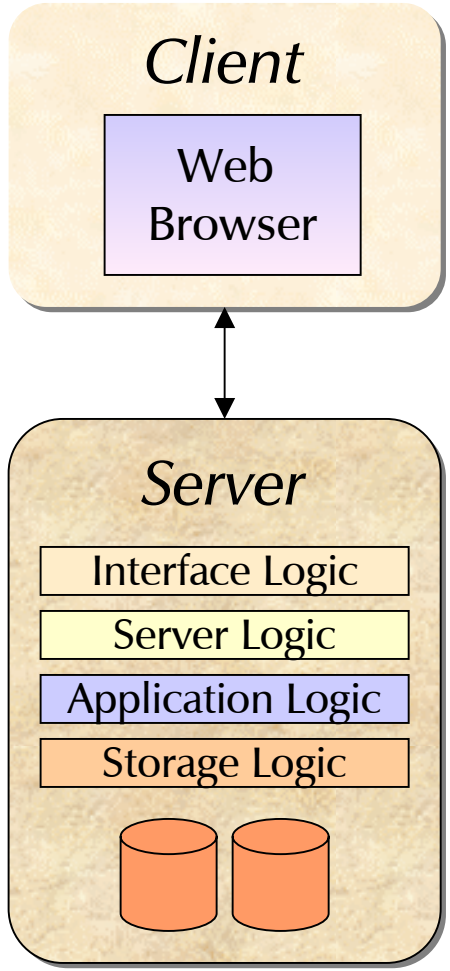
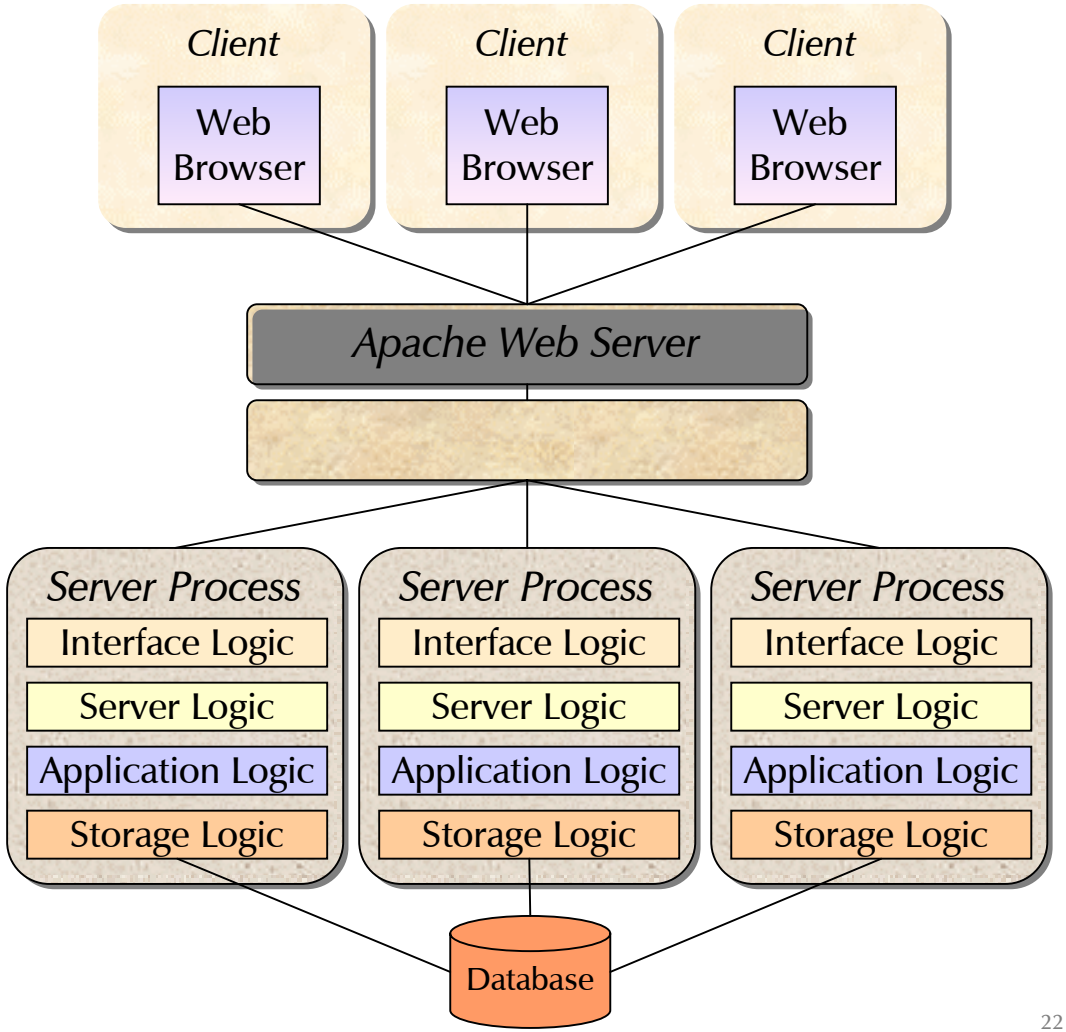


Example: Web Client + Server Application

- Situation:
  - 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
  - Server is connected to a database

Example: Web Client + Server Application

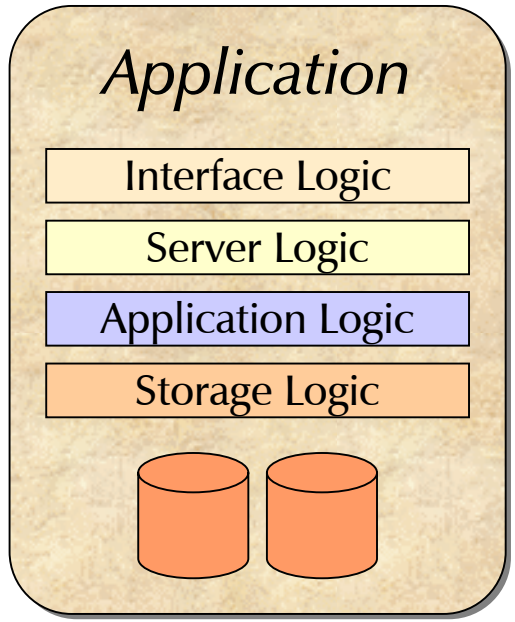
- Solution:
  - Application model: client-server
  - Processing model: multiple process model
  - Layer model: typical application server layers



Find the right *layer model*: ok, but now what … ?

- Layers are usually easy to identify, given the application model

… but often hard to design



Divide et Impera: Layers are still too complex

- Goal: Break down complexity as far as possible !

- Top-down approach:
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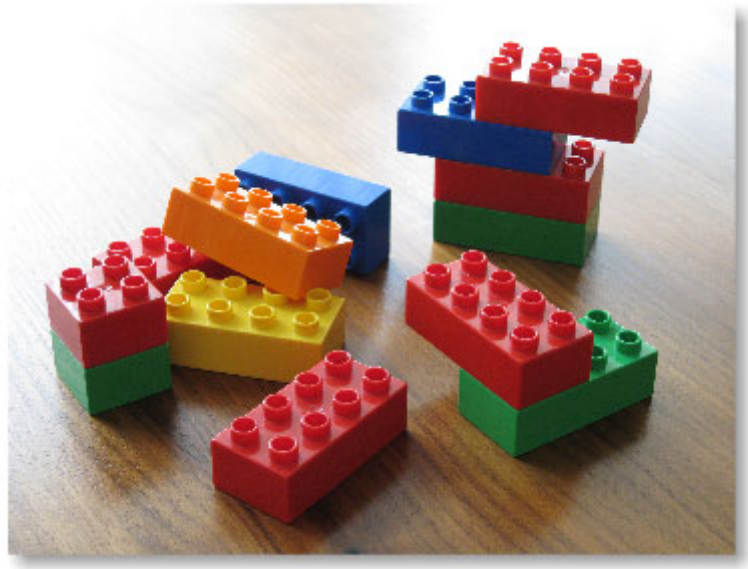


Breaking layers into smaller pieces: *Components*

- 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

Component design

- Components should encapsulate higher level concepts within the application

- Components provide independent building blocks for the application

Component examples

- Components …
  - 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.

Advantages of components: Easily replaceable

- 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 even allow
  switching to a different processing model,
  should the need arise

Advantages of components: Loose coupling

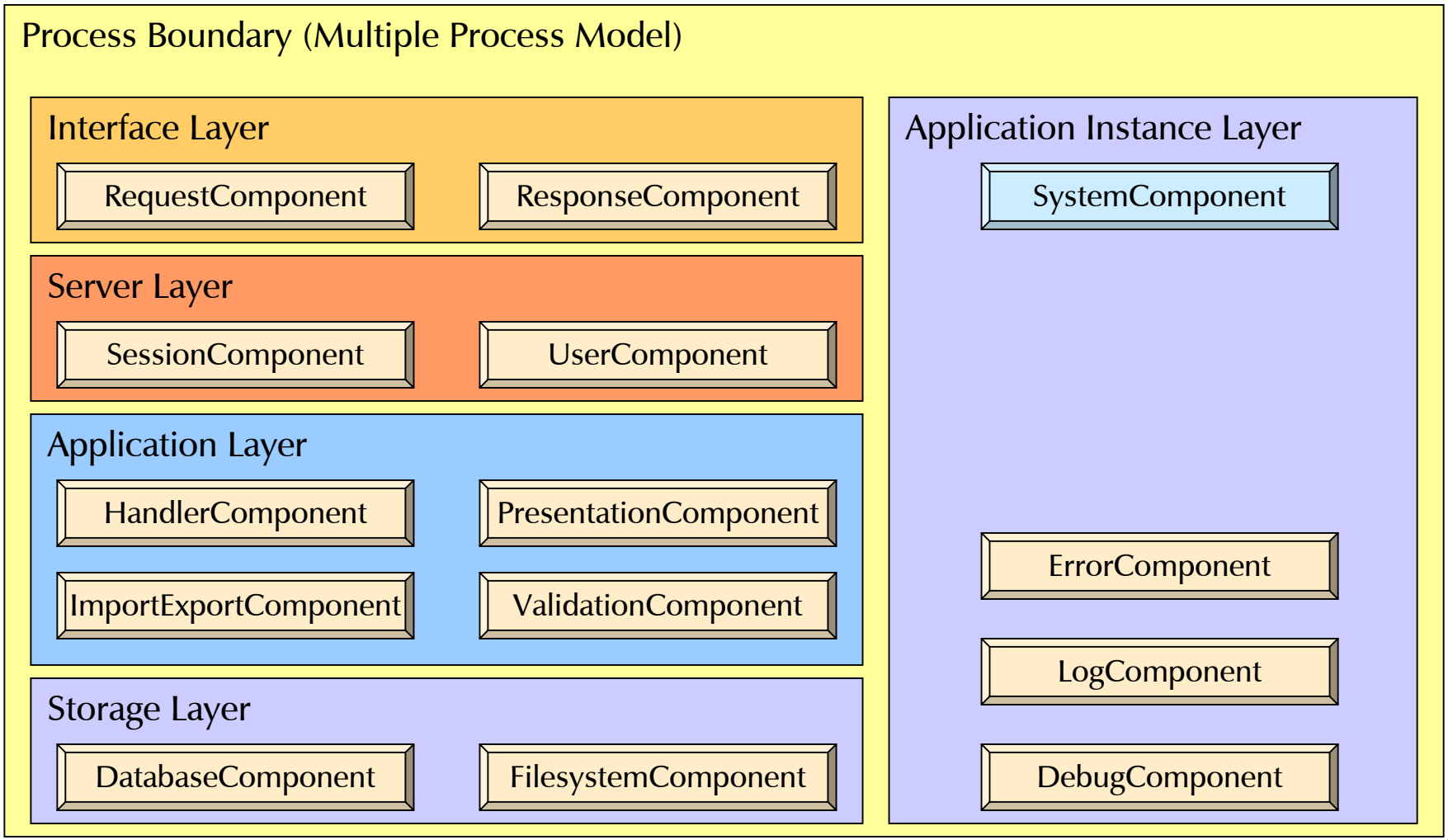
- Loose coupling of the components makes it possible to
  - refine the overall application design,
  - refactor parts of the layer logic, or
  - add new layers

without having to rewrite large parts of the application code

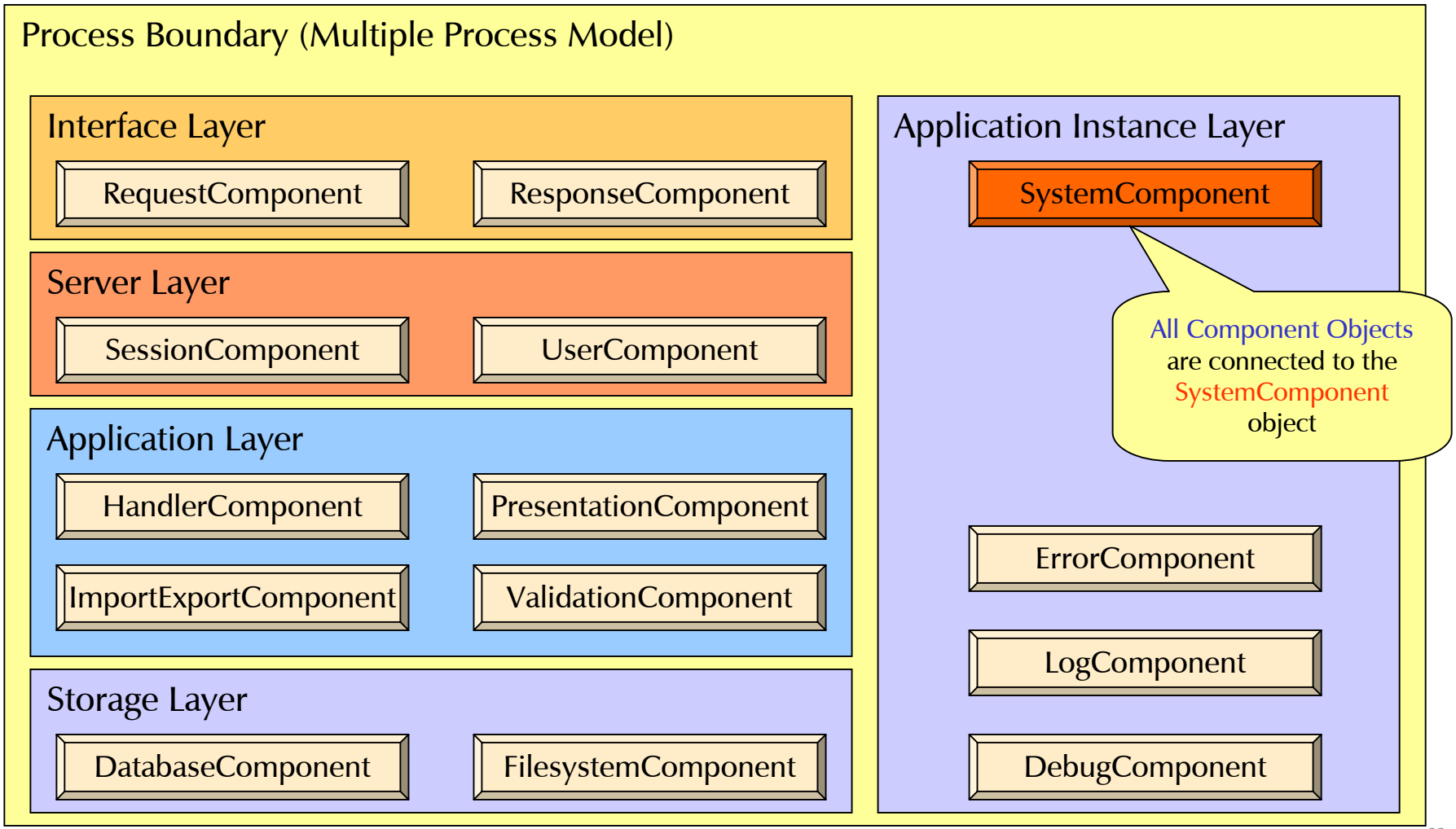
Component implementation

- Each component is represented by a component object
- 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
- Component objects should never keep state across requests
  - Ideally, they should also be thread-safe

Layers and components: The big picture



Layers and components: The big picture

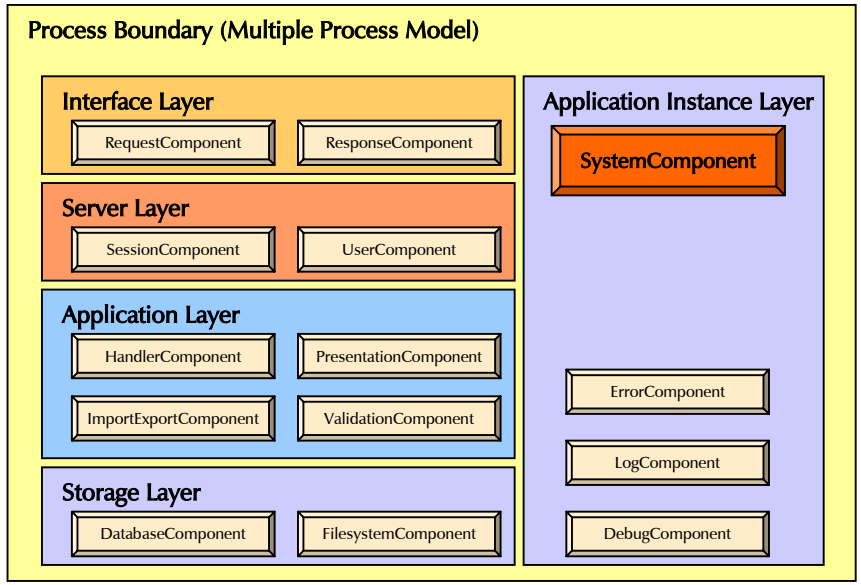


Special component: The *System Object*

- One system component object which represents 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 !)
  - There can be multiple system objects, e.g. one running in each thread

Split layers into components: Summary

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



Divide et Impera: What if components are still too complex ?

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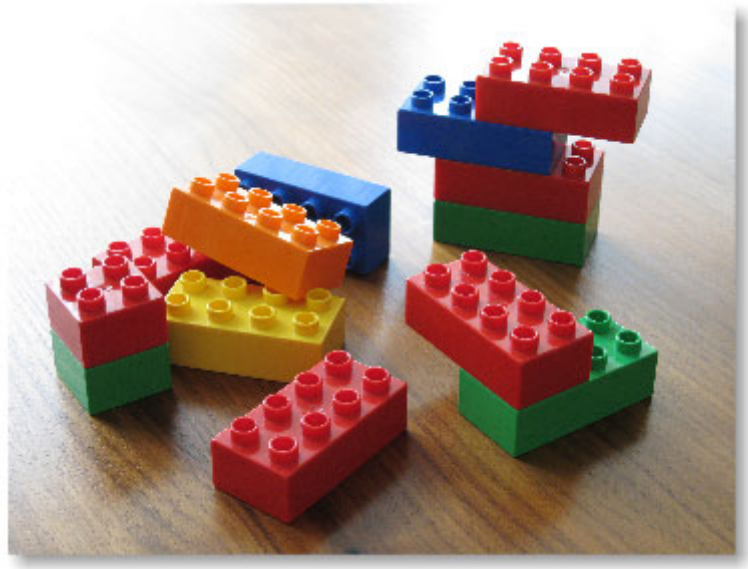

Reduce component complexity: *Management objects*

- Management objects
  - help simplify component object implementations
  - work on or with groups of low-level data/task objects
  - provide application internal APIs
  - interface to the "outside world",
    e.g. file system, database, GUI, etc.

- Note:
  The distinction between management objects and component objects is not always clear …

Management object or component ?

- 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

➢ Try to never mix responsibilities

Divide et Impera: The Lowest Level

- Goal: Break down complexity as far as possible !

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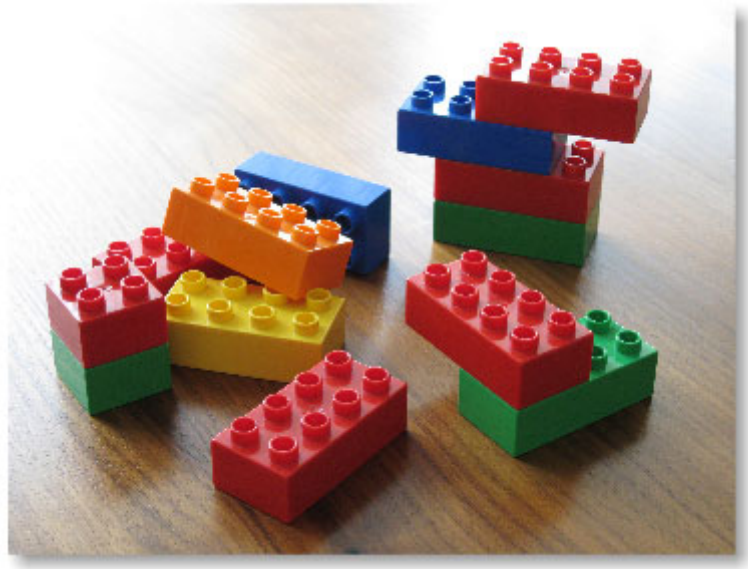
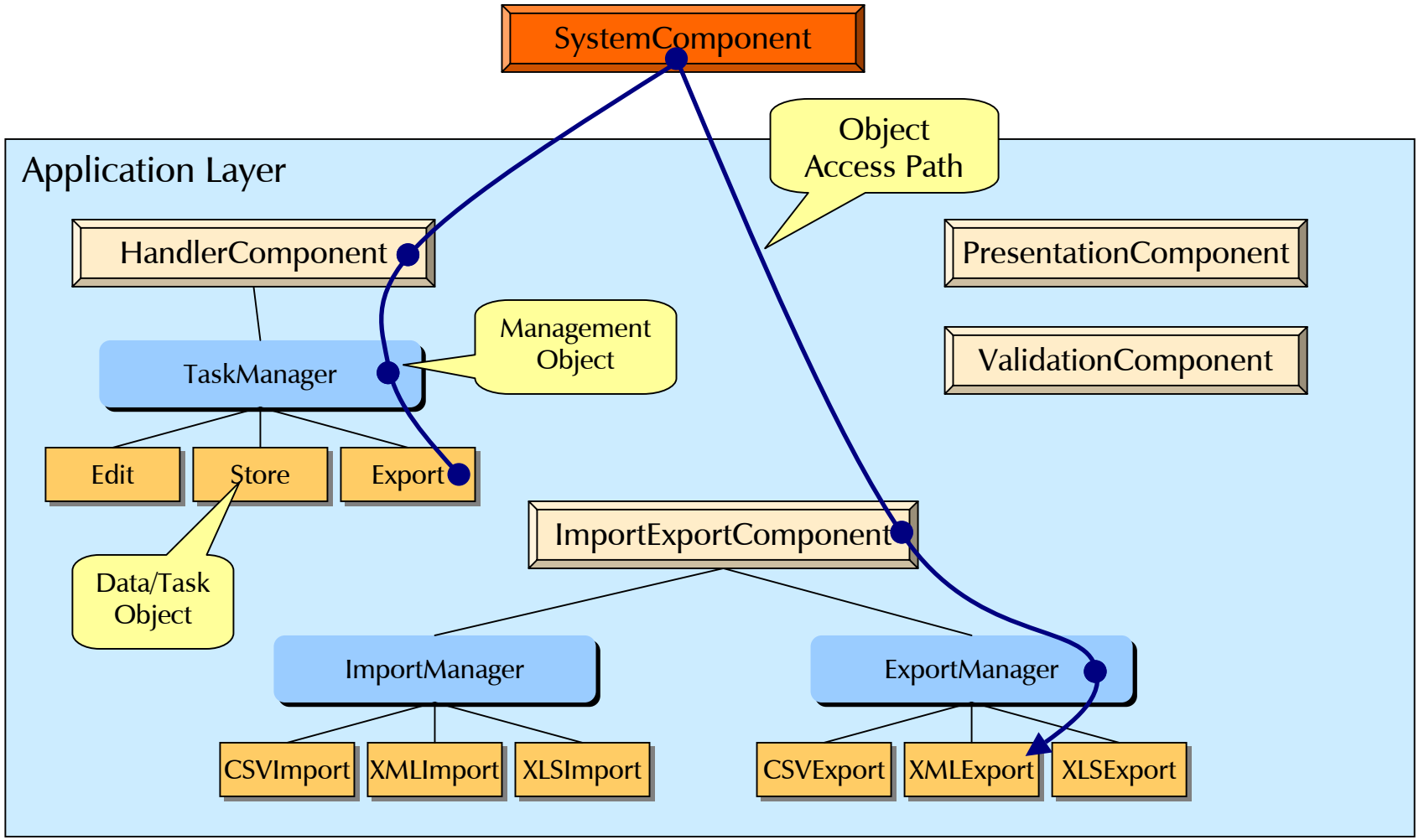


Lowest level: *Data and task objects*

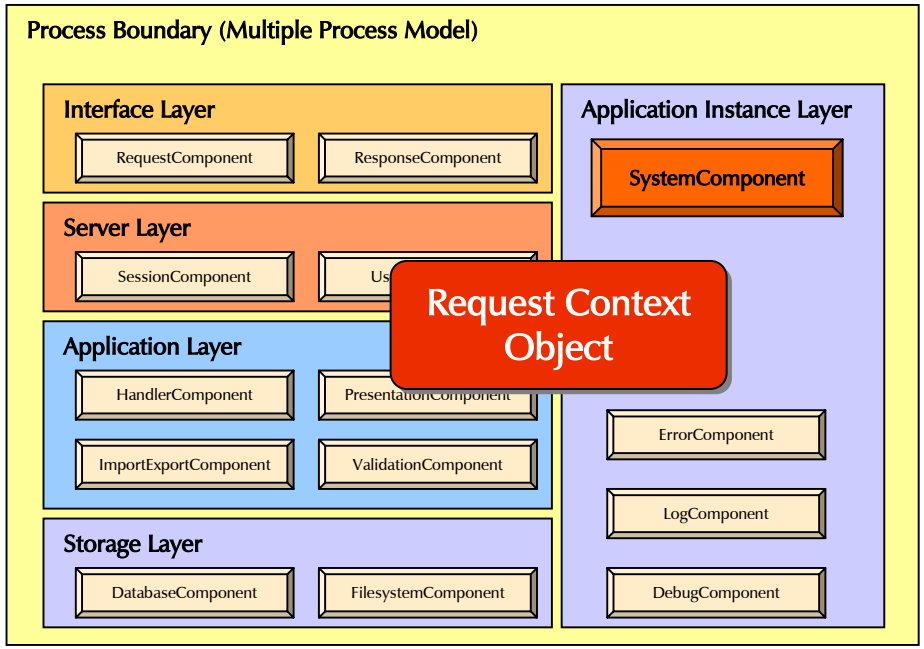
- Data objects
  - encapsulate data (nothing much new here)
- Task objects
  - interaction with multiple objects
  - I/O on collections of objects
  - delegating work to other management objects
  - interfacing to component objects
  - etc.

Example: Internal Communication



Special data object: *Request Context Object*

- This is useful for task based applications, e.g. web applications
- Data management:
  - Components don't store per-request state !
  - ➢ Per-request data is stored and passed around via Request Context Objects



And don't forget: There's beauty in design !

Before you start...

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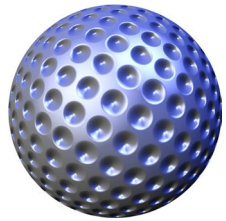


Structuring your modules

- 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

Finding the right package structure

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

- Use the application and layer model as basis for the package layout

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

Data, classes and methods

- Use data objects for data encapsulation…
  - instead of simple types (tuples, lists, dictionaries, etc.)
- Namespace objects are one honking great idea
  - do more of those … ☺

Data, classes and methods

- 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

Data, classes and methods

- 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

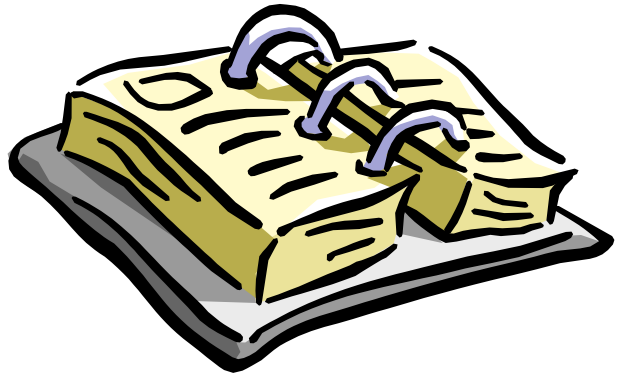
Make mistakes… and learn from them: *Refactoring*

- 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

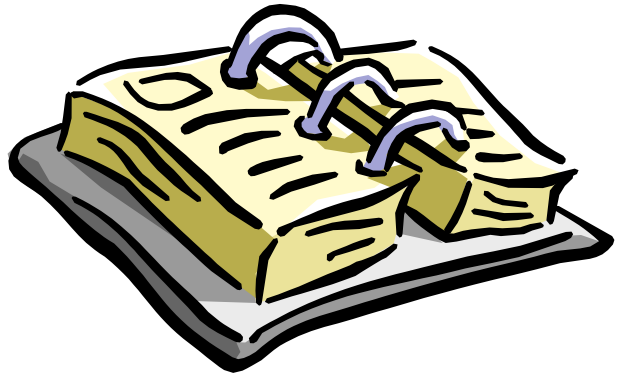
- Always document the code that you write !



- Use doc-strings and inline comments
  - doc-strings represent your method's contracts with the outside world
- Block logical units using empty lines…
  - Python loves whitespace ☺

Often forgotten: Documentation

- 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

Quality Assurance: XP helps !

- 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

Quality Assurance: A few additional tips

- 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

Conclusion

- Structured application design can go a long way
- Divide-et-impera helps keep basic buildings blocks manageable
- Extreme programming doesn't have to spoil the fun

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)

Discussion

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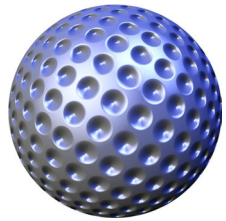

Developing large-scale applications in Python

And finally...

Thank you for your time.

Contact

eGenix.com Software, Skills and Services GmbH
Marc-André Lemburg
Pastor-Löh-Str. 48
D-40764 Langenfeld
Germany

eMail: mal@egenix.com
Phone: +49 211 9304112
Fax: +49 211 3005250
Web: http://www.egenix.com/