Designing large-scale applications in Python

PyWaw Summit 2015
Warsaw, Poland

Marc-André Lemburg

Speaker Introduction

Marc-André Lemburg

- Python since 1993/1994
- Studied Mathematics
- eGenix.com GmbH
- Senior Software Architect
- Consultant / Trainer
- Python Core Developer
- Python Software Foundation
- EuroPython Society
- Based in Düsseldorf, Germany

Agenda

- Introduction
- Application Design
- Before you start ...
- Discussion

Agenda

- Introduction
- Application Design
- Before you start ...
- Discussion

Designing Python Applications (1/2)

- 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

Designing Python Applications (2/2)

- Application design becomes the most important factor in Python projects

- This talk presents a general approach to the problem

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:
    > 100 thousand lines of code
  - Typically a mix of Python code and C extensions

Why write applications in Python ? (1/3)

- Highly efficient
  - Small teams can scale up against large companies
  - Very competitive turn-around times
  - Small investments can result in high gains

Why write applications in Python ? (2/3)

- Very flexible
  - allows rapid design, refactoring and rollout
  - highly adaptive to new requirements and environments
  - no lock-in

Why write applications in Python ? (3/3)

- Time-to-market
  - Develop / add new features
    in weeks rather than months
  - Be ahead of the game *or*
  - Stay competitive

Agenda

- Introduction
- Application Design
- Before you start …
- Discussion

Situation

- A typical application scenario:
  - Complex interactions between program parts
  - Complex work concepts
  - Many different I/O types

High-level view

- Applications typically have to implement…
  - Customer interaction (user interface)
  - Information flow (application interface)
  - Decision process (business logic)
  - Accounting and data keeping (storage interface)

Think outside the box...

- Application design is in many ways like structuring a company:

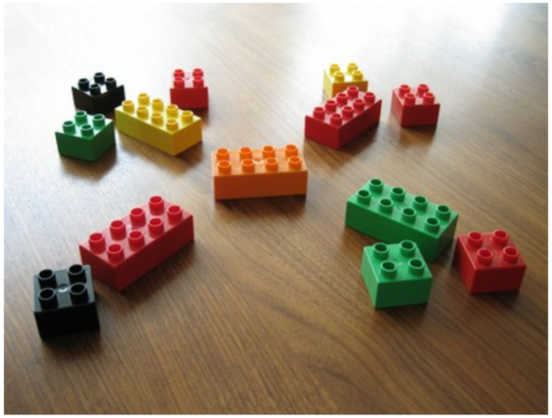
  – Departments and divisions need to be set up

  – Responsibilities need to be defined

  – Processes need to be defined

The Design Concept (1/2)

- Structured approach to application design
  - Divide et Impera (divide and conquer)
  - Top-down method:
    - Application model
    - Processing model
    - Layer model
    - Components
    - Management objects
    - Data and Task objects



- Lots of experience also helps…

The Design Concept (2/2)

Zen of Application Desi… (from this import app)

from this import app...

- Keep things as s… …ossible, but not simpl…
- Before… …gs twice, thin… …Y).
- … start to get too complex, …gement is needed.
- If management doesn't help, decomposition is needed.
- Keep in mind: There's beauty in design.

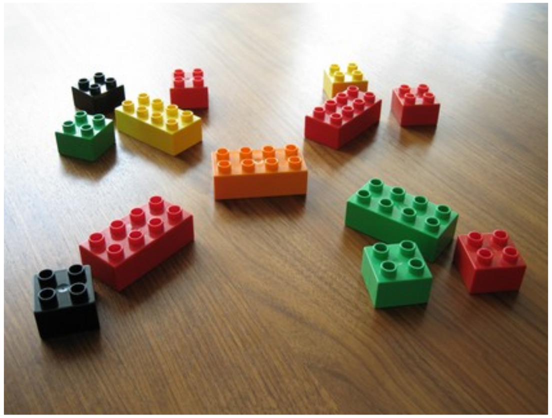
The Design Concept (2/2)

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

Divide et Impera: Step by step

- Goal: Break down complexity as far as possible !

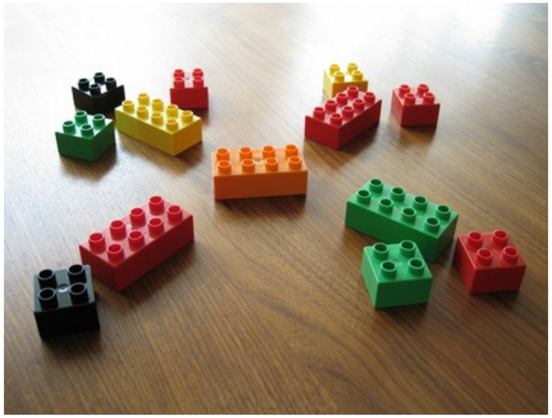
- Top-down method:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



Start with the type of application

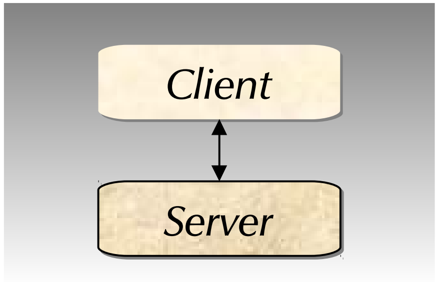
- Goal: Break down complexity as far as possible !

- Top-down method:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects

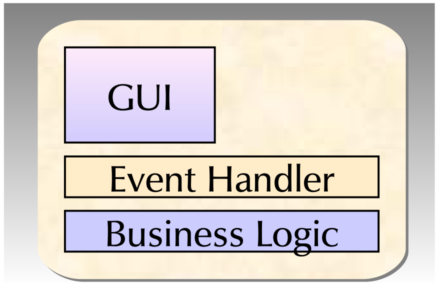


Choose a suitable *application model*

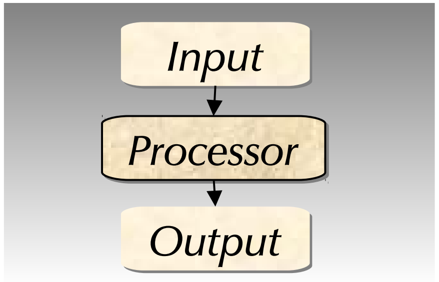
- Client-Server
  - Client application / Server application
  - Web client / Server application



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



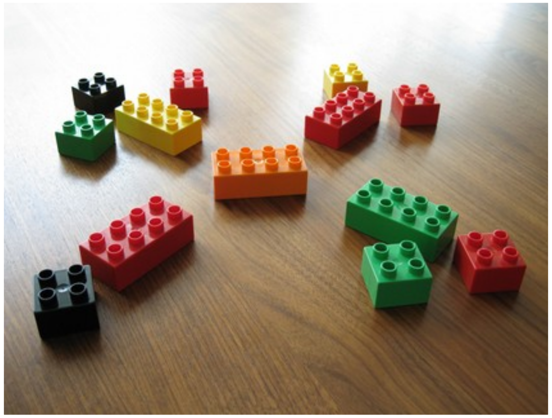
- Single process
  - Command-line application
  - Batch job application
- …



How should requests be processed ?

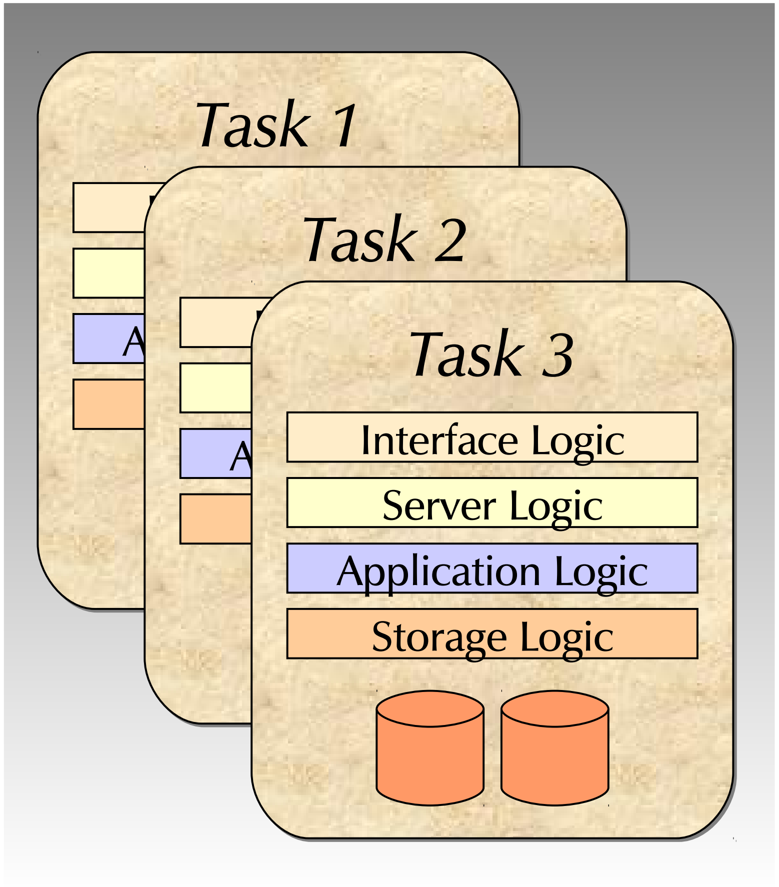
- Goal: Break down complexity as far as possible !

- Top-down method:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



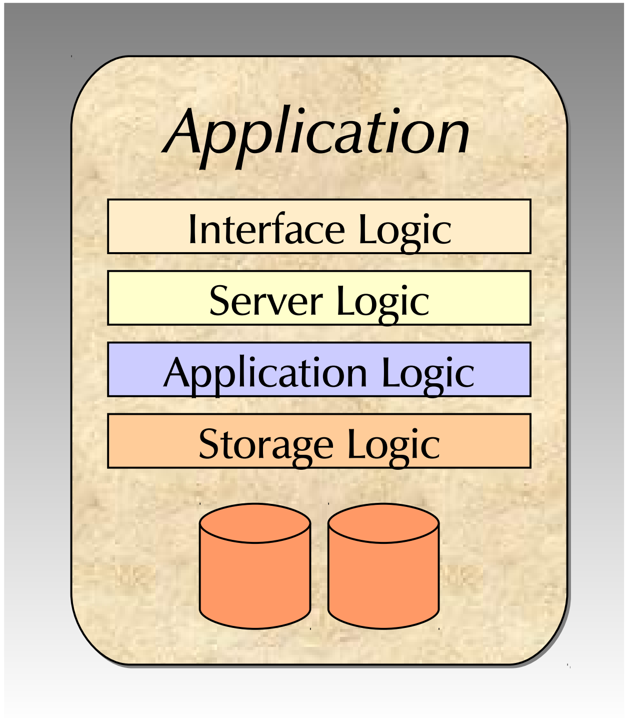
Identify the *processing model*

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



Identify the *processing model*

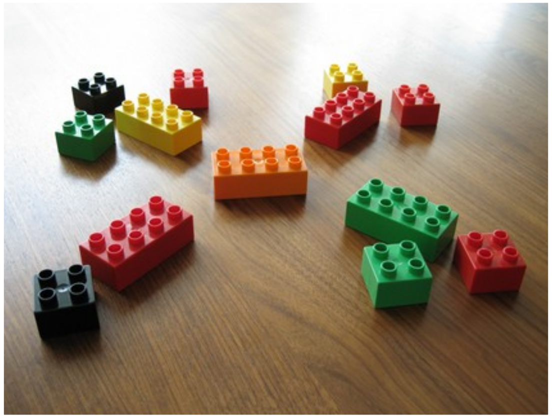
- Identify the process/thread boundaries:
  - Which components (need to) share the same object space ?
  - Where is state kept ?
  - What defines an application instance ?



Break down by functionality

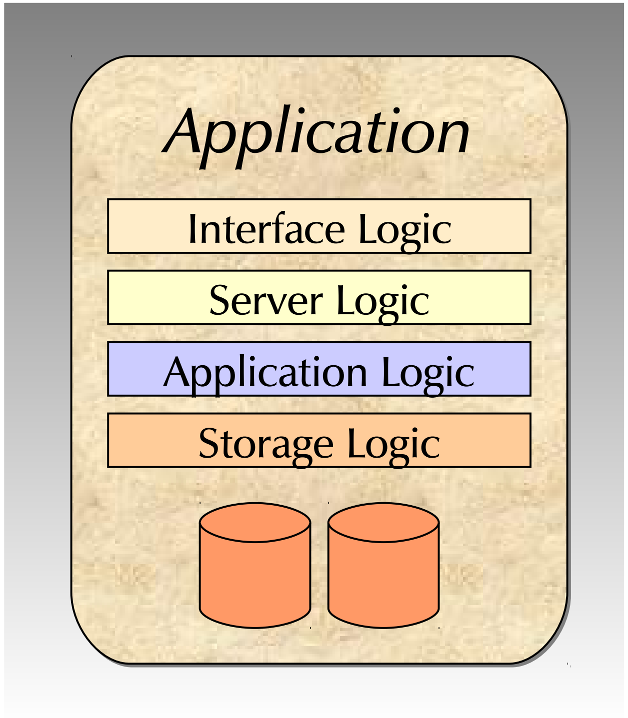
- Goal: Break down complexity as far as possible !

- Top-down method:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



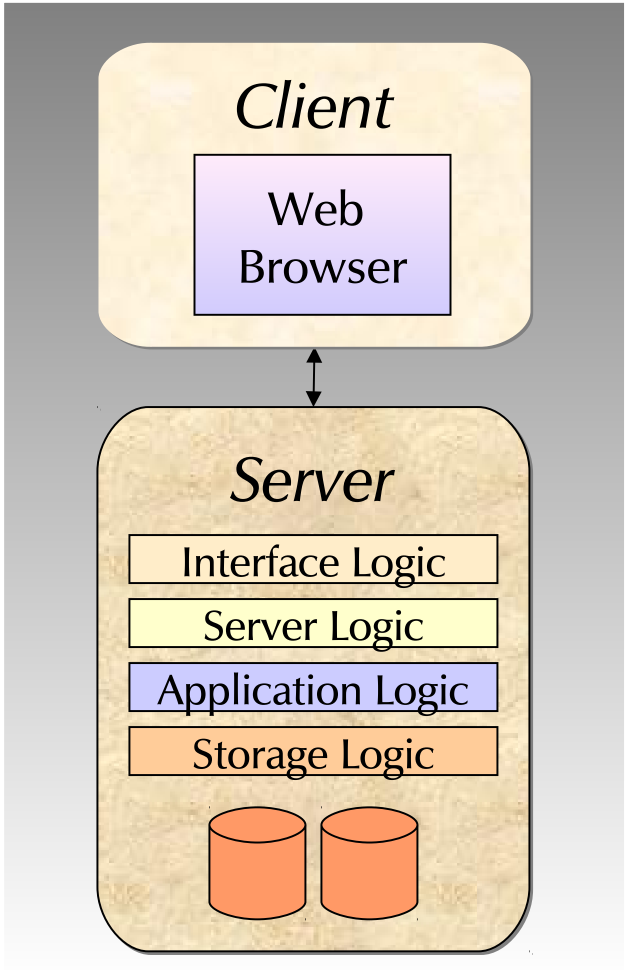
Find the right *layer model*

- 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



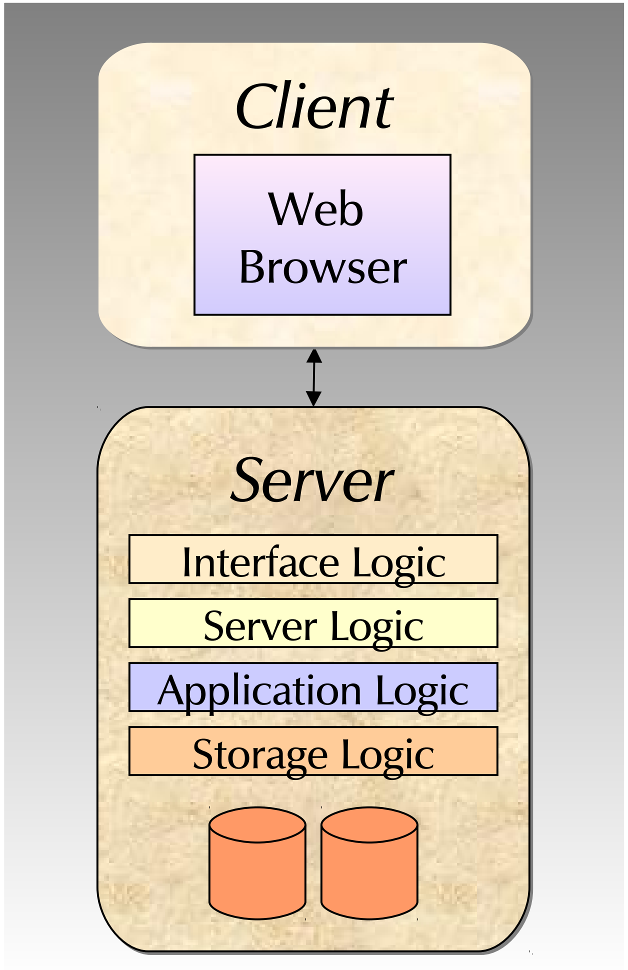
Examples of layer models

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



Examples of layer models

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



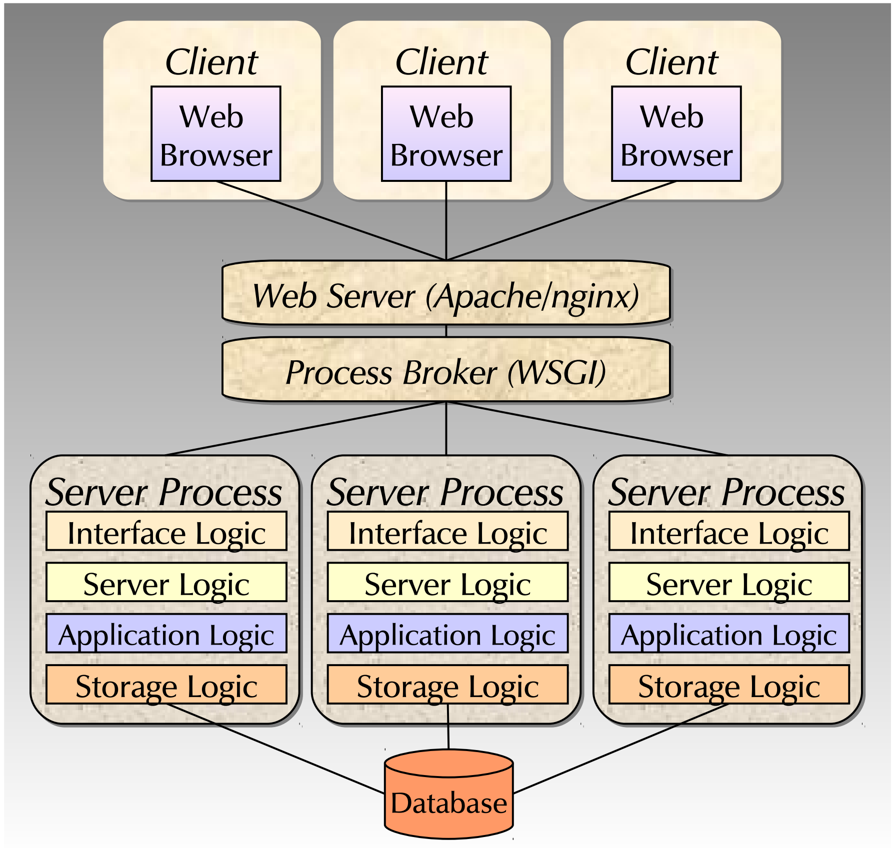
Example: Web Application

- Situation:
  - Client is a standard web-browser
  - Client will do lots of AJAX

  - Server needs to take a lot of load and will have to do most of the calculation work
  - Server needs to be fail-safe
  - Server is connected to a database
  - Server needs to scale

Example: Web Application

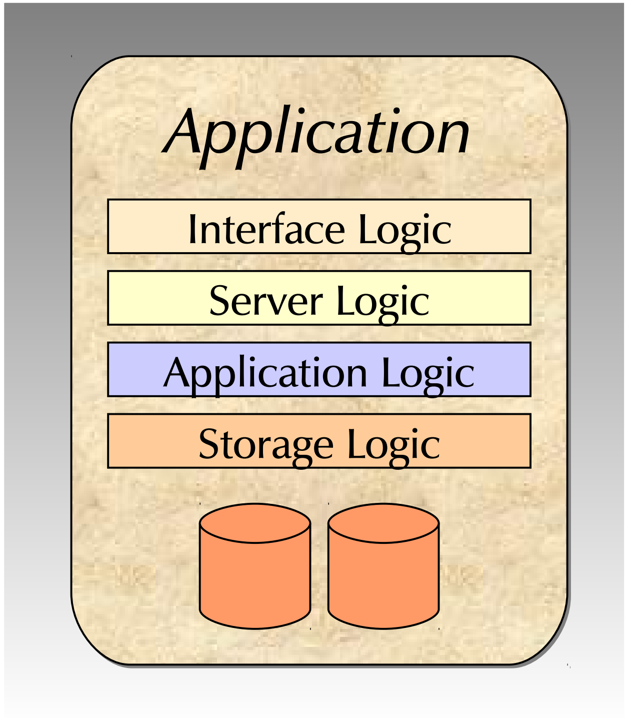
- Solution:
  - Application model: client-server
  - Processing model: multiple process model
  - Layer model: typical application server layers



Found the *layer model*: now what… ?

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

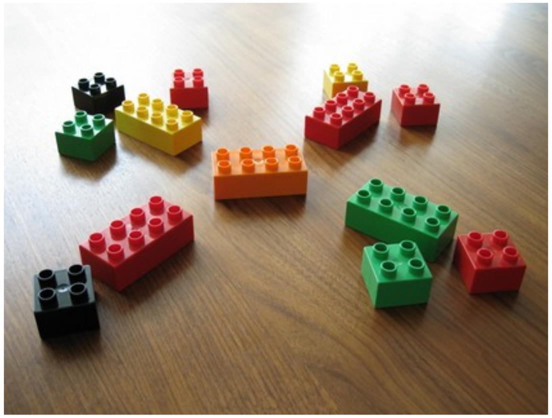
… but often hard to design



Layers are still too complex

- Goal: Break down complexity as far as possible !

- Top-down approach:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



Break up layers into *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 (1/2)

- They should be easily replaceable
  to adapt the application to new
  requirements, e.g.
  - porting 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 (2/2)

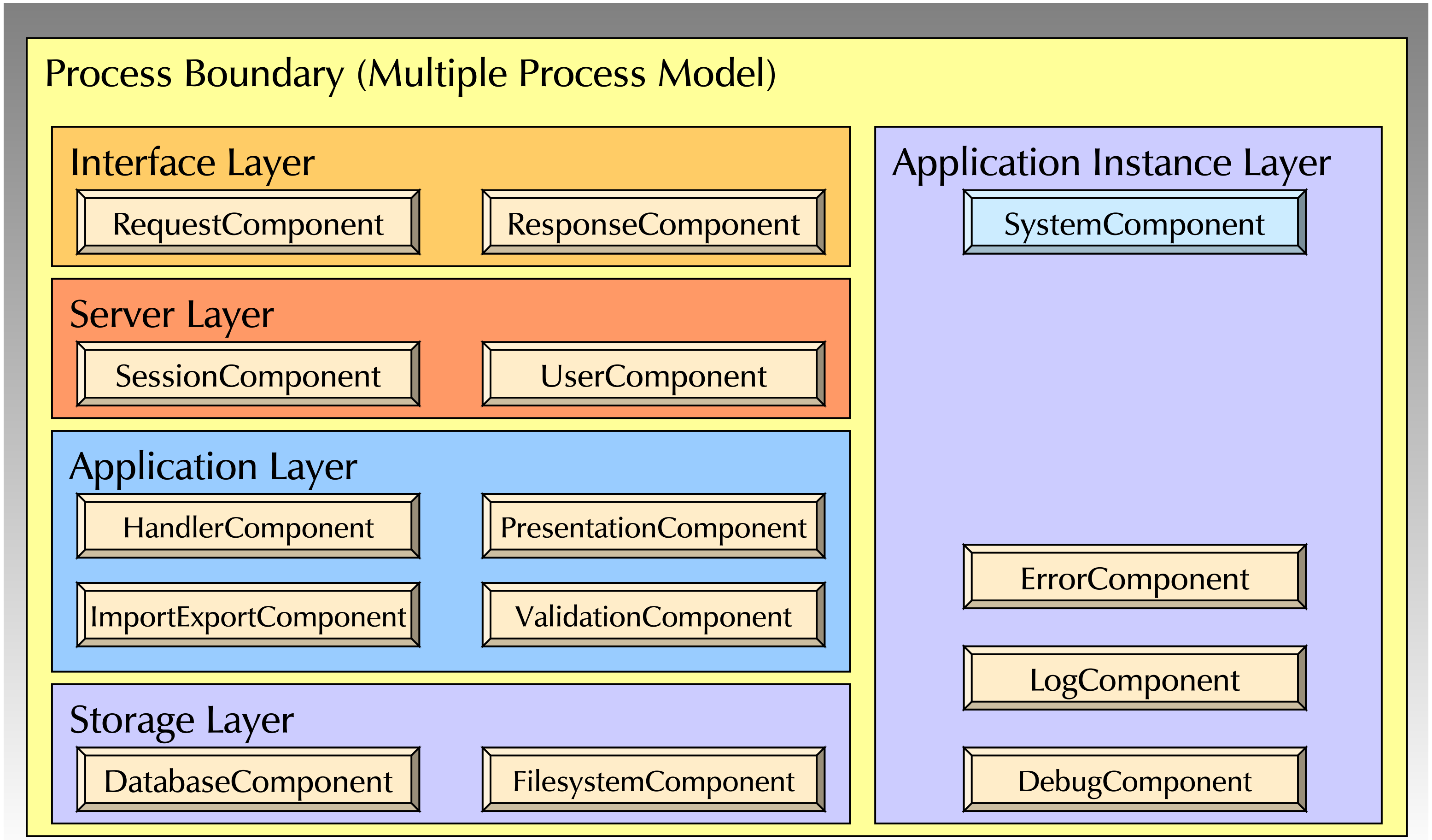
- Loose coupling of the components makes it possible to
  - refine the overall application design,
  - refactor parts of the layer logic, or
  - add new layers

without having to rewrite large parts of the application code

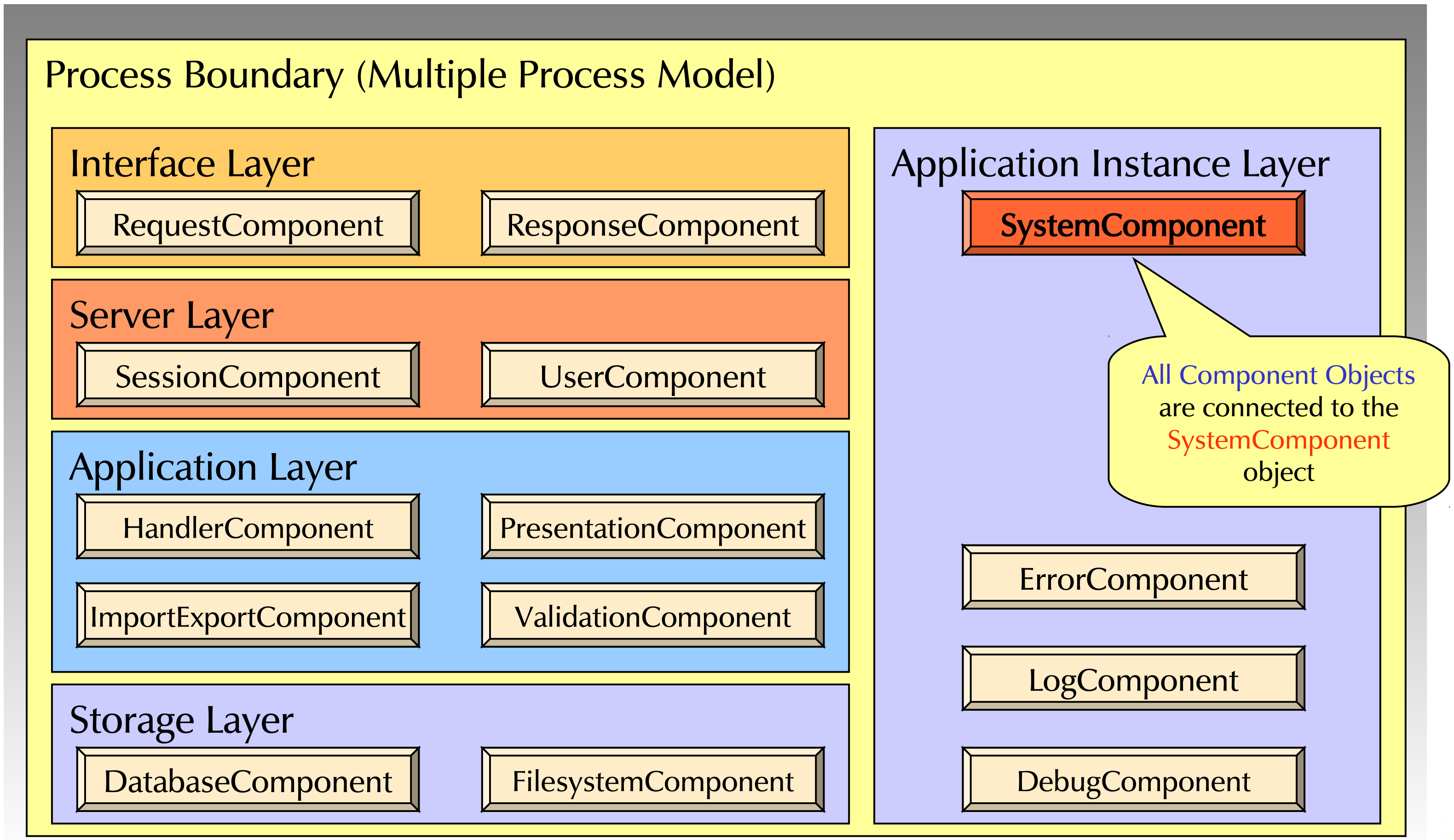
Component implementation

- 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

The Big Picture

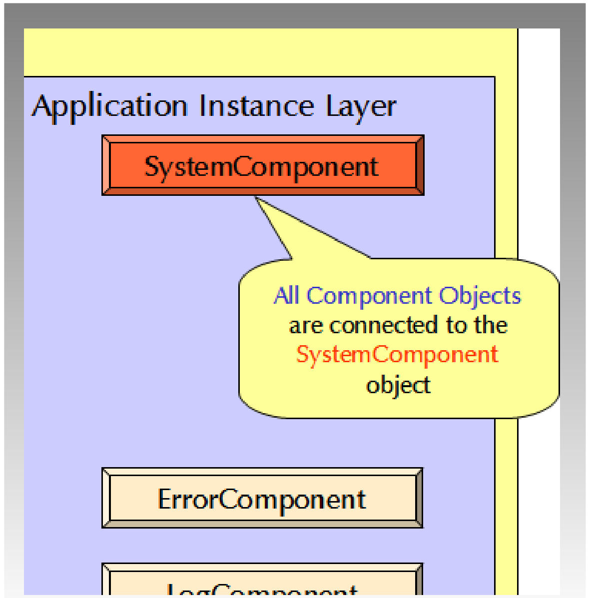


The Big Picture



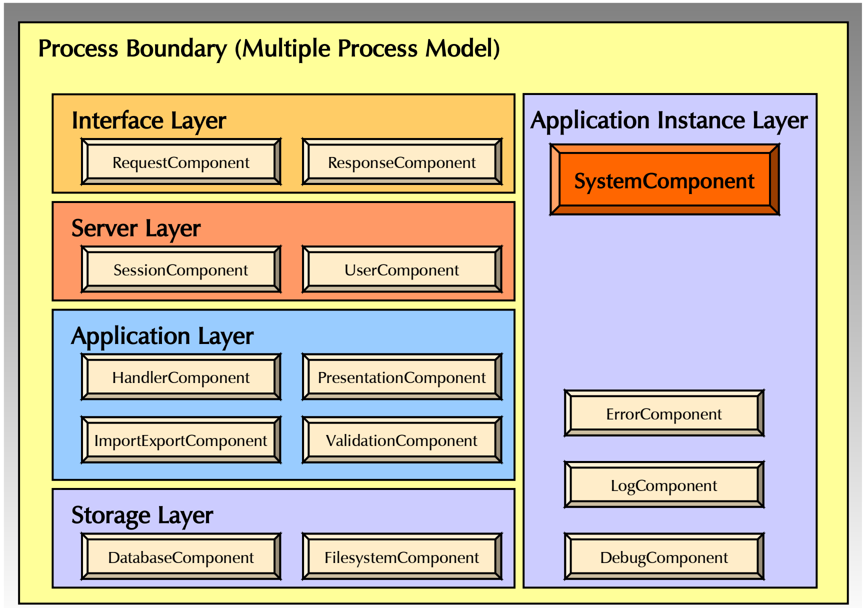
The special *System Object*

- 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



Components: Summary

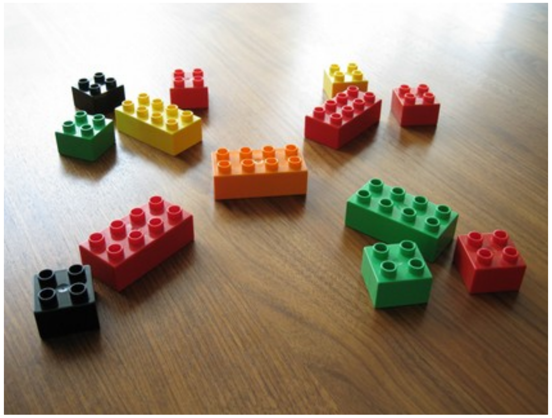
- General approach:
  - One system component that manages the application instance
  - At least one component per layer



Components too complex as well ?

- Goal: Break down complexity as far as possible !

- Top-down approach:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



Add 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…

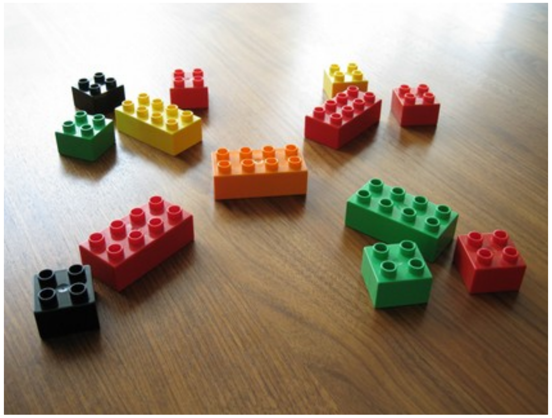
- Use management objects to work on collections of data/task objects
  - to simplify component implementations
  - to avoid direct interfacing between the data/task objects

Try to never mix responsibilities

Divide et Impera: The Lowest Level

- Goal: Break down complexity as far as possible !

- Top-down approach:
  - Application model
  - Processing model
  - Layer model
  - Components
  - Management objects
  - Data and Task objects



Lowest level: Data and task objects

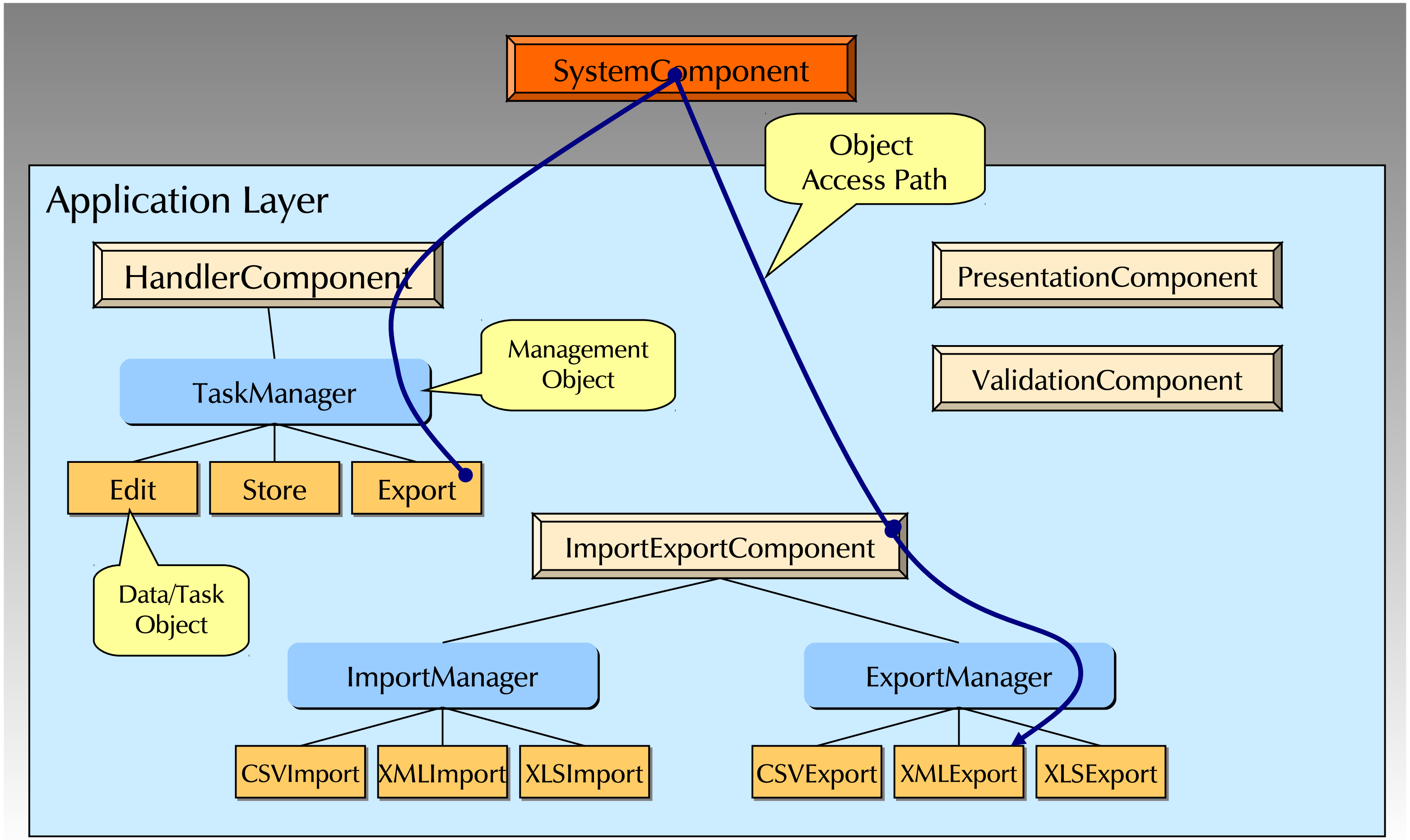
Data objects

- encapsulate data (nothing much new here)

Task objects

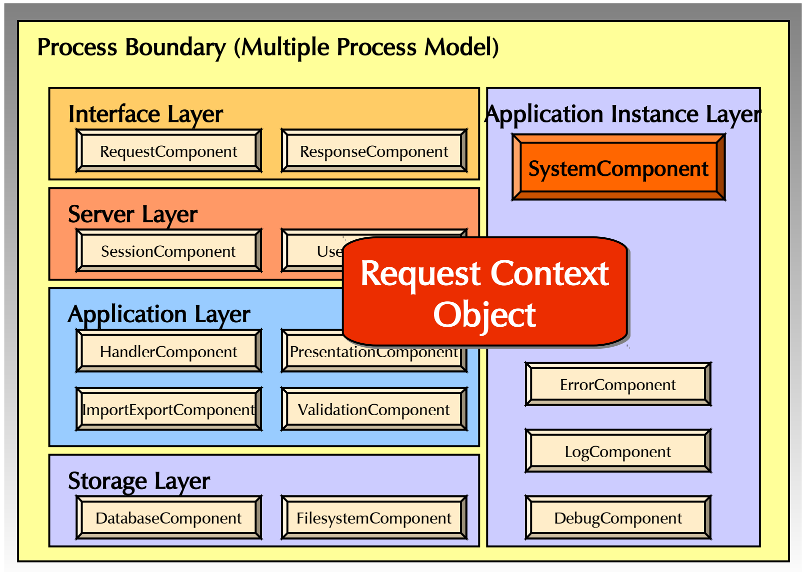
- interaction with multiple objects
- I/O on collections of objects
- delegating work to other management objects
- interfacing to component objects
- etc.

Example: Internal Communication



The *Request Context Data 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



There's beauty in design !

Thinking outside the box... a recap

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

Conclusion

- Structured application design can go a long way
- Divide-et-impera helps keep basic buildings blocks manageable
- Complex doesn't have to be complicated

Agenda

- Introduction
- Application Design
- Before you start ...
- Discussion

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 (1/2)

- 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

Finding the right package structure (2/2)

- Group components and associated management modules in Python packages
- Use the application and layer model as basis for the package layout

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, let's 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 / APIs
  - 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

- 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
  - regroup functionality
  - add more methods
- Magic word: Refactoring

Refactoring

- 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
  - and write tests as functional documentation

- Use descriptive identifier names…
  - even if they take longer to type

Quality Assurance: XP helps !

- Try to use some 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: More tips

- Typos can easily go unnoticed in Python:
  - use the editor's auto-completion function as often as possible
  - Use tools like PyLint to find hidden typos and possibly bugs

- Always test code before committing it to the software repository

Agenda

- Introduction
- Application Design
- Before you start ...
- Discussion

Questions

Thank you for listening

Beautiful is better than ugly.

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/