GUIDE
Graphical User Interface Development Environment

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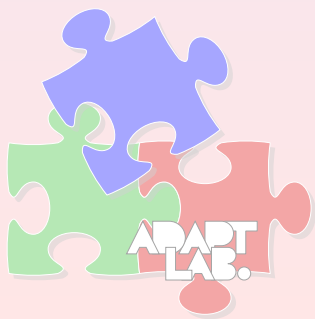
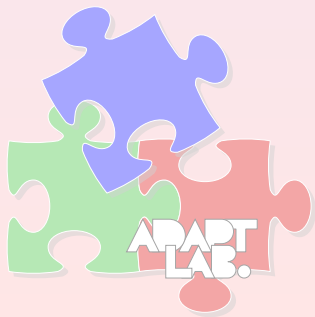


Problem Statement
Graphical User Interface Development

Over the years, Graphical User Interfaces (GUIs) have become a fundamental component of software development.



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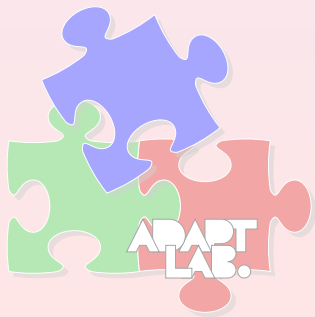
Graphical User Interface Development

Over the years, Graphical User Interfaces (GUIs) have become a fundamental component of software development.

The increase in the number of UI technologies presents a major challenge:

- More technologies mean more languages to learn.
- UI migration requires a full code rewrite.
- Maintaining consistency across platforms adds time and effort.



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The increase in the number of UI technologies presents a major challenge:

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- UI migration requires a full code rewrite.
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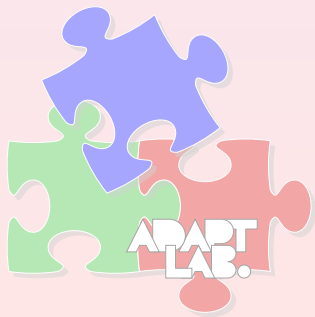
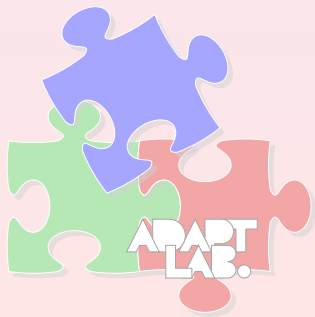
A more modular and framework-independent approach is needed to enable automatic UI generation across different technologies.



Domain-Specific Languages (DSLs)

A **Domain-Specific Language (DSL)** is a programming language tailored to a specific domain:

- **Higher-level abstraction** than General-Purpose Languages (GPLs)
- **Improves productivity** by focusing on domain concepts
- **Reduces errors** by limiting expressiveness to necessary operations
- **Examples**: SQL (databases), HTML (web pages), Gradle (build scripts)



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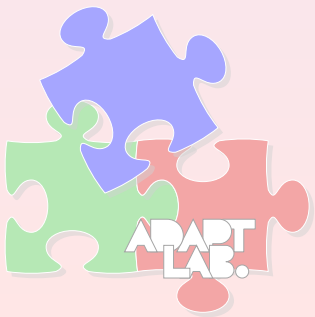
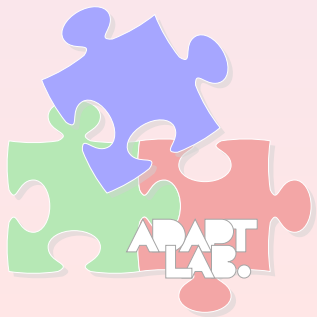
GUIDE's DSL was implemented using Neverlang, a language workbench designed to facilitate modular language development with composition and reuse of language features.



Software Product Lines (SPLs)

A Software Product Line (SPL) is an approach to software development that enables the creation of multiple related software products from a shared set of core assets.

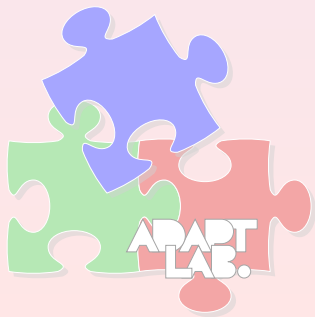


Software Product Lines (SPLs)

A Software Product Line (SPL) is an approach to software development that enables the creation of multiple related software products from a shared set of core assets.

SPLs rely on:

- Core Assets: Shared components and libraries
- Variability Management: Mechanisms to enable/disable features
- Automation: Tools to generate product variants efficiently



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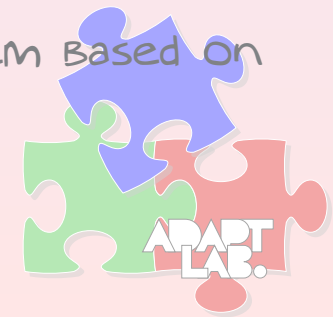
- Variability Management: Mechanisms to enable/disable features
- Automation: Tools to generate product variants efficiently

Key Benefits:

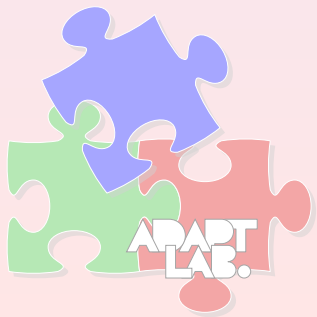
- Reuse: Common components across different product variants
- Scalability: New features can be added without major redesigns
- Customization: Generate tailored versions of a system based on feature selection



Architecture
Introduction

GUIDE (Graphical User Interface Development Environment) is a system that combines:

- Domain-Specific Language (DSL) for UI definition
- Software Product Line (SPL) for modularization
- Code generation framework targeting multiple languages



Architecture
Introduction

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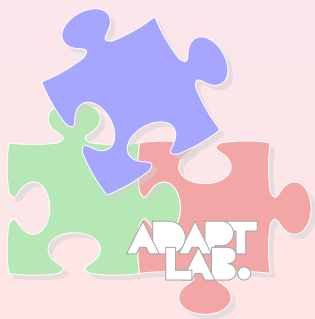
- Software Product Line (SPL) for modularization
- Code generation framework targeting multiple languages

Key Features:

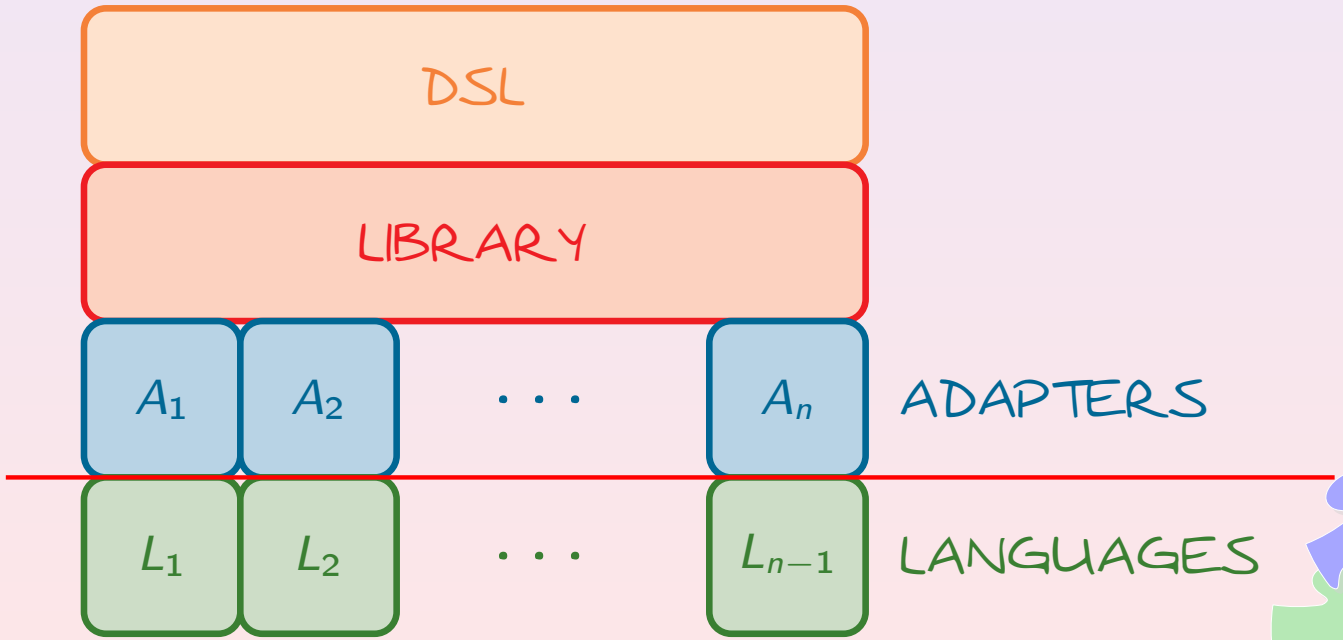
- Multi-language: Supports HTML, Elixir and Python
- Multi-framework: Supports Bootstrap, Phoenix LiveView, and Tkinter
- Multi-platform: Supports Web and Desktop applications
- Extensible: New components, layouts, and languages
- Automated: Reduces manual coding effort

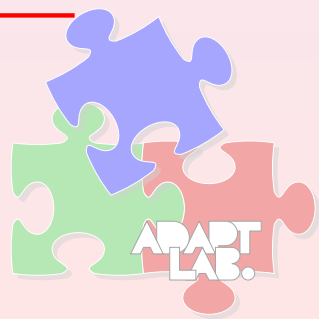


Architecture
Overview

The architecture of GUIDE is organized into three layers:

- DSL Layer: Defines the UI structure and behavior
- Library Layer: Provides core logic and reusable components
- Adapter Layer: Translates UI definitions into target languages





Architecture
Module Structure

DSL

Library

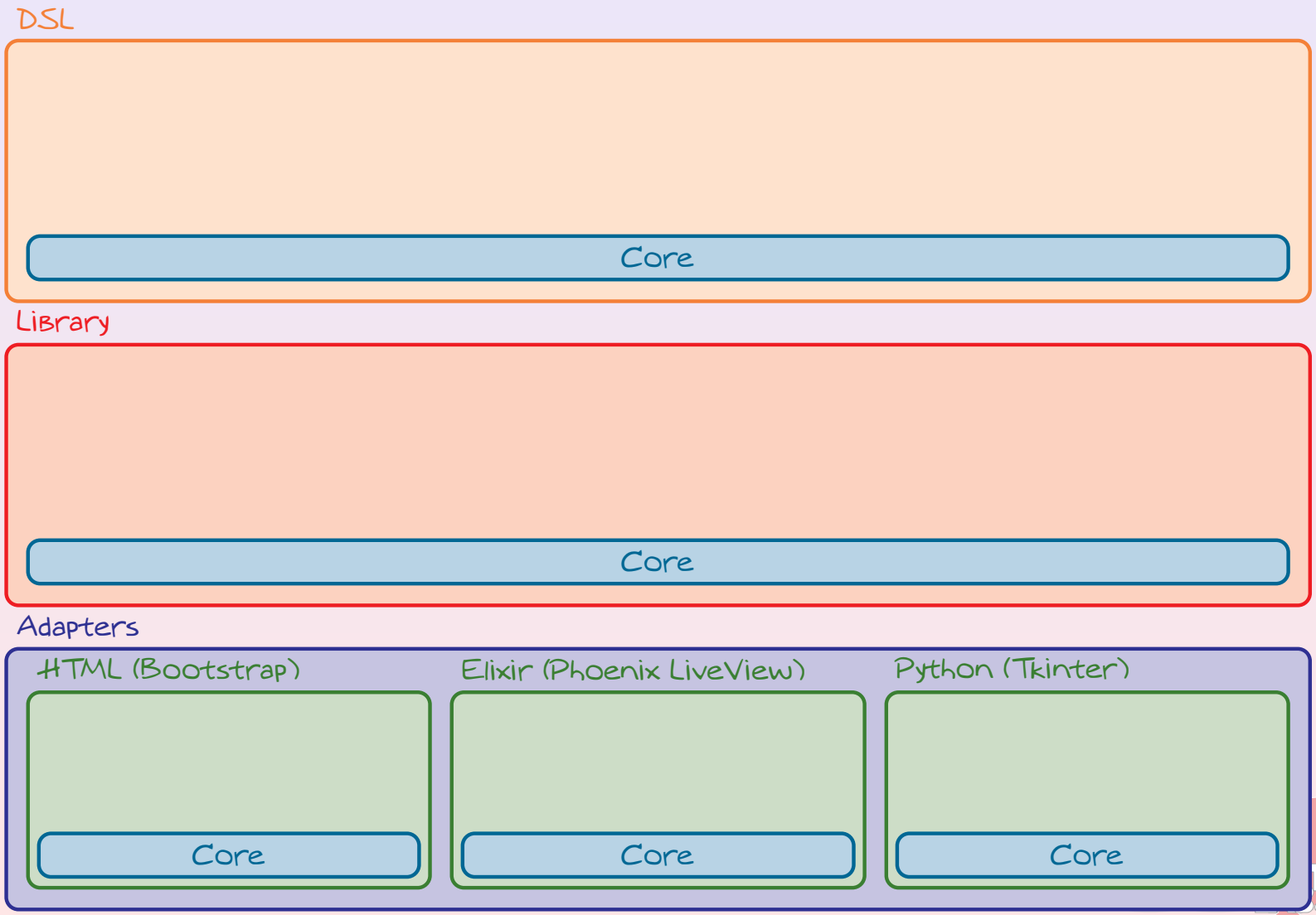
Adapters

HTML (Bootstrap)

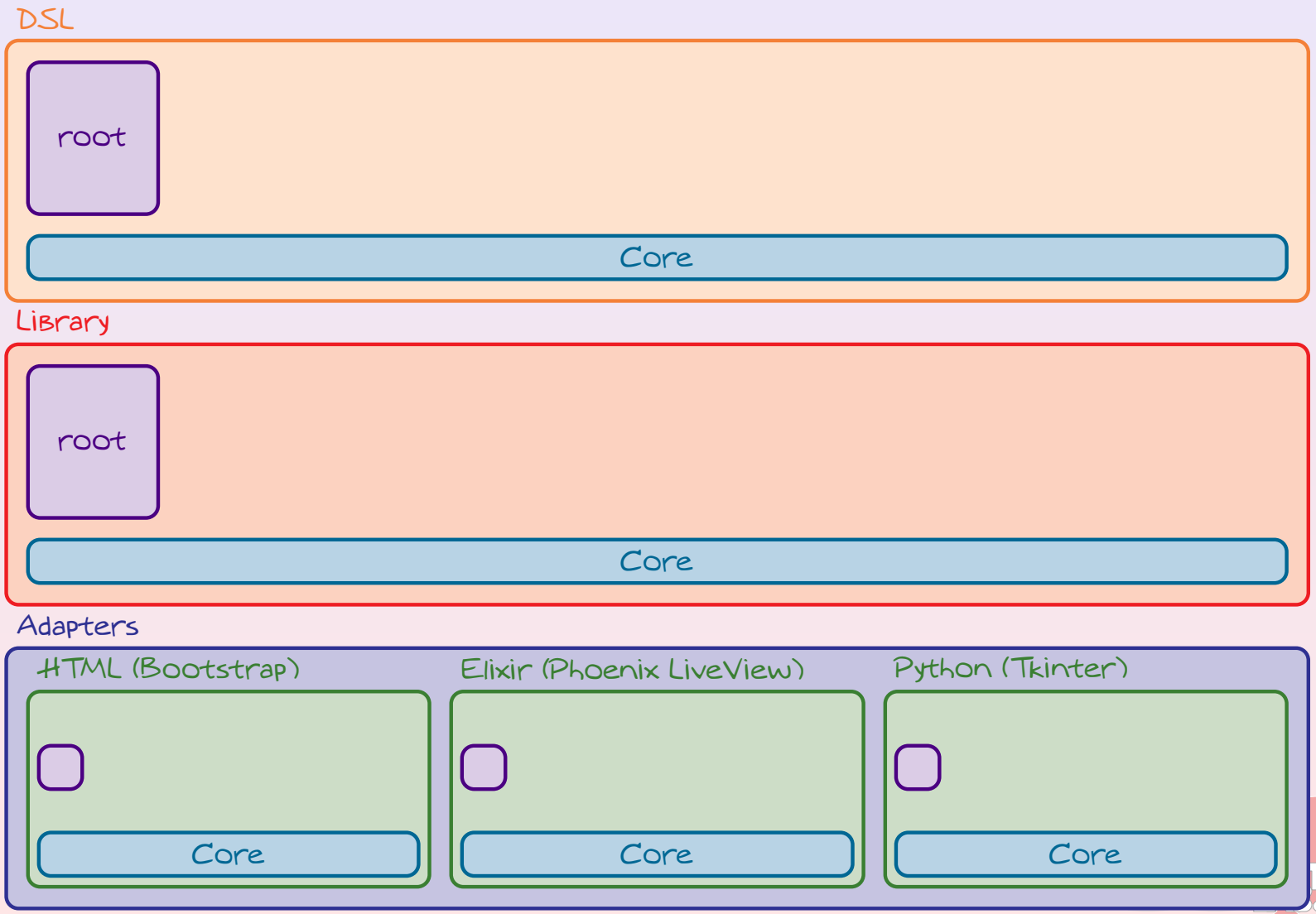
Elixir (Phoenix LiveView)

Python (Tkinter)

Architecture
Module Structure



Architecture
Module Structure



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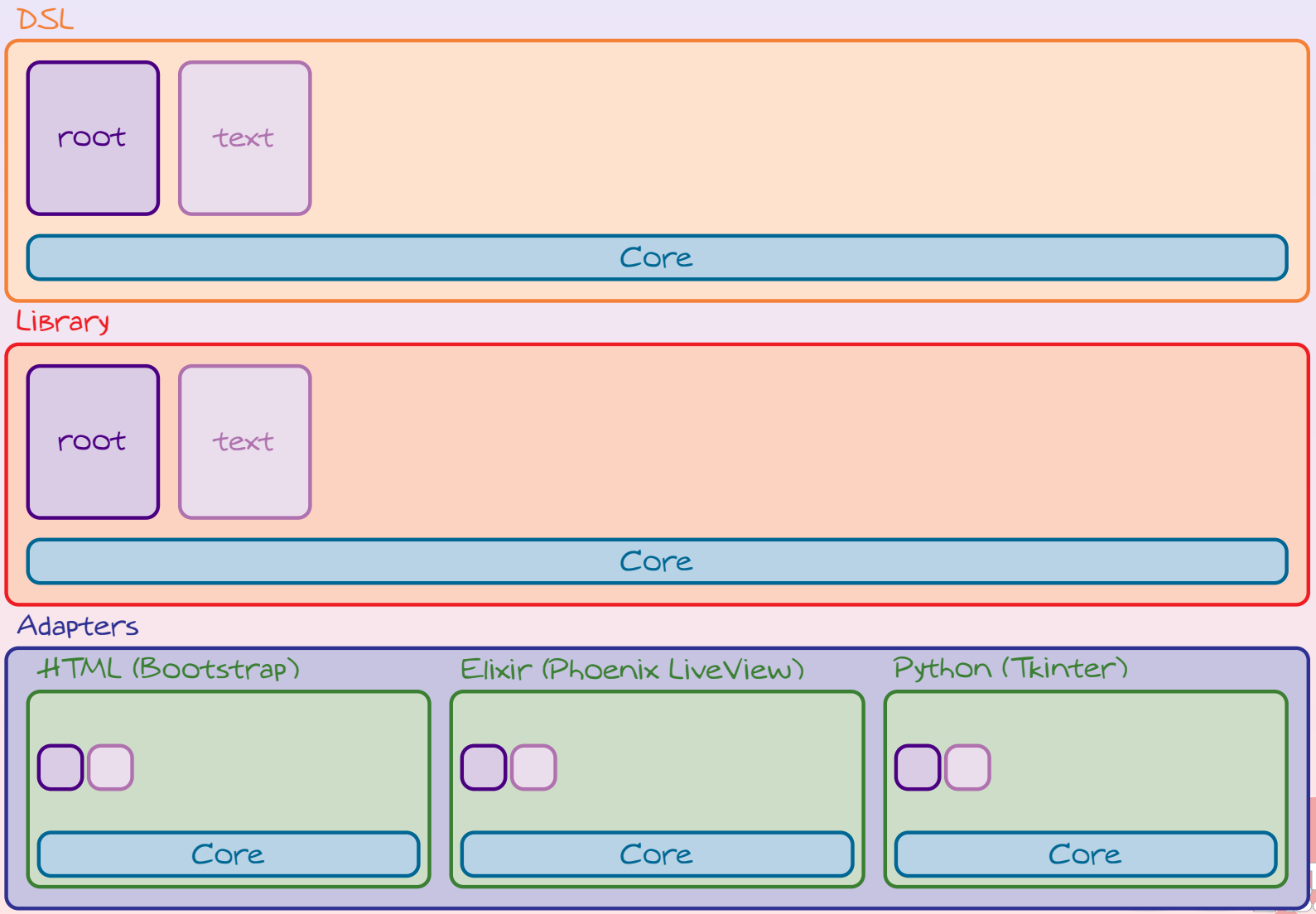
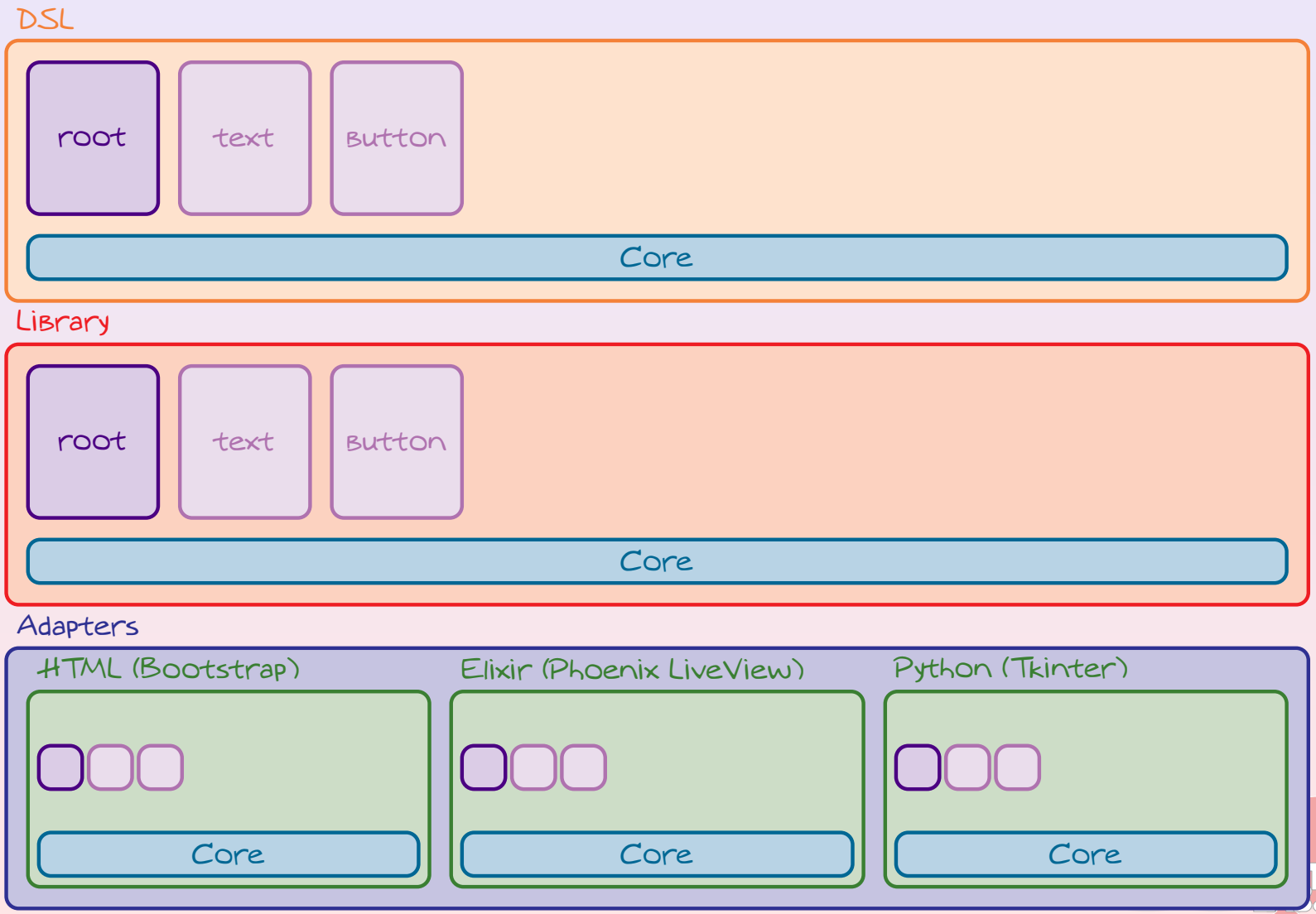
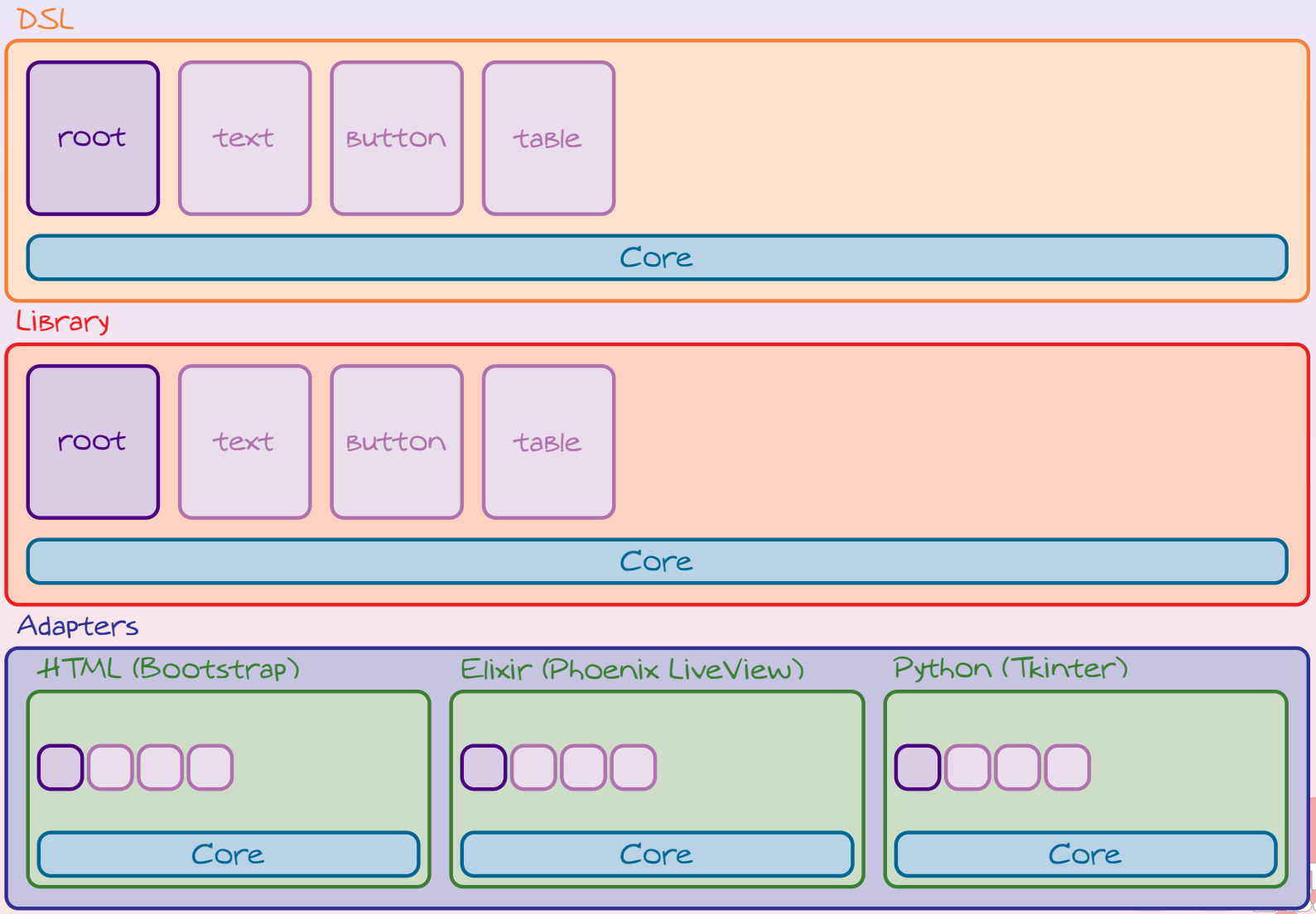


Architecture
Module Structure



Architecture
Module Structure



Architecture
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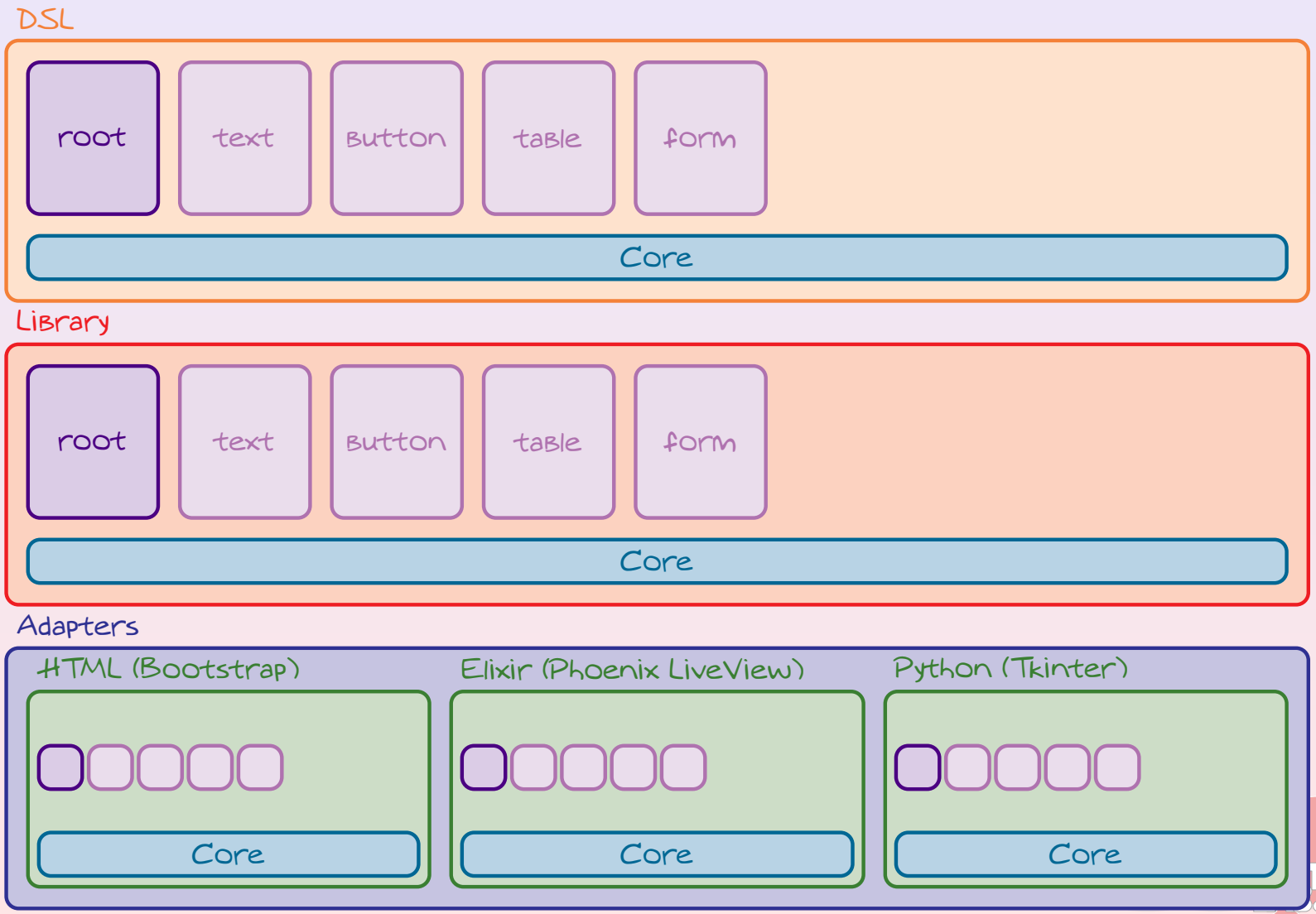

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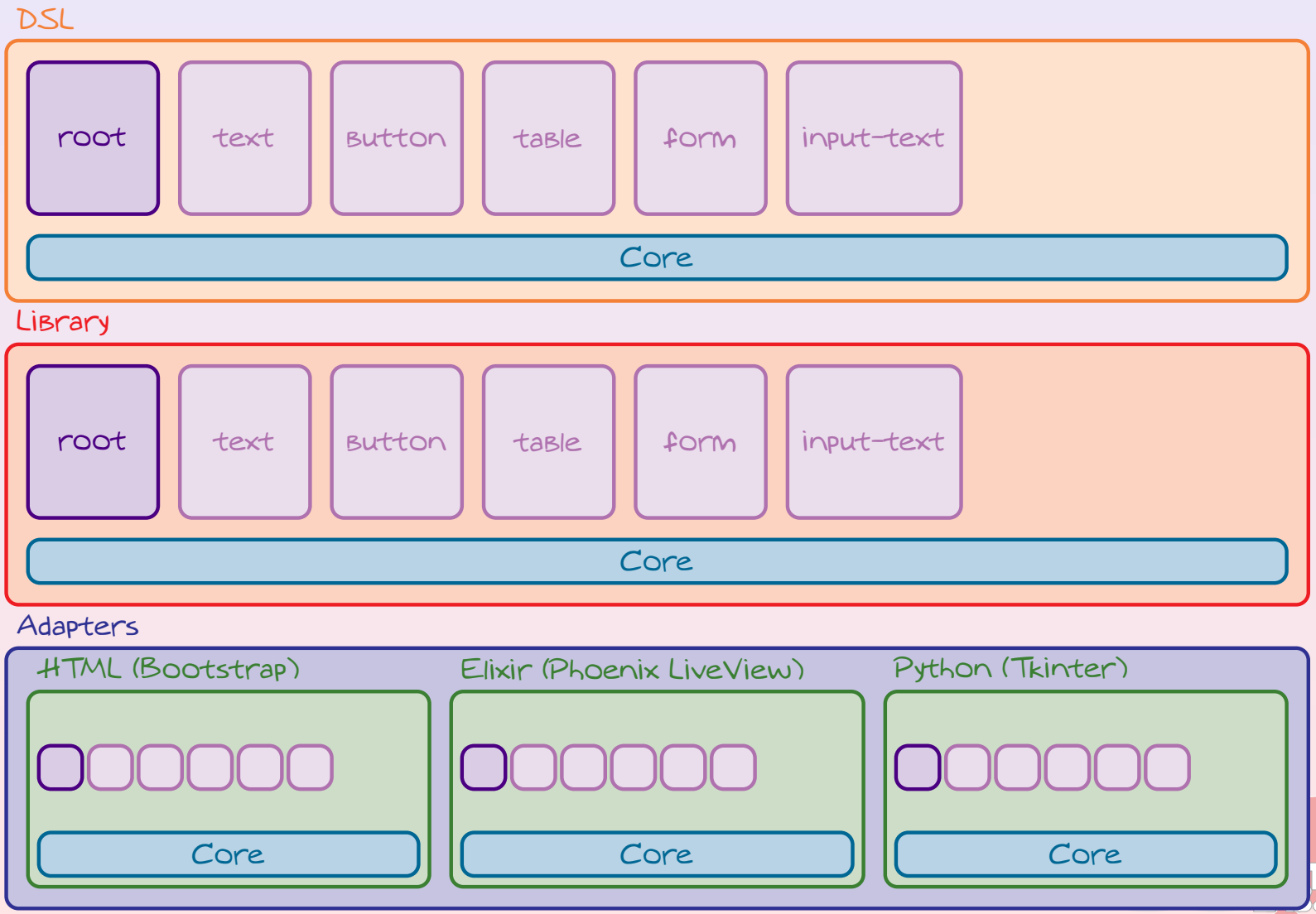
Module Structure



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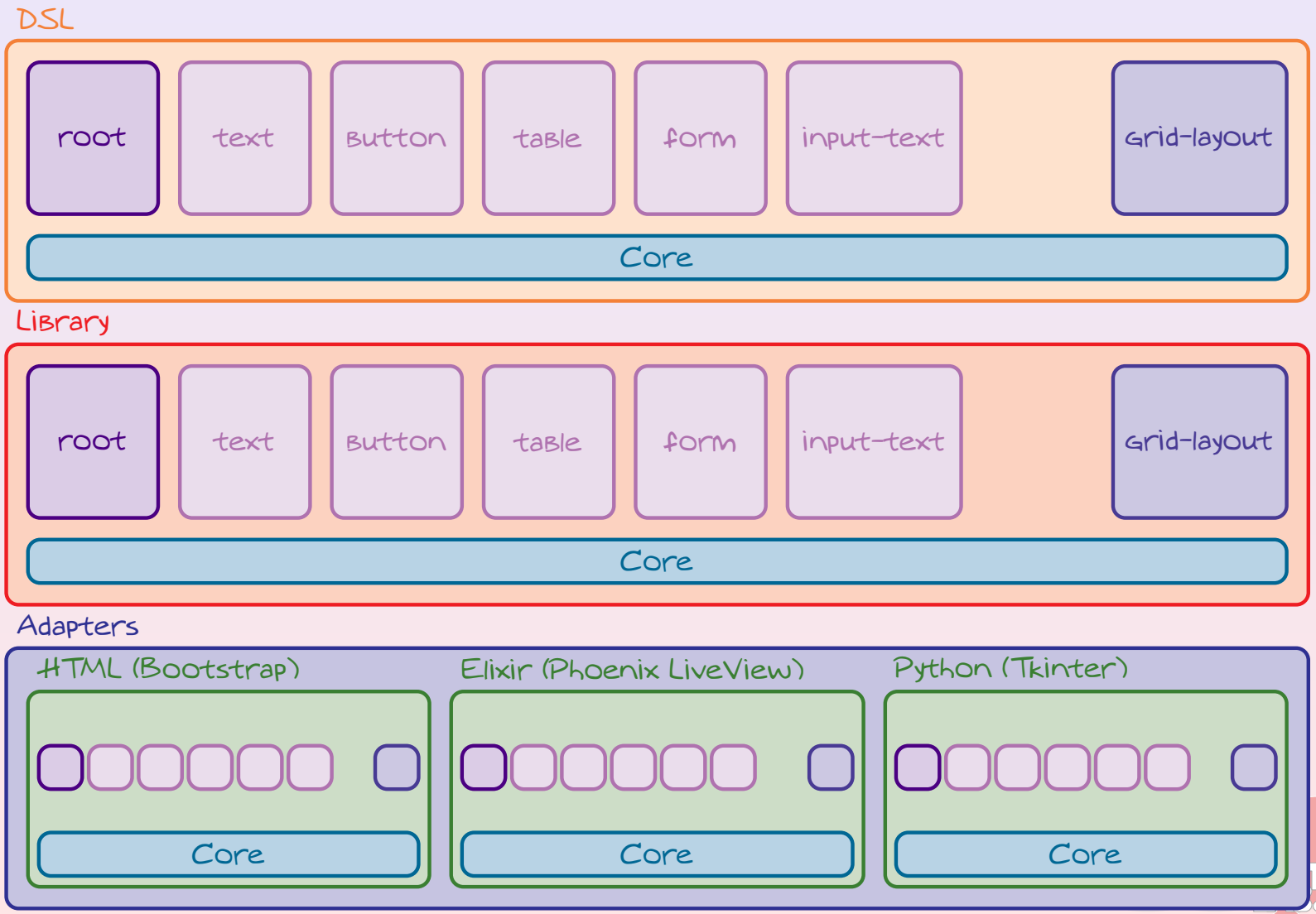
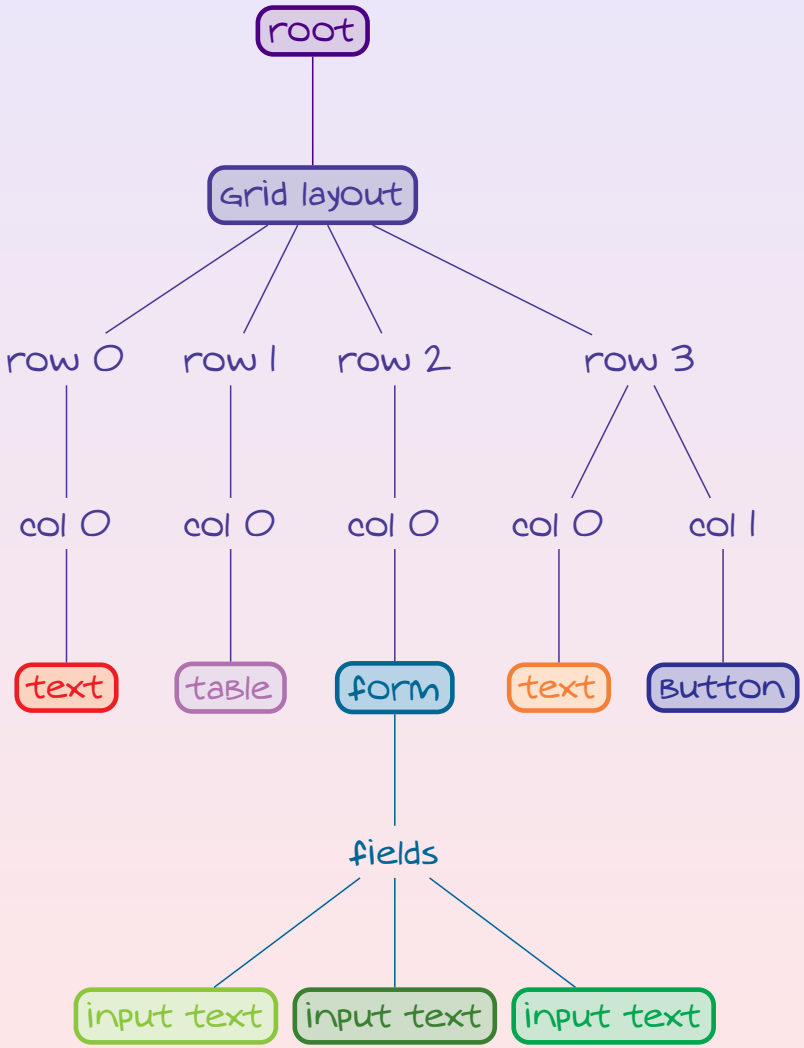
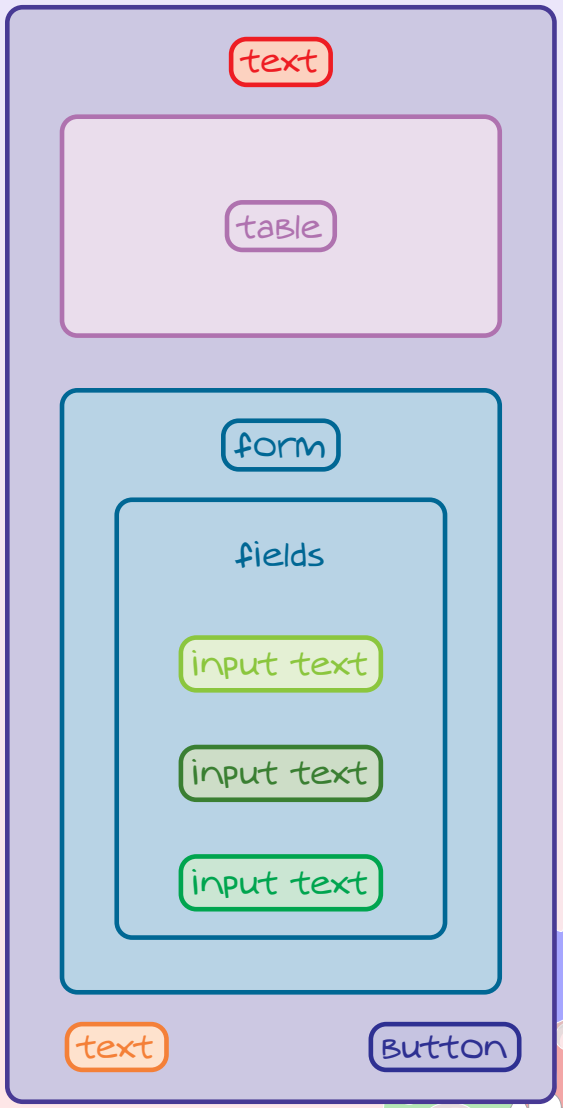
Module Structure



GUIDE in Action
Example UI Structure



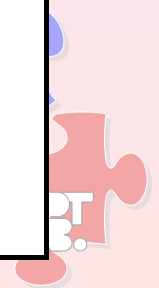


GUIDE in Action
DSL Example


```
Module salaries {




}
```



GUIDE in Action
DSL Example


```
Module salaries {

  root = Root {
    module: "salaries",
    title: title,
    height: 600,
    width: 800,
    callbacksFilename: "salaries_callbacks",
    layout: gridLayout
  }

}
```

GUIDE in Action
DSL Example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  root = Root {
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    title: title,
    height: 600,
    width: 800,
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  }

  title = "Salaries"
  deletePrimaryColor = #color("red")
  deleteSecondaryColor = #color("#000000")

}
```

GUIDE in Action
DSL Example


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  root = Root {
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    title: title,
    height: 600,
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    callbacksFilename: "salaries_callbacks",
    layout: gridLayout
  }

  title = "Salaries"
  deletePrimaryColor = #color("red")
  deleteSecondaryColor = #color("#000000")

  gridLayout = GridLayout {
    titleText;
    salariesTable;
    addForm;
    deleteText, deleteButton;
  }

}
```

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DSL Example


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    height: 600,
    width: 800,
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    layout: gridLayout
  }

  title = "Salaries"
  deletePrimaryColor = #color("red")
  deleteSecondaryColor = #color("#000000")

  gridLayout = GridLayout {
    titleText;
    salariesTable;
    addForm;
    deleteText, deleteButton;
  }

  titleText = Text {
    textColor: #color("blue"),
    backgroundColor: #color("#FFFF00"),
    content: title
  }

  deleteText = Text {
    textColor: deletePrimaryColor,
    backgroundColor: deleteSecondaryColor,
    content: "Delete all salaries: "
  }

}
```

GUIDE in Action
DSL Example


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    width: 800,
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    layout: gridLayout
  }

  title = "Salaries"
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  deleteSecondaryColor = #color("#000000")

  gridLayout = GridLayout {
    titleText;
    salariesTable;
    addForm;
    deleteText, deleteButton;
  }

  deleteButton = Button {
    id: deleteButton,
    textColor: deletePrimaryColor,
    backgroundColor: deleteSecondaryColor,
    content: "Delete",
    onClick: @deleteButtonOnClick
  }

}
```

GUIDE in Action
DSL Example


```
Module salaries {

  root = Root {
    module: "salaries",
    title: title,
    height: 600,
    width: 800,
    callbacksFilename: "salaries_callbacks",
    layout: gridLayout
  }

  title = "Salaries"
  deletePrimaryColor = #color("red")
  deleteSecondaryColor = #color("#000000")

  gridLayout = GridLayout {
    titleText;
    salariesTable;
    addForm;
    deleteText, deleteButton;
  }

  salariesTable = Table {
    id: table,
    headers: ["Name", "Surname", "Salary"],
      rows: [
          "John", "Doe", "1000";
          "Jane", "Doe", "2000";
      ]
  }
}
```

GUIDE in Action
DSL Example


```
Module salaries {

  root = Root {
    module: "salaries",
    title: title,
    height: 600,
    width: 800,
    callbacksFilename: "salaries_callbacks",
    layout: gridLayout
  }

  title = "Salaries"
  deletePrimaryColor = #color("red")
  deleteSecondaryColor = #color("#000000")

  gridLayout = GridLayout {
    titleText;
    salariesTable;
    addForm;
    deleteText, deleteButton;
  }

  addForm = Form {
    id: addForm,
    submitButtonText: "Add salary",
    onSubmit: @addFormOnSubmit,
    fields: [
      "Name": InputText {
        id: name,
        placeholder: "Name"
      },
      "Surname" : InputText {
        id: surname,
        placeholder: "Surname"
      },
      "Salary" : InputText {
        id: salary,
        placeholder: "Salary"
      }
    ]
  }

}
```

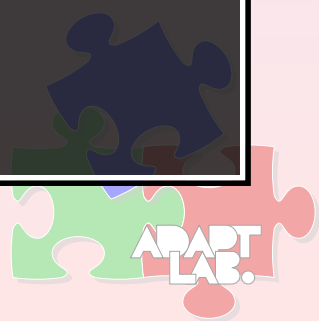
GUIDE in Action
Running the Example

GUIDE help:

```
> java -jar guide.jar --help
Usage: guide [-hV] -l=<language> -o=<output> -r=<rootName> [-s=<srcDir>]
Guide DSL compiler
  -h, --help              Show this help message and exit.
  -l, --language=<language>
                          Valid languages: python, elixir, html
  -o, --output=<output>   Output file
  -r, --root=<rootName>   Root name
  -s, --srcDir=<srcDir>   Source directory
  -V, --version           Print version information and exit.
```

Generate the code:

```
> java -jar guide.jar -l html -o salaries.html -r salaries.root
Successfully wrote to the file salaries.html

> java -jar guide.jar -l elixir -o salaries.ex -r salaries.root
Successfully wrote to the file salaries.ex

> java -jar guide.jar -l python -o salaries.py -r salaries.root
Successfully wrote to the file salaries.py
```



GUIDE in Action
HTML (Bootstrap) Generated Code


```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Salaries</title>
    <!-- Bootstrap CSS -->
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.3.2/dist/css/bootstrap.min.css"
          ↪  rel="stylesheet">
    <!-- jQuery -->
    <script src="https://code.jquery.com/jquery-3.5.1.min.js"></script>
    <!-- Callbacks functions -->
    <script src="salaries_callbacks.js"></script>
  </head>
  <body>
    <div id="HtmlGridLayout8" class="container">
  <div class="row">
  <div class="col">
<p id="HtmlText0" class="text-start" style="color:#0000FF; background-color:#FFFF00;">Salaries</p>
</div>
</div>
<div class="row">
  <div class="col">
<table id="table" class="table">
  <thead>
    <tr><th>Name</th><th>Surname</th><th>Salary</th></tr>
  </thead>
  <tbody>
```

GUIDE in Action
HTML (Bootstrap) Result

Salaries

Name	Surname	Salary
John	Doe	1000
Jane	Doe	2000

Name

Name

Surname

Surname

Salary

Salary

Add salary

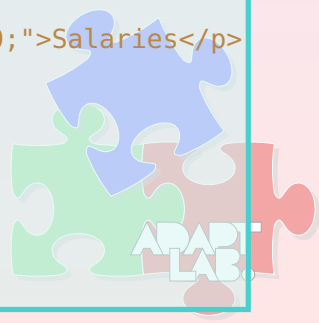
Delete all salaries:

Delete

GUIDE in Action

Elixir (Phoenix LiveView) Generated Code


```
defmodule Salaries do
  use Phoenix.LiveView
  alias Salaries_callbacks

  def mount(_params, _session, socket) do
    socket = assign(socket, :tableheaderOnLoad, ["Name", "Surname", "Salary"])
    socket = assign(socket, :tabletableOnLoad, [["John", "Doe", "1000"], ["Jane", "Doe", "2000"]])
    socket = assign(socket, :addFormOnSubmit, Salaries_callbacks.addFormOnSubmit())
    {:ok, socket}
  end

  def handle_event("addFormOnSubmit", value, socket) do
    Salaries_callbacks.addFormOnSubmit(value, socket)
  end

  def handle_event("deleteButtonOnClick", value, socket) do
    Salaries_callbacks.deleteButtonOnClick(value, socket)
  end

  def render(assigns) do
    ~H"""
<div id="ElixirGridLayout8" class="container mx-auto">
  <div class="grid grid-cols-1">
  <div class="col-span-1">
<p id="ElixirText0" class="text-left" style="color:#0000FF; background-color:#FFFF00;">Salaries</p>
</div>
</div>
<div class="grid grid-cols-1">
  <div class="col-span-1">
<table id="table" class="min-w-full divide-y divide-gray-200 table-auto">
  <thead class="bg-gray-50">
```



GUIDE in Action
Elixir (Phoenix LiveView) Result

Salaries

Name	Surname	Salary
John	Doe	1000
Jane	Doe	2000

Name

Name

Surname

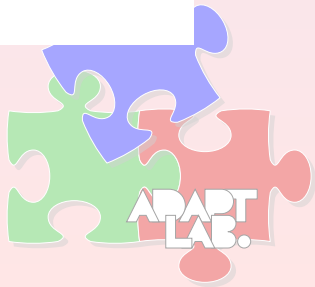
Surname

Salary

Salary

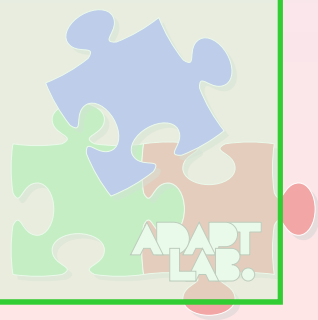
Add salary

Delete all salaries: Delete

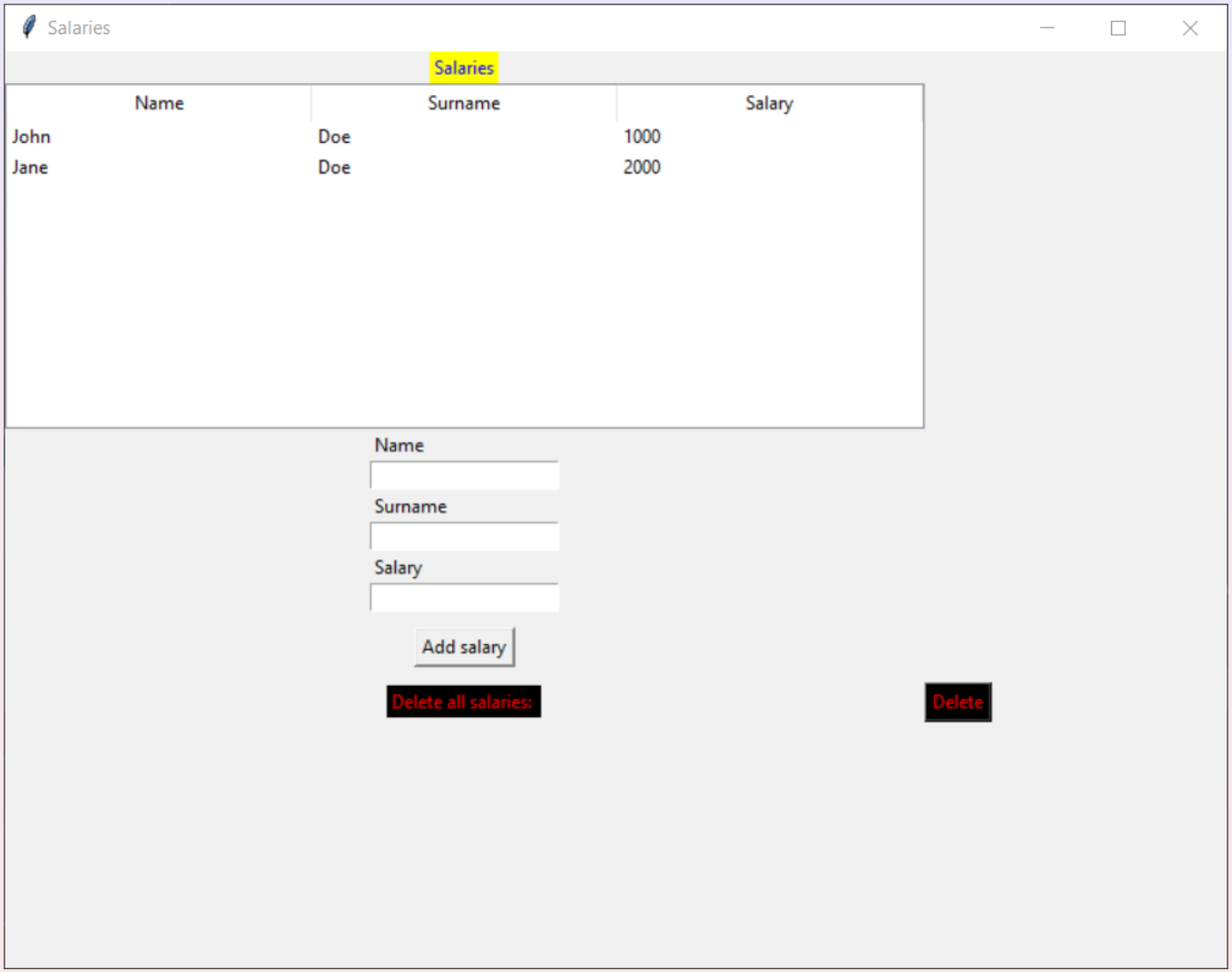


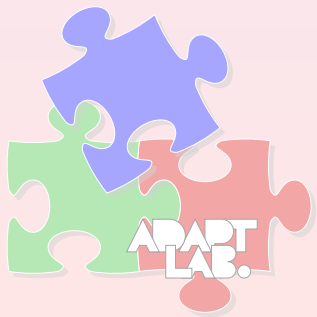
GUIDE in Action
Python (Tkinter) Generated Code


```
import tkinter as tk
from tkinter import ttk
import salaries_callbacks

class salaries:
  def __init__(self, PythonRoot9):
    self.PythonRoot9 = PythonRoot9
    self.PythonRoot9.title("Salaries")
    self.PythonRoot9.geometry("800x600")

    self.PythonText0 = tk.Label(master=self.PythonRoot9, text="Salaries", fg="#0000FF", bg="#FFFF00")
    self.PythonText0.grid(row=0, column=0)

    self.table = ttk.Treeview(master=self.PythonRoot9, columns=(0, 1, 2), show="headings")
    self.table.heading("0", text="Name")
    self.table.heading("1", text="Surname")
    self.table.heading("2", text="Salary")
    self.table.insert("", tk.END, values=["John", "Doe", "1000"])
    self.table.insert("", tk.END, values=["Jane", "Doe", "2000"])
    self.table.grid(row=1, column=0)

    self.addForm = tk.Frame(master=self.PythonRoot9)

    self.nameLabel = tk.Label(master=self.addForm, text="Name")
    self.nameLabel.pack(anchor="w")
    self.name = tk.Entry(master=self.addForm, state=tk.NORMAL)
    self.name.insert(0, "")
    self.name.pack(fill="x")

    self.surnameLabel = tk.Label(master=self.addForm, text="Surname")
    self.surnameLabel.pack(anchor="w")
    self.surname = tk.Entry(master=self.addForm, state=tk.NORMAL)
```



GUIDE in Action
Python (Tkinter) Result





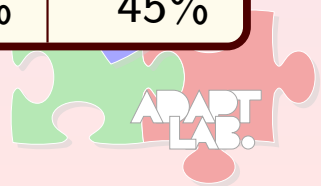
Experiments
Code Generation

Compare the amount of code written manually vs. generated by GUIDE

The GUIDE program in the example consists of:

- 63 lines of code (LOC)
- 1353 characters (Char)
- 60 minutes of development time

Language	LOC Gen.	Expansion Factor (LOC)	Char Gen.	Expansion Factor (Char)	Time Saved
HTML	62	−2%	2067	+53%	51%
Elixir	81	+29%	3232	+139%	63%
Python	55	−13%	2517	+86%	45%



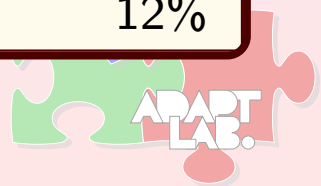
Experiments
Feature Extension

Evaluate the ease of adding new features using the code generation tool

Automatucally generated code for the new feature includes:

- Gradle module structure with dependencies and Build scripts
- Java classes declaration
- Test files declaration
- Factory interfaces definition
- Neverlang modules declaration

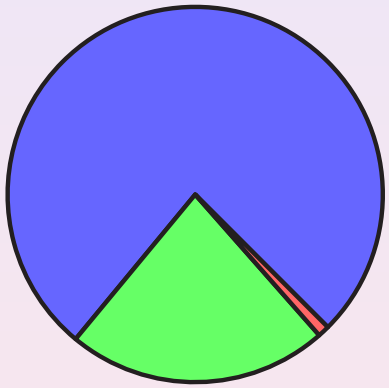
Feature Type	Feature LOC	Gen. LOC	Effort Reduction
New Language Adapter	$\sim$ 458	108	24%
New Component	$\sim$ 594	68	12%



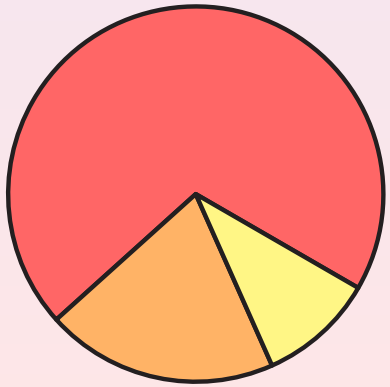
Experiments
Feature Selection

Measure the impact of feature selection on storage and distribuition efficiency

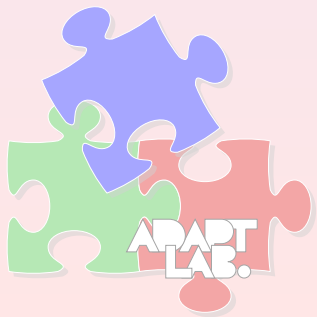
Size of the generated JAR file with all features enabled:



- Neverlang (77%)
- Other Dependencies (23%)
- GUIDE (1%)



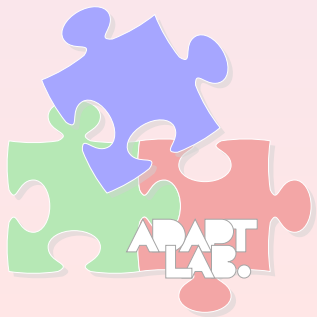
- GUIDE DSL (70%)
- Adapters (20%)
- GUIDE Library (10%)



Conclusion

Interesting results:

- GUIDE **simplifies GUI development** by combining DSLs and SPLs.
- Significant **reduction in manual code writing**.
- **Multi-language support** enables flexibility but requires adapters for new languages.
- Feature selection enables **delivering only paid features** to clients in enterprise contexts.



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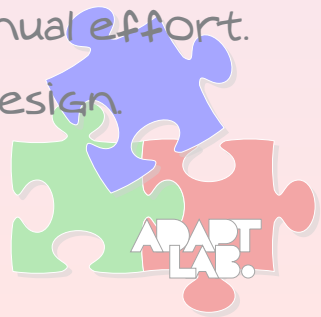
Future Work:

- Extend GUIDE to support **additional GUI frameworks** and languages.
- Improve dependency management for **better storage efficiency**.
- Automate **callback file generation** to further reduce manual effort.
- Develop a **visual UI editor** for drag-and-drop interface design.



Thanks for your attention!