PytoWeb 框架技术文档

1. 框架概述

PytoWeb 是一个基于 Python 的现代化 Web 应用开发框架，专注于提供高效的前端开发解决方案。本框架采用创新的架构设计，通过将 Python 代码编译为高性能的前端代码，实现了前后端的无缝集成。框架内置了完整的组件化开发体系，结合高效的虚拟 DOM 渲染引擎和响应式状态管理系统，为开发者提供了一站式的 Web 应用开发平台。

1.1 技术架构

1. 核心引擎
2. Python-to-JavaScript 转译系统
3. 虚拟 DOM 差异计算引擎
4. 响应式状态管理系统
5. 事件处理与代理机制

事件处理与代理机制

6. 运行时系统

运行时系统

7. 高效的内存管理
8. 自动化的垃圾回收
9. 异步任务调度器
10. 性能监控系统

性能监控系统

11. 开发工具链

开发工具链

12. 集成开发环境支持
13. 热重载开发服务器
14. 自动化构建系统
15. 调试与性能分析工具

1.2 核心功能

16. 组件化开发体系
17. 基于类的组件定义
18. 完整的生命周期管理
19. 组件间通信机制
20. 状态与属性系统

状态与属性系统

21. 虚拟 DOM 引擎

虚拟 DOM 引擎

22. 高效的 DOM 差异算法
23. 智能的批量更新策略
24. DOM 操作优化
25. 内存使用优化

内存使用优化

26. 状态管理系统

状态管理系统

27. 集中式状态管理

28. 响应式数据绑定
29. 状态持久化支持
30. 状态回滚机制

状态回滚机制

31. 路由系统

路由系统

32. 声明式路由配置
33. 动态路由匹配
34. 路由守卫机制
35. 路由状态管理

路由状态管理

36. 表单验证系统

表单验证系统

37. 内置验证规则库
38. 自定义验证逻辑
39. 异步验证支持
40. 验证状态管理

验证状态管理

41. 样式与主题

样式与主题

42. 动态主题系统
43. CSS-in-Python 支持
44. 响应式布局
45. 主题继承机制

主题继承机制

46. 性能优化

性能优化

47. 代码分割
48. 懒加载支持
49. 资源预加载
50. 缓存优化

1.3 技术优势

51. 开发效率
52. 统一的 Python 技术栈
53. 简化的开发流程
54. 完善的类型系统
55. 丰富的开发工具

丰富的开发工具

56. 性能表现

性能表现

57. 优化的运行时性能
58. 最小化资源占用
59. 高效的更新机制
60. 智能的缓存策略

智能的缓存策略

61. 可维护性

可维护性

62. 清晰的代码组织
63. 模块化的架构
64. 完整的测试支持
65. 详细的文档说明

详细的文档说明

66. 扩展性

扩展性

67. 插件化架构
68. 中间件系统
69. 自定义扩展点
70. 第三方集成支持

2. 环境要求

2.1 硬件要求

71. 处理器

72. 最低：双核处理器，2.0GHz 以上
73.
    推荐：四核处理器，3.0GHz 以上

推荐：四核处理器，3.0GHz 以上

74.
    内存

内存

75. 最低：4GB RAM
76.
    推荐：8GB RAM 或更高

推荐：8GB RAM 或更高

77.
    存储

存储

78. 最低：10GB 可用空间
79. 推荐：20GB 或更多可用空间

2.2 软件要求

80. 操作系统
81. Windows 10/11 64 位
82. macOS 10.15 或更高版本
83.
    Linux（主流发行版）

Linux（主流发行版）

84.
Python 环境

Python 环境

85.Python 3.8 或更高版本
86.pip 包管理器
87.
virtualenv（推荐）

virtualenv（推荐）

88.
依赖组件

依赖组件

89.Node.js 14.0 或更高版本
90.npm 6.0 或更高版本
91.Git 2.0 或更高版本

2.3 开发工具

92.IDE 支持
93.Visual Studio Code（推荐）
94.PyCharm Professional
95.
Sublime Text 3

Sublime Text 3

96.
浏览器要求

浏览器要求

97.Chrome 80+ （推荐）

98. Firefox 75+
99. Safari 13+
100. Edge 80+

Edge 80+

101. 开发工具扩展

开发工具扩展

102. PytoWeb DevTools
103. Python Language Server
104. Debugger for Chrome

3. 安装配置

3.1 基础安装

```
# 创建虚拟环境
python -m venv pytoweb-env

# 激活虚拟环境
# Windows
pytoweb-env\Scripts\activate
# macOS/Linux
source pytoweb-env/bin/activate

# 安装 PytoWeb
pip install pytoweb

# 安装开发依赖
pip install pytoweb[dev]

# 创建虚拟环境
python -m venv pytoweb-env

# 激活虚拟环境
# Windows
```

```
pytoweb-env\Scripts\activate
# macOS/Linux
source pytoweb-env/bin/activate

# 安装 PytoWeb
pip install pytoweb

# 安装开发依赖
pip install pytoweb[dev]
```

3.2 项目初始化

```
# 创建新项目
pytoweb init my-project

# 进入项目目录
cd my-project

# 安装项目依赖
pip install -r requirements.txt

# 启动开发服务器
pytoweb serve

# 创建新项目
pytoweb init my-project

# 进入项目目录
cd my-project

# 安装项目依赖
pip install -r requirements.txt

# 启动开发服务器
pytoweb serve
```

3.3 配置说明

105.

基础配置

python

```python
# config.py
PYTOWEB_CONFIG = {
    "debug": True,
    "host": "localhost",
    "port": 8000,
    "static_url": "/static/",
    "template_dir": "templates/"
}
```

基础配置

python

```python
# config.py
PYTOWEB_CONFIG = {
    "debug": True,
    "host": "localhost",
    "port": 8000,
    "static_url": "/static/",
    "template_dir": "templates/"
}
```

python

```python
# config.py
PYTOWEB_CONFIG = {
    "debug": True,
    "host": "localhost",
    "port": 8000,
    "static_url": "/static/",
    "template_dir": "templates/"
}
```

106.

开发配置

```python
# development.py
from config import PYTOWEB_CONFIG
```

开发配置

```python
# development.py
from config import PYTOWEB_CONFIG

PYTOWEB_CONFIG.update({
    "hot_reload": True,
    "source_maps": True,
    "cache": False
})
```

107. 生产配置

```python
# production.py
from config import PYTOWEB_CONFIG

PYTOWEB_CONFIG.update({
    "debug": False,
    "hot_reload": False,
    "cache": True,
    "min_files": True
})
```

4. 组件系统

4.1 组件基础

108. 组件定义

```python
from pytoweb.components import Component

class MyComponent(Component):
    def init(self):
        super().init()
        self.state = {
            'count': 0
        }
```

```
    def render(self):
        return self.html('''
            <div>
                <h1>计数器：{self.state.count}</h1>
                <button @click="self.increment">增加</button>
            </div>
        ''')

    def increment(self):
        self.setState({'count': self.state.count + 1})

    def render(self):
        return self.html('''
            <div>
                <h1>计数器：{self.state.count}</h1>
                <button @click="self.increment">增加</button>
            </div>
        ''')

    def increment(self):
        self.setState({'count': self.state.count + 1})
```

109. 生命周期方法

```python
def componentDidMount(self):
    # 组件挂载后执行
    print("组件已挂载")

def componentWillUpdate(self, nextProps, nextState):
    # 组件更新前执行
    print("组件即将更新")

def componentDidUpdate(self, prevProps, prevState):
    # 组件更新后执行
    print("组件已更新")

def componentWillUnmount(self):
    # 组件卸载前执行
```

```
        print("组件即将卸载")
```

4.2 组件通信

110. 属性传递

```python
class ParentComponent(Component):
    def render(self):
        return self.html('''

        ''')

class ChildComponent(Component):
    def render(self):
        return self.html('''

{self.props.title}
更新

        ''')
```

{self.props.title}

---

111. 事件通信

python

```
    def handleUpdate(self, event):
        # 处理子组件事件
        self.setState({'updated': True})
```

python

```
    def handleUpdate(self, event):
        # 处理子组件事件
        self.setState({'updated': True})
```

4.3 高级特性

112. 插槽系统

```python
class Container(Component):
```

```
        def render(self):
            return self.html('''

            ''')

# 使用插槽
    def render(self):
        return self.html('''

主要内容

        ''')
    ```
```

---

113. 混入（Mixins）

```
    ```python
    class LoggerMixin:
        def log(self, message):
            print(f"[{self.class.name}] {message}")

class MyComponent(Component, LoggerMixin):
     def componentDidMount(self):
         self.log("组件已挂载")
    ```
```
```

5. 状态管理

5.1 组件状态

114.

状态定义

python

```
def __init__(self):
    super().__init__()
    self.state = {
        'count': 0,
        'items': [],
        'loading': False
    }
```

状态定义

python

```
def __init__(self):
    super().__init__()
    self.state = {
        'count': 0,
        'items': [],
        'loading': False
    }
```

python

```
def __init__(self):
    super().__init__()
    self.state = {
        'count': 0,
        'items': [],
        'loading': False
    }
```

115.

状态更新

```python
# 单个状态更新
```

```
        self.setState({'count': self.state.count + 1})
```

状态更新

```python
# 单个状态更新
self.setState({'count': self.state.count + 1})

# 批量状态更新
self.setState({
    'loading': True,
    'items': new_items,
    'lastUpdate': datetime.now()
})

# 基于之前的状态更新
self.setState(lambda prev_state: {
    'count': prev_state.count + 1
})
```

5.2 全局状态管理

116. 状态存储

```python
from pytoweb.store import Store

class AppStore(Store):
    def init(self):
        self.state = {
            'user': None,
            'theme': 'light',
            'notifications': []
        }

    def mutations(self):
        return {
            'SET_USER': self.setUser,
            'TOGGLE_THEME': self.toggleTheme,
            'ADD_NOTIFICATION': self.addNotification
```

```
        }

    def setUser(self, state, user):
        state.user = user

    def toggleTheme(self, state):
        state.theme = 'dark' if state.theme == 'light' else 'light'

    def addNotification(self, state, notification):
        state.notifications.append(notification)

    def mutations(self):
        return {
            'SET_USER': self.setUser,
            'TOGGLE_THEME': self.toggleTheme,
            'ADD_NOTIFICATION': self.addNotification
        }

    def setUser(self, state, user):
        state.user = user

    def toggleTheme(self, state):
        state.theme = 'dark' if state.theme == 'light' else 'light'

    def addNotification(self, state, notification):
        state.notifications.append(notification)
```

117.

状态访问

```python
class MyComponent(Component):
    def render(self):
        return self.html('''

欢迎, {self.store.state.user.name}
```

切换主题

```
            ''')
    def toggleTheme(self):
        self.store.commit('TOGGLE_THEME')
```

状态访问

```python
class MyComponent(Component):
    def render(self):
        return self.html('''

欢迎, {self.store.state.user.name}

切换主题

        ''')
```

欢迎, {self.store.state.user.name}

```
def toggleTheme(self):
    self.store.commit('TOGGLE_THEME')
```

118.

异步操作

```python
class AppStore(Store):
    async def actions(self):
        return {
            'FETCH_USER': self.fetchUser,
            'UPDATE_PROFILE': self.updateProfile
        }
async def fetchUser(self, context, user_id):
    try:
```

```
            user = await api.getUser(user_id)
            context.commit('SET_USER', user)
        except Exception as e:
            context.commit('SET_ERROR', str(e))
```

异步操作

```python
class AppStore(Store):
    async def actions(self):
        return {
            'FETCH_USER': self.fetchUser,
            'UPDATE_PROFILE': self.updateProfile
        }

async def fetchUser(self, context, user_id):
    try:
        user = await api.getUser(user_id)
        context.commit('SET_USER', user)
    except Exception as e:
        context.commit('SET_ERROR', str(e))

# 在组件中使用
async def loadUser(self):
    await self.store.dispatch('FETCH_USER', self.user_id)
```

5.3 状态持久化

119.

本地存储

```python
class PersistentStore(Store):
    def init(self):
        super().init()
        self.loadFromStorage()
def loadFromStorage(self):
    stored = localStorage.getItem('app_state')
    if stored:
```

```
            self.state.update(json.loads(stored))
    def saveToStorage(self):
            localStorage.setItem('app_state',
                json.dumps(self.state))
    def commit(self, mutation, args):
            super().commit(mutation, args)
            self.saveToStorage()
```

本地存储

```python
class PersistentStore(Store):
    def init(self):
        super().init()
        self.loadFromStorage()

def loadFromStorage(self):
    stored = localStorage.getItem('app_state')
    if stored:
        self.state.update(json.loads(stored))

def saveToStorage(self):
    localStorage.setItem('app_state',
        json.dumps(self.state))

def commit(self, mutation, args):
    super().commit(mutation, args)
    self.saveToStorage()
```

120.

状态恢复

```python
class App(Component):
    def componentDidMount(self):
        # 恢复应用状态
        self.store.dispatch('RESTORE_STATE')
```

```
async def beforeUnload(self):
        # 保存应用状态
        await self.store.dispatch('SAVE_STATE')
```

状态恢复

```python
class App(Component):
    def componentDidMount(self):
        # 恢复应用状态
        self.store.dispatch('RESTORE_STATE')

async def beforeUnload(self):
    # 保存应用状态
    await self.store.dispatch('SAVE_STATE')
```

6. 路由系统

6.1 基础路由

121. 路由配置

```python
from pytoweb.router import Router, Route

router = Router([
    Route('/', HomeComponent),
    Route('/about', AboutComponent),
    Route('/users/:id', UserComponent),
    Route('/posts/:category/:id', PostComponent),
])
```

122. 路由参数

```python
class UserComponent(Component):
    def componentDidMount(self):
```

```
            user_id = self.route.params.id
            self.loadUser(user_id)
    def render(self):
        return self.html('''

    用户详情：{self.route.params.id}
    类别：{self.route.params.category}

        ''')
    ```


路由参数
    ```python
    class UserComponent(Component):
        def componentDidMount(self):
            user_id = self.route.params.id
            self.loadUser(user_id)

def render(self):
        return self.html('''

用户详情：{self.route.params.id}
类别：{self.route.params.category}

        ''')
    ```

用户详情：{self.route.params.id}

类别：{self.route.params.category}

6.2 路由导航

123. 编程式导航
    ```python
    # 基础导航
    self.router.push('/about')
    ```

```
# 带参数导航
    self.router.push({
        'path': '/users',
        'params': {'id': 123}
    })

# 带查询参数
    self.router.push({
        'path': '/search',
        'query': {'q': 'python'}
    })

# 返回上一页
    self.router.back()

# 前进下一页
    self.router.forward()
    ```

124. 声明式导航
    python
        def render(self):
            return self.html('''
                <nav>
                    <Link to="/">首页</Link>
                    <Link to="/about">关于</Link>
                    <Link to="/users/{self.user_id}">用户</Link>
                </nav>
            ''')

python
    def render(self):
        return self.html('''
            <nav>
                <Link to="/">首页</Link>
                <Link to="/about">关于</Link>
                <Link to="/users/{self.user_id}">用户</Link>
            </nav>
        ''')
```
```

6.3 路由守卫

125. 全局守卫

```python
@router.beforeEach
async def checkAuth(to, _from, next):
    if to.meta.requiresAuth:
        if not isAuthenticated():
            # 重定向到登录页
            return next('/login')
    return next()

@router.afterEach
def logNavigation(to, _from):
    print(f"导航到：{to.path}")
```

126.

组件内守卫

```python
class AdminComponent(Component):
    async def beforeRouteEnter(self, to, _from, next):
        if not hasAdminPermission():
            return next('/403')
        return next()
async def beforeRouteLeave(self, to, _from, next):
    if self.hasUnsavedChanges:
        if await self.confirm('确定要离开吗？'):
            return next()
        return False
    return next()
```

组件内守卫

```python
class AdminComponent(Component):
    async def beforeRouteEnter(self, to, _from, next):
```

```
            if not hasAdminPermission():
                return next('/403')
            return next()

async def beforeRouteLeave(self, to, _from, next):
        if self.hasUnsavedChanges:
            if await self.confirm('确定要离开吗？'):
                return next()
            return False
        return next()
```

7. 表单验证

7.1 基础验证

127. 验证规则定义

```python
from pytoweb.validation import Validator, Required, Length, Email

class UserForm(Validator):
    rules = {
        'username': [Required(), Length(min=3, max=20)],
        'email': [Required(), Email()],
        'password': [Required(), Length(min=6)],
        'age': [Required(), Range(min=18, max=100)]
    }

    messages = {
        'username.required': '用户名不能为空',
        'username.length': '用户名长度必须在 3-20 个字符之间',
        'email.email': '请输入有效的邮箱地址',
        'password.length': '密码长度不能少于 6 个字符',
        'age.range': '年龄必须在 18-100 岁之间'
    }

    messages = {
        'username.required': '用户名不能为空',
        'username.length': '用户名长度必须在 3-20 个字符之间',
        'email.email': '请输入有效的邮箱地址',
        'password.length': '密码长度不能少于 6 个字符',
```

```
        'age.range': '年龄必须在 18-100 岁之间'
    }

```

128.
    表单组件
        ```python
        class RegistrationForm(Component):
            def init(self):
                super().init()
                self.validator = UserForm()
                self.state = {
                    'form': {
                        'username': '',
                        'email': '',
                        'password': '',
                        'age': ''
                    },
                    'errors': {}
                }
    def validate(self, field=None):
            if field:
                errors = self.validator.validate_field(
                    self.state.form, field)
            else:
                errors = self.validator.validate(self.state.form)
            self.setState({'errors': errors})
            return not errors
    def handleSubmit(self, event):
            event.preventDefault()
            if self.validate():
                self.submitForm()
    def render(self):
            return self.html('''
        ```

```
                    {self.state.errors.get('username', '')}
```

注册

```
        ''')
    ```
```

表单组件

```python
class RegistrationForm(Component):
    def init(self):
        super().init()
        self.validator = UserForm()
        self.state = {
            'form': {
                'username': '',
                'email': '',
                'password': '',
                'age': ''
            },
            'errors': {}
        }

def validate(self, field=None):
    if field:
        errors = self.validator.validate_field(
            self.state.form, field)
    else:
        errors = self.validator.validate(self.state.form)
    self.setState({'errors': errors})
    return not errors
```
```

```
def handleSubmit(self, event):
        event.preventDefault()
        if self.validate():
            self.submitForm()

def render(self):
        return self.html('''




                            {self.state.errors.get('username', '')}



注册

        ''')
    ```
```

### 7.2 高级验证

129. 自定义验证规则

    ```python
    from pytoweb.validation import ValidationRule

class PasswordStrength(ValidationRule):
        def init(self, min_score=3):
            self.min_score = min_score

    def validate(self, value):
        score = self.calculate_strength(value)
        return score >= self.min_score

    def calculate_strength(self, password):
        score = 0
        if len(password) >= 8:
            score += 1
        if re.search(r'[A-Z]', password):
            score += 1
```
```

```
        if re.search(r'[a-z]', password):
            score += 1
        if re.search(r'[0-9]', password):
            score += 1
        if re.search(r'[!@#$%^&*]', password):
            score += 1
        return score

    def validate(self, value):
        score = self.calculate_strength(value)
        return score >= self.min_score

    def calculate_strength(self, password):
        score = 0
        if len(password) >= 8:
            score += 1
        if re.search(r'[A-Z]', password):
            score += 1
        if re.search(r'[a-z]', password):
            score += 1
        if re.search(r'[0-9]', password):
            score += 1
        if re.search(r'[!@#$%^&*]', password):
            score += 1
        return score

# 使用自定义规则
    class UserForm(Validator):
        rules = {
            'password': [Required(), PasswordStrength(min_score=4)]
        }
    ```
```

130. 异步验证

```
    ```python
    class UsernameAvailable(ValidationRule):
        async def validate(self, value):
            response = await api.checkUsername(value)
            return response['available']
```

```
class RegistrationForm(Component):
       async def validateUsername(self):
           validator = UsernameAvailable()
           is_valid = await validator.validate(
               self.state.form.username)
           if not is_valid:
               self.setState({
                   'errors': {
                       'username': '用户名已被使用'
                   }
               })
           return is_valid
```

7.3 表单状态管理

131.

表单状态追踪

```python
class FormState:
    def init(self):
        self.touched = set()
        self.dirty = set()
        self.pending = set()
        self.valid = False
def markTouched(self, field):
        self.touched.add(field)
def markDirty(self, field):
        self.dirty.add(field)
def setPending(self, field, is_pending):
        if is_pending:
            self.pending.add(field)
        else:
            self.pending.remove(field)
```

表单状态追踪

```python
```

```
   class FormState:
       def init(self):
           self.touched = set()
           self.dirty = set()
           self.pending = set()
           self.valid = False

def markTouched(self, field):
       self.touched.add(field)

def markDirty(self, field):
       self.dirty.add(field)

def setPending(self, field, is_pending):
       if is_pending:
           self.pending.add(field)
       else:
           self.pending.remove(field)

class RegistrationForm(Component):
       def init(self):
           super().init()
           self.form_state = FormState()

   def handleBlur(self, field):
       self.form_state.markTouched(field)
       self.validate(field)

   def handleInput(self, field):
       self.form_state.markDirty(field)

   def handleBlur(self, field):
       self.form_state.markTouched(field)
       self.validate(field)

   def handleInput(self, field):
       self.form_state.markDirty(field)

```

132. 表单重置

python

```
def resetForm(self):
    self.setState({
        'form': {
            'username': '',
            'email': '',
            'password': '',
            'age': ''
        },
        'errors': {}
    })
    self.form_state = FormState()
```

python

```
def resetForm(self):
    self.setState({
        'form': {
            'username': '',
            'email': '',
            'password': '',
            'age': ''
        },
        'errors': {}
    })
    self.form_state = FormState()
```

8. 样式系统

8.1 基础样式

133.

内联样式

python

```
def render(self):
    return self.html('''
        <div style="color: blue; font-size: 16px">
            内联样式示例
        </div>
```

```
        ''')
```

内联样式

python

```
    def render(self):
        return self.html('''
            <div style="color: blue; font-size: 16px">
                内联样式示例
            </div>
        ''')
```

python

```
    def render(self):
        return self.html('''
            <div style="color: blue; font-size: 16px">
                内联样式示例
            </div>
        ''')
```

134.

样式对象

```python
    class StyledComponent(Component):
        def init(self):
            super().init()
            self.styles = {
                'container': {
                    'display': 'flex',
                    'flexDirection': 'column',
                    'padding': '20px',
                    'backgroundColor': '#f5f5f5'
                },
                'title': {
                    'fontSize': '24px',
                    'fontWeight': 'bold',
                    'marginBottom': '16px'
                }
            }
```

```
    def render(self):
        return self.html('''

    样式对象示例

        ''')
    ```
```

样式对象

```
    ```python
    class StyledComponent(Component):
        def init(self):
            super().init()
            self.styles = {
                'container': {
                    'display': 'flex',
                    'flexDirection': 'column',
                    'padding': '20px',
                    'backgroundColor': '#f5f5f5'
                },
                'title': {
                    'fontSize': '24px',
                    'fontWeight': 'bold',
                    'marginBottom': '16px'
                }
            }

def render(self):
        return self.html('''

样式对象示例

        ''')
    ```
```

## 样式对象示例
```

8.2 CSS-in-Python

135. 样式定义

```python
from pytoweb.styles import StyleSheet

class MyStyles(StyleSheet):
    styles = {
        'container': {
            'display': 'grid',
            'gridTemplateColumns': 'repeat(auto-fit, minmax(300px, 1fr))',
            'gap': '20px',
            'padding': '20px',
            '@media (max-width: 768px)': {
                'gridTemplateColumns': '1fr'
            }
        },
        'card': {
            'borderRadius': '8px',
            'boxShadow': '0 2px 4px rgba(0,0,0,0.1)',
            'padding': '16px',
            'transition': 'transform 0.2s ease',
            ':hover': {
                'transform': 'translateY(-4px)'
            }
        }
    }
```

136. 样式使用

```python
class CardGrid(Component):
    def init(self):
        super().init()
        self.styles = MyStyles()
def render(self):
```

```
        return self.html('''

                卡片内容

        ''')
    ```

样式使用
```python
class CardGrid(Component):
    def init(self):
        super().init()
        self.styles = MyStyles()

def render(self):
    return self.html('''

            卡片内容

    ''')
```

8.3 高级样式特性

137. 动态样式
```python
class DynamicStyles(StyleSheet):
    def getStyles(self, props):
        return {
            'button': {
                'backgroundColor': props.get('color', '#007bff'),
                'color': 'white',
                'padding': '8px 16px',
```

```
                    'borderRadius': '4px',
                    'opacity': '1' if not props.get('disabled') else
'0.5'
                }
            }

class Button(Component):
    def render(self):
        styles = DynamicStyles().getStyles(self.props)
        return self.html('''

                {self.props.children}

        ''')
```

138. CSS 变量支持

```
python
    class ThemeStyles(StyleSheet):
        styles = {
            'root': {
                '--primary-color': '#007bff',
                '--secondary-color': '#6c757d',
                '--font-size-base': '16px',
                '--spacing-unit': '8px'
            },
            'container': {
                'color': 'var(--primary-color)',
                'fontSize': 'var(--font-size-base)',
                'padding': 'calc(var(--spacing-unit) * 2)'
            }
        }

python
    class ThemeStyles(StyleSheet):
        styles = {
            'root': {
                '--primary-color': '#007bff',
```

```
            '--secondary-color': '#6c757d',
            '--font-size-base': '16px',
            '--spacing-unit': '8px'
        },
        'container': {
            'color': 'var(--primary-color)',
            'fontSize': 'var(--font-size-base)',
            'padding': 'calc(var(--spacing-unit) * 2)'
        }
    }
```

9. 主题系统

9.1 主题定义

139. 基础主题

```python
from pytoweb.theme import Theme

class LightTheme(Theme):
    colors = {
        'primary': '#007bff',
        'secondary': '#6c757d',
        'success': '#28a745',
        'danger': '#dc3545',
        'warning': '#ffc107',
        'info': '#17a2b8',
        'light': '#f8f9fa',
        'dark': '#343a40'
    }

    typography = {
        'fontFamily': '-apple-system, BlinkMacSystemFont, "Segoe UI", Roboto',
        'fontSize': {
            'xs': '12px',
            'sm': '14px',
            'base': '16px',
            'lg': '18px',
            'xl': '20px'
        },
```

```
        'fontWeight': {
            'normal': 400,
            'medium': 500,
            'bold': 700
        }
    }

    spacing = {
        'xs': '4px',
        'sm': '8px',
        'md': '16px',
        'lg': '24px',
        'xl': '32px'
    }

    breakpoints = {
        'sm': '576px',
        'md': '768px',
        'lg': '992px',
        'xl': '1200px'
    }

    typography = {
        'fontFamily': '-apple-system, BlinkMacSystemFont, "Segoe UI",
Roboto',
        'fontSize': {
            'xs': '12px',
            'sm': '14px',
            'base': '16px',
            'lg': '18px',
            'xl': '20px'
        },
        'fontWeight': {
            'normal': 400,
            'medium': 500,
            'bold': 700
        }
    }

    spacing = {
        'xs': '4px',
```

```
        'sm': '8px',
        'md': '16px',
        'lg': '24px',
        'xl': '32px'
    }

    breakpoints = {
        'sm': '576px',
        'md': '768px',
        'lg': '992px',
        'xl': '1200px'
    }

```

140.
    暗色主题
        ```python
        class DarkTheme(LightTheme):
            colors = {
                **LightTheme.colors,
                'primary': '#375a7f',
                'background': '#222',
                'surface': '#333',
                'text': '#fff'
            }
        shadows = {
            'sm': '0 2px 4px rgba(0,0,0,0.4)',
            'md': '0 4px 8px rgba(0,0,0,0.4)',
            'lg': '0 8px 16px rgba(0,0,0,0.4)'
        }
        ```


暗色主题
    ```python
    class DarkTheme(LightTheme):
        colors = {
    ```

```
            **LightTheme.colors,
            'primary': '#375a7f',
            'background': '#222',
            'surface': '#333',
            'text': '#fff'
        }

shadows = {
        'sm': '0 2px 4px rgba(0,0,0,0.4)',
        'md': '0 4px 8px rgba(0,0,0,0.4)',
        'lg': '0 8px 16px rgba(0,0,0,0.4)'
    }
    ```
```

## 9.2 主题使用

141. 主题提供者

```python
from pytoweb.theme import ThemeProvider

class App(Component):
    def init(self):
        super().init()
        self.state = {
            'theme': 'light'
        }

    def render(self):
        theme = LightTheme() if self.state.theme == 'light' else
DarkTheme()
        return self.html('''
            <ThemeProvider theme={theme}>
                <div class="app">
                    {self.props.children}
                </div>
            </ThemeProvider>
        ''')

    def render(self):
        theme = LightTheme() if self.state.theme == 'light' else
```
```

```
DarkTheme()
        return self.html('''
            <ThemeProvider theme={theme}>
                <div class="app">
                    {self.props.children}
                </div>
            </ThemeProvider>
        ''')

```

142. 主题消费

```
   python
      class ThemedButton(Component):
          def render(self):
              theme = self.useTheme()
              return self.html('''
                  <button style={{
                      backgroundColor: theme.colors.primary,
                      color: theme.colors.text,
                      padding: f"{theme.spacing.sm} {theme.spacing.md}",
                      fontSize: theme.typography.fontSize.base
                  }}>
                      {self.props.children}
                  </button>
              ''')

python
   class ThemedButton(Component):
       def render(self):
           theme = self.useTheme()
           return self.html('''
               <button style={{
                   backgroundColor: theme.colors.primary,
                   color: theme.colors.text,
                   padding: f"{theme.spacing.sm} {theme.spacing.md}",
                   fontSize: theme.typography.fontSize.base
               }}>
                   {self.props.children}
```

```
            </button>
        ''')
```

9.3 响应式主题

143.

媒体查询

python

```
    class ResponsiveTheme(Theme):
        def getStyles(self):
            return {
                'container': {
                    'width': '100%',
                    'padding': self.spacing.md,
                    '@media (min-width: ' + self.breakpoints.sm + ')':
{
                        'width': '540px'
                    },
                    '@media (min-width: ' + self.breakpoints.md + ')':
{
                        'width': '720px'
                    },
                    '@media (min-width: ' + self.breakpoints.lg + ')':
{
                        'width': '960px'
                    }
                }
            }
```

媒体查询

python

```
    class ResponsiveTheme(Theme):
        def getStyles(self):
            return {
                'container': {
                    'width': '100%',
                    'padding': self.spacing.md,
```

```
                '@media (min-width: ' + self.breakpoints.sm + ')': {
                    'width': '540px'
                },
                '@media (min-width: ' + self.breakpoints.md + ')': {
                    'width': '720px'
                },
                '@media (min-width: ' + self.breakpoints.lg + ')': {
                    'width': '960px'
                }
            }
        }
```

python
```
class ResponsiveTheme(Theme):
    def getStyles(self):
        return {
            'container': {
                'width': '100%',
                'padding': self.spacing.md,
                '@media (min-width: ' + self.breakpoints.sm + ')': {
                    'width': '540px'
                },
                '@media (min-width: ' + self.breakpoints.md + ')': {
                    'width': '720px'
                },
                '@media (min-width: ' + self.breakpoints.lg + ')': {
                    'width': '960px'
                }
            }
        }
```

144.

主题切换

```python
class ThemeSwitcher(Component):
    def toggleTheme(self):
        current = self.state.theme
        new_theme = 'dark' if current == 'light' else 'light'
        self.setState({'theme': new_theme})
        # 保存主题偏好
```

```
            localStorage.setItem('theme', new_theme)
    def componentDidMount(self):
        # 恢复主题偏好
        saved_theme = localStorage.getItem('theme')
        if saved_theme:
            self.setState({'theme': saved_theme})
    def render(self):
        return self.html('''

                切换到{
                    '暗色主题' if self.state.theme == 'light'
                    else '亮色主题'
                }

        ''')
```

主题切换

```python
class ThemeSwitcher(Component):
    def toggleTheme(self):
        current = self.state.theme
        new_theme = 'dark' if current == 'light' else 'light'
        self.setState({'theme': new_theme})
        # 保存主题偏好
        localStorage.setItem('theme', new_theme)

def componentDidMount(self):
    # 恢复主题偏好
    saved_theme = localStorage.getItem('theme')
    if saved_theme:
        self.setState({'theme': saved_theme})

def render(self):
    return self.html('''
```

```
            切换到{
                '暗色主题' if self.state.theme == 'light'
                else '亮色主题'
            }

        ''')
```

10. 虚拟 DOM 系统

10.1 核心概念

145. 虚拟节点

```python
from pytoweb.vdom import VNode

# 创建虚拟节点
node = VNode(
    tag='div',
    props={'class': 'container'},
    children=[
        VNode('h1', {}, ['标题']),
        VNode('p', {'style': 'color: blue'}, ['内容'])
    ]
)
```

146. DOM 差异计算

```python
from pytoweb.vdom import VDOMDiffer

# 计算两个虚拟节点之间的差异
old_node = VNode('div', {'class': 'old'}, [
    VNode('p', {}, ['旧文本'])
])
new_node = VNode('div', {'class': 'new'}, [
    VNode('p', {}, ['新文本'])
])
```

```
# 生成补丁
    patches = VDOMDiffer.diff(old_node, new_node)
    ```
```

## 10.2 渲染系统

147. 渲染器

```python
from pytoweb.vdom import VDOMRenderer

class CustomRenderer(VDOMRenderer):
    def createElement(self, vnode):
        element = document.createElement(vnode.tag)
        self.updateProps(element, {}, vnode.props)
        return element

    def updateProps(self, element, old_props, new_props):
        # 移除旧属性
        for key in old_props:
            if key not in new_props:
                element.removeAttribute(key)

        # 设置新属性
        for key, value in new_props.items():
            if old_props.get(key) != value:
                element.setAttribute(key, value)

    def createTextNode(self, text):
        return document.createTextNode(text)

    def updateProps(self, element, old_props, new_props):
        # 移除旧属性
        for key in old_props:
            if key not in new_props:
                element.removeAttribute(key)

        # 设置新属性
        for key, value in new_props.items():
            if old_props.get(key) != value:
                element.setAttribute(key, value)
```
```

```
    def createTextNode(self, text):
        return document.createTextNode(text)
```

148.
    组件渲染
        ```python
        class Component:
            def init(self):
                self.renderer = CustomRenderer()
                self.vnode = None
                self.element = None
    def mount(self, container):
            self.vnode = self.render()
            self.element = self.renderer.render(self.vnode)
            container.appendChild(self.element)
    def update(self):
            new_vnode = self.render()
            patches = VDOMDiffer.diff(self.vnode, new_vnode)
            self.renderer.patch(self.element, patches)
            self.vnode = new_vnode
        ```

组件渲染
    ```python
    class Component:
        def init(self):
            self.renderer = CustomRenderer()
            self.vnode = None
            self.element = None

def mount(self, container):
        self.vnode = self.render()
        self.element = self.renderer.render(self.vnode)
        container.appendChild(self.element)
    ```

```
def update(self):
        new_vnode = self.render()
        patches = VDOMDiffer.diff(self.vnode, new_vnode)
        self.renderer.patch(self.element, patches)
        self.vnode = new_vnode
```

10.3 优化策略

149. 批量更新

```python
from pytoweb.vdom import BatchUpdate

class BatchUpdateManager:
    def init(self):
        self.updates = []
        self.is_batching = False

    def queue_update(self, component):
        self.updates.append(component)
        if not self.is_batching:
            self.process_queue()

    def process_queue(self):
        self.is_batching = True
        try:
            while self.updates:
                component = self.updates.pop(0)
                component.update()
        finally:
            self.is_batching = False

    def queue_update(self, component):
        self.updates.append(component)
        if not self.is_batching:
            self.process_queue()

    def process_queue(self):
        self.is_batching = True
        try:
            while self.updates:
```

```
                component = self.updates.pop(0)
                component.update()
        finally:
            self.is_batching = False

# 使用批量更新
batch_manager = BatchUpdateManager()
with BatchUpdate(batch_manager):
    component1.setState({'value': 1})
    component2.setState({'value': 2})
```

150.

虚拟节点缓存

```python
class CachedComponent(Component):
    def init(self):
        super().init()
        self.cache = {}
def createVNode(self, key, props):
        if key in self.cache and self.shouldUseCache(key, props):
            return self.cache[key]
    vnode = self.renderVNode(key, props)
    self.cache[key] = vnode
    return vnode

def shouldUseCache(self, key, props):
        # 判断是否可以使用缓存
        cached = self.cache.get(key)
        return (cached and
                cached.props == props and
                not self.isDirty(key))
def invalidateCache(self, key=None):
        if key is None:
            self.cache.clear()
        else:
            self.cache.pop(key, None)
```

```

虚拟节点缓存

```python
class CachedComponent(Component):
    def init(self):
        super().init()
        self.cache = {}

def createVNode(self, key, props):
    if key in self.cache and self.shouldUseCache(key, props):
        return self.cache[key]

    vnode = self.renderVNode(key, props)
    self.cache[key] = vnode
    return vnode

    vnode = self.renderVNode(key, props)
    self.cache[key] = vnode
    return vnode

def shouldUseCache(self, key, props):
    # 判断是否可以使用缓存
    cached = self.cache.get(key)
    return (cached and
            cached.props == props and
            not self.isDirty(key))

def invalidateCache(self, key=None):
    if key is None:
        self.cache.clear()
    else:
        self.cache.pop(key, None)
```
```

11. Web Workers 系统

11.1 基础使用

151. Worker 定义

```python
from pytoweb.workers import PyWorker

class DataProcessor(PyWorker):
    def process_data(self, data):
        # 耗时的数据处理
        result = perform_heavy_computation(data)
        return result

    def handle_message(self, message):
        if message.type == 'PROCESS':
            result = self.process_data(message.data)
            self.post_message('DONE', result)

    def handle_message(self, message):
        if message.type == 'PROCESS':
            result = self.process_data(message.data)
            self.post_message('DONE', result)
```

152. Worker 使用

```python
class DataComponent(Component):
    def init(self):
        super().init()
        self.worker = DataProcessor()
        self.state = {'result': None}
    def componentDidMount(self):
        self.worker.onmessage = self.handle_result
        self.worker.start()
    def handle_result(self, message):
        if message.type == 'DONE':
            self.setState({'result': message.data})
```

```
    def process(self):
        self.worker.post_message('PROCESS', self.state.data)
```

Worker 使用

```python
class DataComponent(Component):
    def init(self):
        super().init()
        self.worker = DataProcessor()
        self.state = {'result': None}

def componentDidMount(self):
    self.worker.onmessage = self.handle_result
    self.worker.start()

def handle_result(self, message):
    if message.type == 'DONE':
        self.setState({'result': message.data})

def process(self):
    self.worker.post_message('PROCESS', self.state.data)
```

11.2 Worker 池

153. 池管理器

```python
from pytoweb.workers import WorkerPool

class ProcessingPool:
    def init(self, size=4):
        self.pool = WorkerPool(DataProcessor, size)
        self.tasks = {}

    async def process_data(self, data, task_id):
        worker = await self.pool.acquire()
        try:
            result = await worker.process_data(data)
```

```
            self.tasks[task_id] = result
        finally:
            self.pool.release(worker)

    def get_result(self, task_id):
        return self.tasks.get(task_id)

    async def process_data(self, data, task_id):
        worker = await self.pool.acquire()
        try:
            result = await worker.process_data(data)
            self.tasks[task_id] = result
        finally:
            self.pool.release(worker)

    def get_result(self, task_id):
        return self.tasks.get(task_id)
```

154.
    池使用
        ```python
        class BatchProcessor(Component):
            def init(self):
                super().init()
                self.pool = ProcessingPool()
                self.state = {
                    'tasks': {},
                    'results': {}
                }
    async def process_batch(self, items):
            tasks = {}
            for item in items:
                task_id = generate_id()
                tasks[task_id] = self.pool.process_data(
                    item, task_id)
        # 等待所有任务完成
        await asyncio.gather(*tasks.values())
        ```

```
        # 收集结果
        results = {
            task_id: self.pool.get_result(task_id)
            for task_id in tasks
        }
        self.setState({'results': results})

    ```


池使用
    ```python
    class BatchProcessor(Component):
        def init(self):
            super().init()
            self.pool = ProcessingPool()
            self.state = {
                'tasks': {},
                'results': {}
            }

async def process_batch(self, items):
        tasks = {}
        for item in items:
            task_id = generate_id()
            tasks[task_id] = self.pool.process_data(
                item, task_id)

    # 等待所有任务完成
    await asyncio.gather(*tasks.values())

    # 收集结果
    results = {
        task_id: self.pool.get_result(task_id)
        for task_id in tasks
    }
```

```
    self.setState({'results': results})

    # 等待所有任务完成
    await asyncio.gather(*tasks.values())

    # 收集结果
    results = {
        task_id: self.pool.get_result(task_id)
        for task_id in tasks
    }
    self.setState({'results': results})
```

11.3 高级特性

155. 共享内存

```python
from pytoweb.workers import SharedMemory

class SharedDataWorker(PyWorker):
    def init(self):
        super().init()
        self.shared_data = SharedMemory(1024)  # 1KB

    def process_shared_data(self):
        # 直接访问共享内存
        data = self.shared_data.read()
        processed = self.process(data)
        self.shared_data.write(processed)

    def process_shared_data(self):
        # 直接访问共享内存
        data = self.shared_data.read()
        processed = self.process(data)
        self.shared_data.write(processed)

# 主线程使用
    worker = SharedDataWorker()
    worker.shared_data.write(initial_data)
    worker.post_message('PROCESS_SHARED')
```

```
result = worker.shared_data.read()
```

156.

错误处理

```python
class RobustWorker(PyWorker):
    def handle_message(self, message):
        try:
            if message.type == 'PROCESS':
                result = self.process_data(message.data)
                self.post_message('DONE', result)
        except Exception as e:
            self.post_message('ERROR', {
                'error': str(e),
                'traceback': traceback.format_exc()
            })
def process_data(self, data):
        if not self.validate_data(data):
            raise ValueError('Invalid data format')
        return self.perform_processing(data)
```

错误处理

```python
class RobustWorker(PyWorker):
    def handle_message(self, message):
        try:
            if message.type == 'PROCESS':
                result = self.process_data(message.data)
                self.post_message('DONE', result)
        except Exception as e:
            self.post_message('ERROR', {
                'error': str(e),
                'traceback': traceback.format_exc()
            })
```

```
def process_data(self, data):
        if not self.validate_data(data):
            raise ValueError('Invalid data format')
        return self.perform_processing(data)

# 使用健壮的 Worker
    class RobustComponent(Component):
        def handle_worker_message(self, message):
            if message.type == 'ERROR':
                self.setState({
                    'error': message.data.error,
                    'traceback': message.data.traceback
                })
                self.logger.error(
                    f"Worker error: {message.data.error}")
            elif message.type == 'DONE':
                self.setState({
                    'result': message.data,
                    'error': None
                })
    ```
```

## 12. 最佳实践与性能优化

### 12.1 代码组织

157.

项目结构

```
my-project/
    ├── src/
    │   ├── components/   # 组件目录
    │   │   ├── common/   # 通用组件
    │   │   ├── layout/   # 布局组件
    │   │   └── pages/   # 页面组件
    │   ├── styles/   # 样式文件
    │   ├── store/   # 状态管理
    │   ├── utils/   # 工具函数
    │   ├── workers/   # Web Workers
```
```

```
│   └── main.py          # 入口文件
├── tests/               # 测试文件
├── public/              # 静态资源
├── config.py            # 配置文件
└── requirements.txt     # 依赖管理
```

项目结构

```
my-project/
    ├── src/
    │   ├── components/      # 组件目录
    │   │   ├── common/      # 通用组件
    │   │   ├── layout/      # 布局组件
    │   │   └── pages/       # 页面组件
    │   ├── styles/          # 样式文件
    │   ├── store/           # 状态管理
    │   ├── utils/           # 工具函数
    │   ├── workers/         # Web Workers
    │   └── main.py          # 入口文件
    ├── tests/               # 测试文件
    ├── public/              # 静态资源
    ├── config.py            # 配置文件
    └── requirements.txt     # 依赖管理
```

```
my-project/
    ├── src/
    │   ├── components/      # 组件目录
    │   │   ├── common/      # 通用组件
    │   │   ├── layout/      # 布局组件
    │   │   └── pages/       # 页面组件
    │   ├── styles/          # 样式文件
    │   ├── store/           # 状态管理
    │   ├── utils/           # 工具函数
    │   ├── workers/         # Web Workers
    │   └── main.py          # 入口文件
    ├── tests/               # 测试文件
    ├── public/              # 静态资源
    ├── config.py            # 配置文件
    └── requirements.txt     # 依赖管理
```

158.
命名规范

命名规范

159. 组件使用大驼峰命名：UserProfile

UserProfile
160. 文件使用小写下划线：user_profile.py

user_profile.py
161. 常量使用大写下划线：MAX_ITEMS

MAX_ITEMS
162. 私有方法使用下划线前缀：_handle_event

_handle_event

12.2 性能优化

163.
渲染优化
```python
class OptimizedComponent(Component):
    def shouldComponentUpdate(self, nextProps, nextState):
        # 避免不必要的重渲染
        return (self.props != nextProps or
                self.state != nextState)
def render(self):
        # 使用列表虚拟化
        return self.html('''

        ''')
```

渲染优化
```python
class OptimizedComponent(Component):
    def shouldComponentUpdate(self, nextProps, nextState):
```

```
            # 避免不必要的重渲染
            return (self.props != nextProps or
                    self.state != nextState)

def render(self):
       # 使用列表虚拟化
       return self.html('''

       ''')
   ```

164.
   资源加载
      ```python
      class LazyComponent(Component):
          def init(self):
              super().init()
              self.state = {
                  'module': None
              }
   async def componentDidMount(self):
          # 按需加载模块
          module = await import_module('heavy_module')
          self.setState({'module': module})
   def render(self):
          if not self.state.module:
              return self.html('')
          return self.renderContent()
      ```


资源加载
   ```python
   class LazyComponent(Component):
       def init(self):
           super().init()
           self.state = {
```

```
            'module': None
        }

async def componentDidMount(self):
        # 按需加载模块
        module = await import_module('heavy_module')
        self.setState({'module': module})

def render(self):
        if not self.state.module:
            return self.html('')
        return self.renderContent()
```

12.3 安全最佳实践

165. 输入验证

```python
from pytoweb.security import sanitize_html, validate_input

class SecureComponent(Component):
        def process_user_input(self, input_data):
            # 验证输入
            if not validate_input(input_data):
                raise ValueError("Invalid input")

        # 清理 HTML
        clean_html = sanitize_html(input_data)
        return clean_html

    def render(self):
        return self.html('''
            <div>
                {self.process_user_input(self.props.content)}
            </div>
        ''')

        # 清理 HTML
        clean_html = sanitize_html(input_data)
        return clean_html
```

```
    def render(self):
        return self.html('''
            <div>
                {self.process_user_input(self.props.content)}
            </div>
        ''')
```

166.

状态保护

```python
class SecureStore(Store):
    def init(self):
        super().init()
        self._freeze_state()
def _freeze_state(self):
    # 防止状态被直接修改
    self.state = ReadOnlyDict(self.state)
def mutation(self, type, payload):
    # 验证 mutation 类型
    if type not in self.mutations:
        raise ValueError(f"Unknown mutation: {type}")
# 创建状态副本
new_state = copy.deepcopy(self.state)
self.mutations[type](new_state, payload)
self._freeze_state()
```

状态保护

```python
class SecureStore(Store):
    def init(self):
        super().init()
        self._freeze_state()
```

```
def _freeze_state(self):
        # 防止状态被直接修改
        self.state = ReadOnlyDict(self.state)

def mutation(self, type, payload):
        # 验证 mutation 类型
        if type not in self.mutations:
            raise ValueError(f"Unknown mutation: {type}")

    # 创建状态副本
    new_state = copy.deepcopy(self.state)
    self.mutations[type](new_state, payload)
    self._freeze_state()

    # 创建状态副本
    new_state = copy.deepcopy(self.state)
    self.mutations[type](new_state, payload)
    self._freeze_state()
```

12.4 测试策略

167. 单元测试

```python
import pytest
from pytoweb.testing import render, fireEvent

def test_component():
    # 渲染组件
    result = render(MyComponent, props={'title': 'Test'})

    # 检查渲染结果
    assert result.getByText('Test')

    # 触发事件
    button = result.getByRole('button')
    fireEvent.click(button)

    # 验证状态更新
    assert result.state.clicked == True
```

```
    # 检查渲染结果
    assert result.getByText('Test')

    # 触发事件
    button = result.getByRole('button')
    fireEvent.click(button)

    # 验证状态更新
    assert result.state.clicked == True
```

168.
    集成测试
        ```python
        class TestApp:
            @pytest.fixture
            def app(self):
                return render(App)
    def test_navigation(self, app):
            # 测试路由导航
            link = app.getByText('About')
            fireEvent.click(link)
            assert app.location.pathname == '/about'
    def test_data_flow(self, app):
            # 测试数据流
            input = app.getByLabelText('Username')
            fireEvent.change(input, 'test')
            assert app.store.state.user.name == 'test'
        ```


集成测试
    ```python
    class TestApp:
        @pytest.fixture
        def app(self):
            return render(App)
    ```

```
def test_navigation(self, app):
        # 测试路由导航
        link = app.getByText('About')
        fireEvent.click(link)
        assert app.location.pathname == '/about'

def test_data_flow(self, app):
        # 测试数据流
        input = app.getByLabelText('Username')
        fireEvent.change(input, 'test')
        assert app.store.state.user.name == 'test'
```

12.5 部署优化

169.

构建优化

python

```
# config/production.py
PYTOWEB_CONFIG = {
    'optimization': {
        'minimize': True,
        'split_chunks': True,
        'tree_shaking': True,
        'scope_hoisting': True
    },
    'caching': {
        'enable': True,
        'max_age': 3600,
        'include_hash': True
    },
    'compression': {
        'enable': True,
        'algorithm': 'gzip'
    }
}
```

构建优化

python

```
# config/production.py
PYTOWEB_CONFIG = {
    'optimization': {
        'minimize': True,
        'split_chunks': True,
        'tree_shaking': True,
        'scope_hoisting': True
    },
    'caching': {
        'enable': True,
        'max_age': 3600,
        'include_hash': True
    },
    'compression': {
        'enable': True,
        'algorithm': 'gzip'
    }
}
```

python

```
# config/production.py
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    'optimization': {
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        'split_chunks': True,
        'tree_shaking': True,
        'scope_hoisting': True
    },
    'caching': {
        'enable': True,
        'max_age': 3600,
        'include_hash': True
    },
    'compression': {
        'enable': True,
        'algorithm': 'gzip'
```

```
        }
    }
```

170.

性能监控

```python
from pytoweb.monitoring import Performance
```

性能监控

```python
from pytoweb.monitoring import Performance

class MonitoredApp(App):
        def init(self):
            super().init()
            self.performance = Performance()

    def componentDidMount(self):
        # 记录关键指标
        self.performance.mark('app_mounted')
        self.performance.measure(
            'mount_time',
            'navigation_start',
            'app_mounted'
        )

    def componentDidUpdate(self):
        # 监控重渲染性能
        self.performance.mark('update_complete')
        self.performance.measure(
            'update_time',
            'update_start',
            'update_complete'
        )

    def componentDidMount(self):
        # 记录关键指标
        self.performance.mark('app_mounted')
        self.performance.measure(
            'mount_time',
```

```
            'navigation_start',
            'app_mounted'
        )

    def componentDidUpdate(self):
        # 监控重渲染性能
        self.performance.mark('update_complete')
        self.performance.measure(
            'update_time',
            'update_start',
            'update_complete'
        )
```

13. 总结

PytoWeb 框架提供了一套完整的现代化 Web 应用开发解决方案，主要特点包括：

171. 开发效率
172. 纯 Python 开发体验
173. 完整的组件化支持
174. 强大的工具链和开发体验

强大的工具链和开发体验

175. 性能表现

性能表现

176. 高效的虚拟 DOM 实现
177. 智能的批量更新策略
178. 完善的缓存机制

完善的缓存机制

179.
可维护性

可维护性

180. 清晰的项目结构
181. 统一的代码风格
182.
完整的测试支持

完整的测试支持

183.
扩展性

扩展性

184. 插件化架构
185. 丰富的 API
186. 灵活的定制能力

13.1 版本规划

187. 近期计划
188. 性能优化增强
189. 开发工具改进
190.
文档系统升级

文档系统升级

191.
长期目标

长期目标

192. 生态系统建设

193. 企业级特性
194. 云原生支持

13.2 参与贡献

195. 贡献方式
196. 提交 Issue
197. 贡献代码
198. 完善文档
199. 分享经验

分享经验

200. 开发指南

开发指南

201. 遵循代码规范
202. 编写测试用例
203. 更新文档
204. 参与讨论