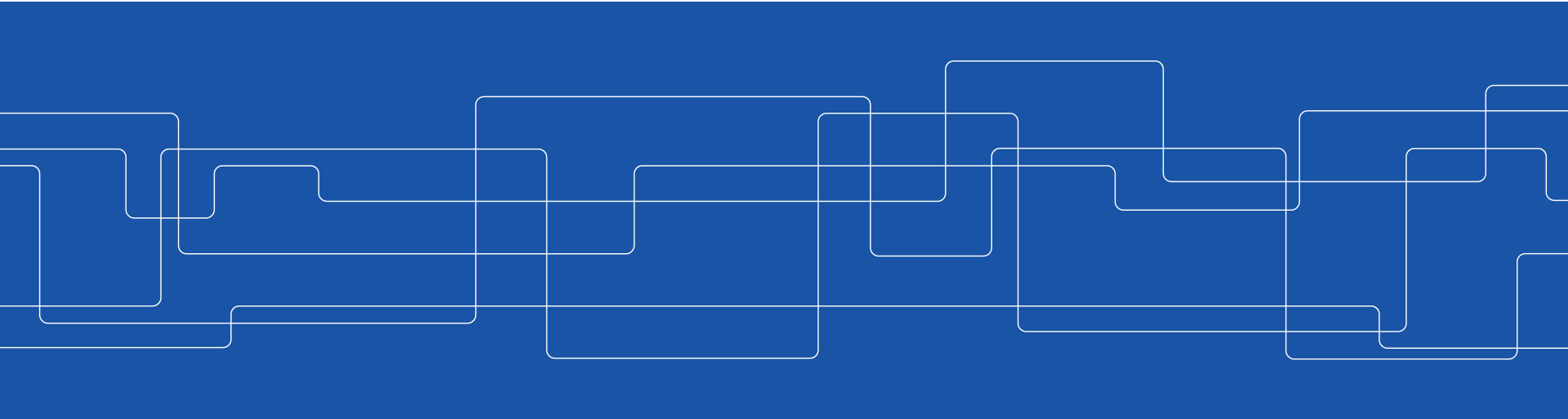
Self-healing Middleware Support for Python/Django Web Applications

Presenter: Yi-Pei Tu
Examiner: Martin Monperrus
Supervisor: Long Zhang



Outline

- Introduction
- Empirical Study
- Design & Implementation
- Experiment
- Results
- Discussion
- Conclusion

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Introduction - Background

- Web framework
  - routing
  - web servies
  - web resources
  - templating
  - session management
  - ...etc

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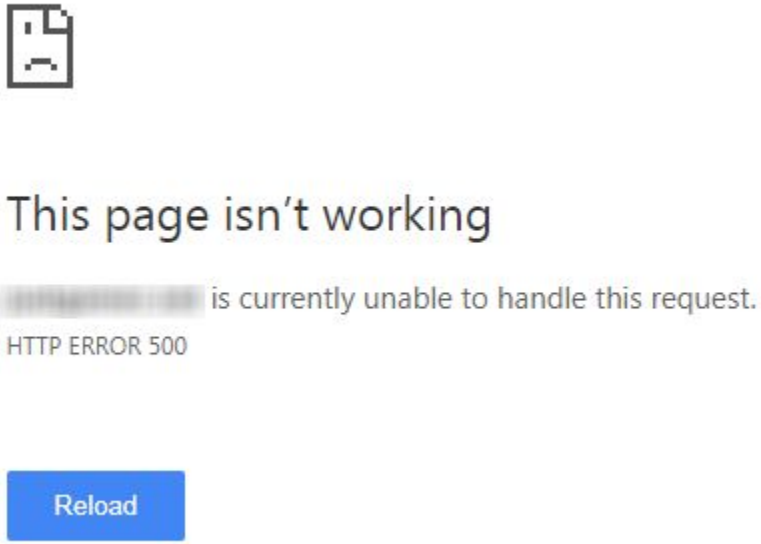

Introduction - Background & Related Work

- Automatic software repair
  - Monperrus, M. (2018). Automatic software repair: a bibliography. ACM Computing Surveys (CSUR), 51(1), 1-24.

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  - Behavioral repair
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    - Self-healing

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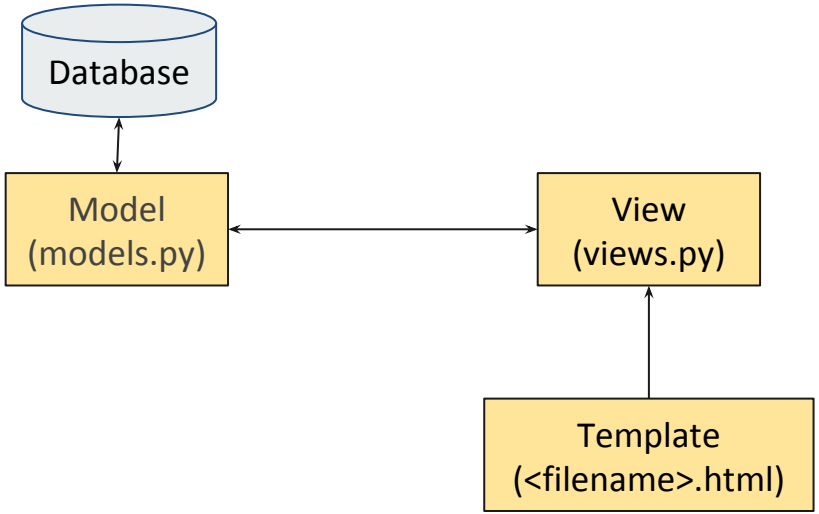
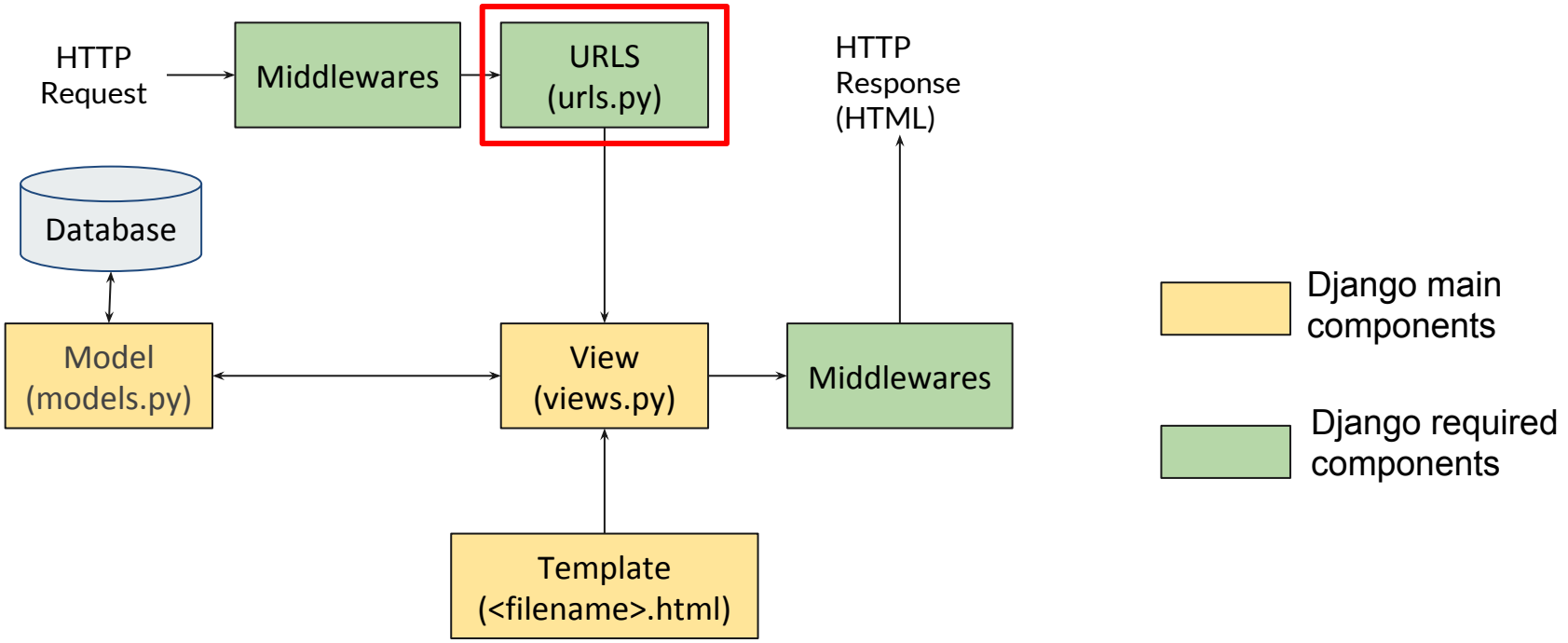
Introduction - Django

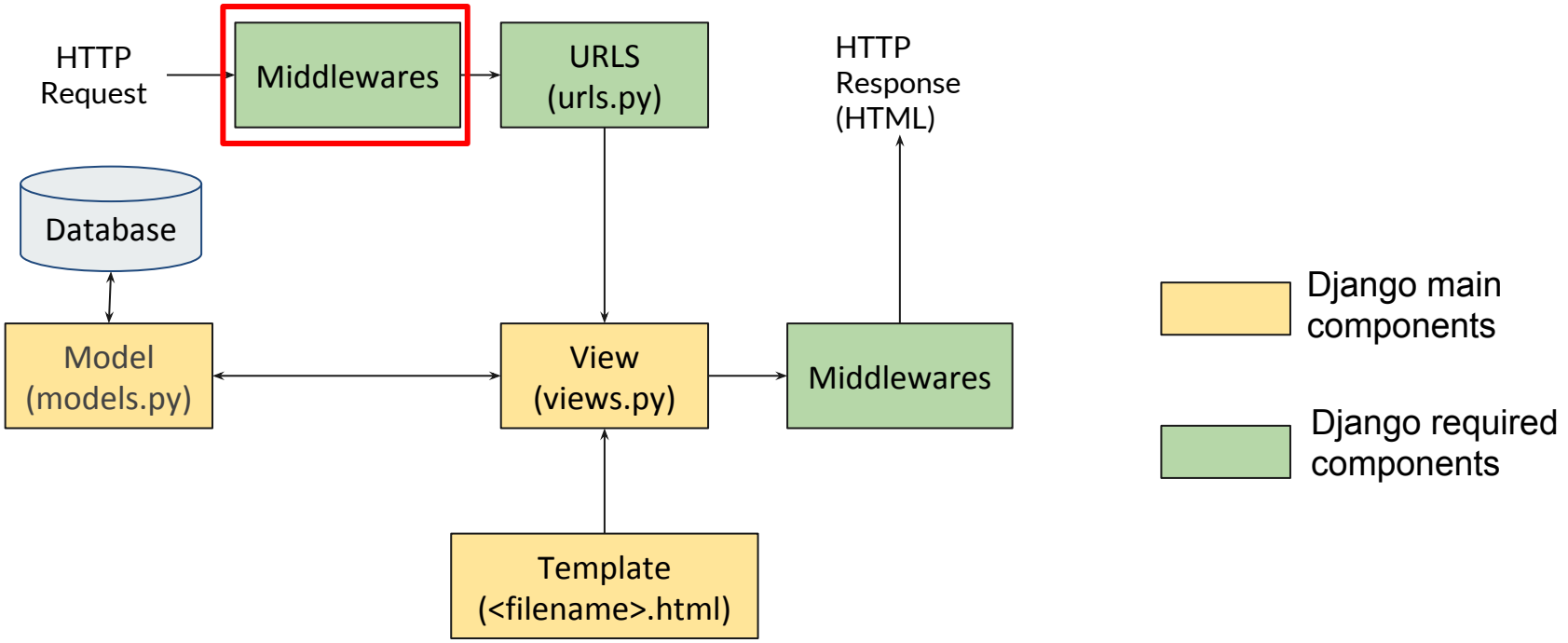


Django main components

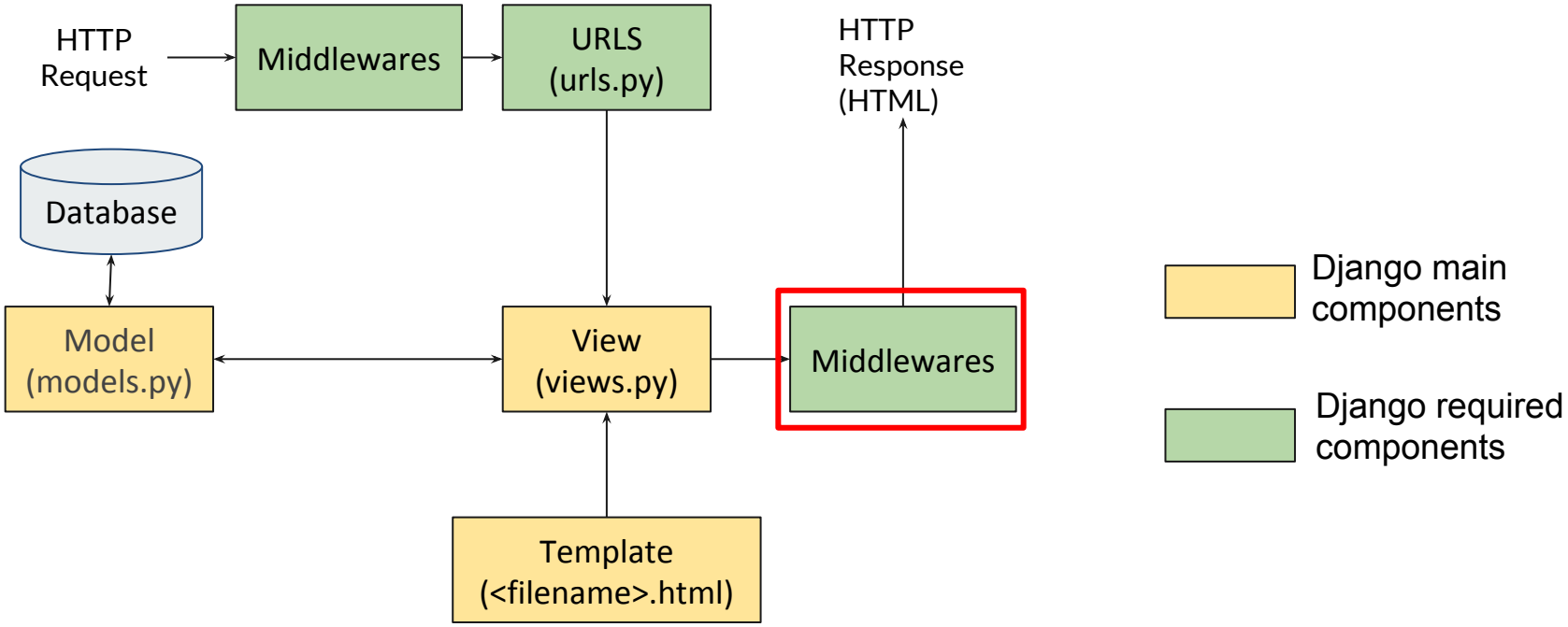
Introduction - Django



Introduction - Django



Introduction - Django



Introduction - Research Questions

1. What are the common errors in the current Django web framework?

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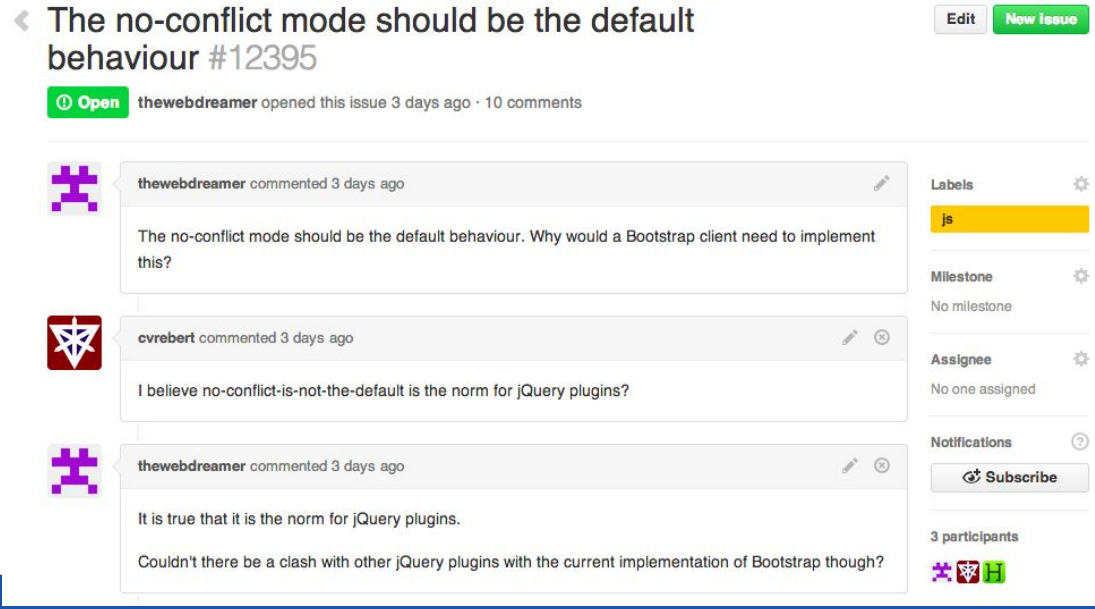
4. How to evaluate the self-healing prototype with respect to overhead?

Empirical Study - Protocol

- 16 Django popular projects (374~6,297 stars)

Empirical Study - Protocol

- 16 Django popular projects (374~6,297 stars)
- 19,442 issues



Empirical Study - Analysis

- 5 types of Django exception
  - URL Resolver exceptions
  - Http exceptions
  - Database exceptions
  - Transaction exceptions
  - Core exceptions

Empirical Study - Results

- Top 4 covers 57.35% issues

Exception Type	Exception	Frequency	Percentage
URL Resolver Exceptions	NoReverseMatch	44/265	16.6%
Database Exceptions	OperationalError	42/265	15.85%
Core Exceptions	ValidationError	38/265	14.33%
Database Exceptions	IntegrityError	28/265	10.57%

Design & Implementation - Architecture

1. Request monitor
2. Controller
3. Strategy executor
4. Strategy verifier

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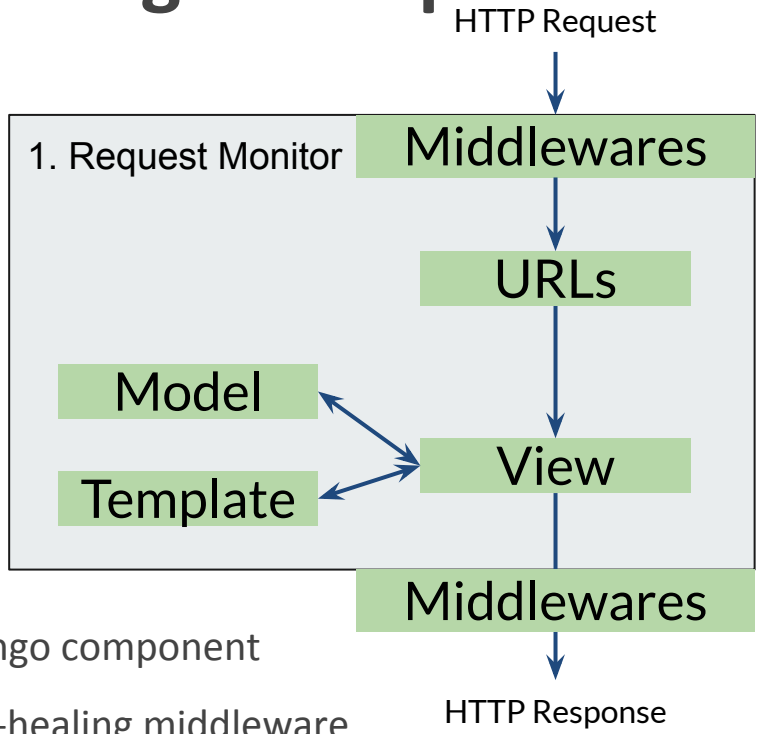
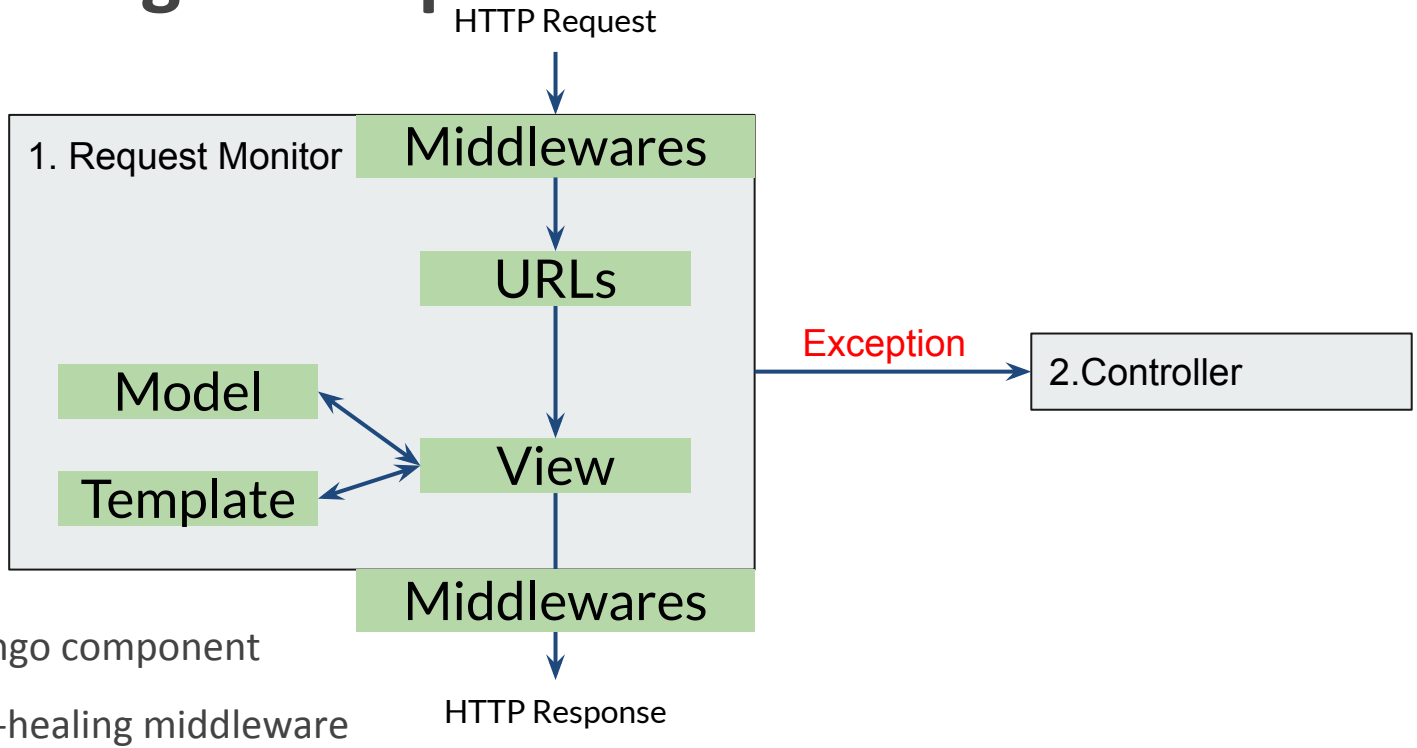
Design & Implementation - Workflow



django component

self-healing middleware component

Design & Implementation - Workflow



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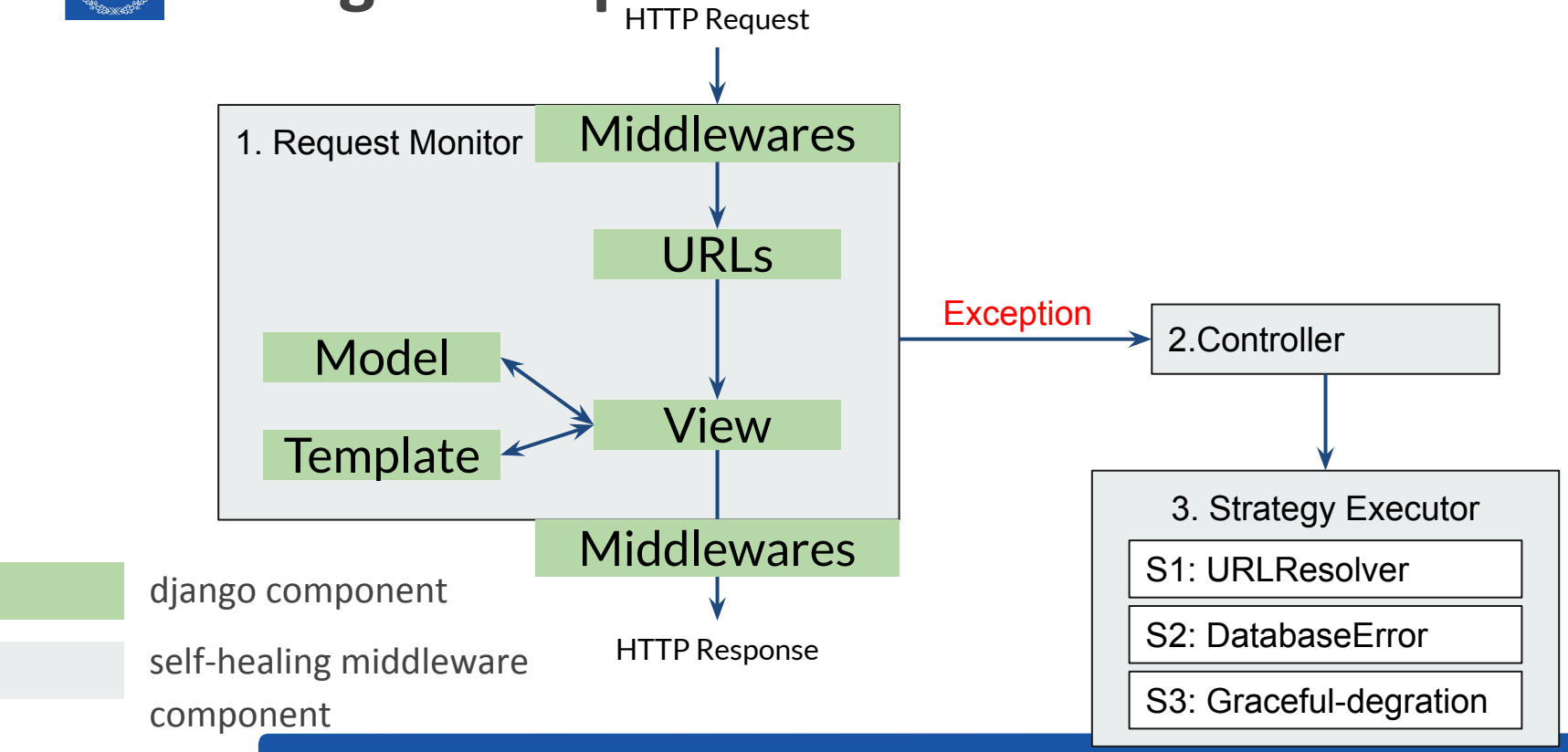

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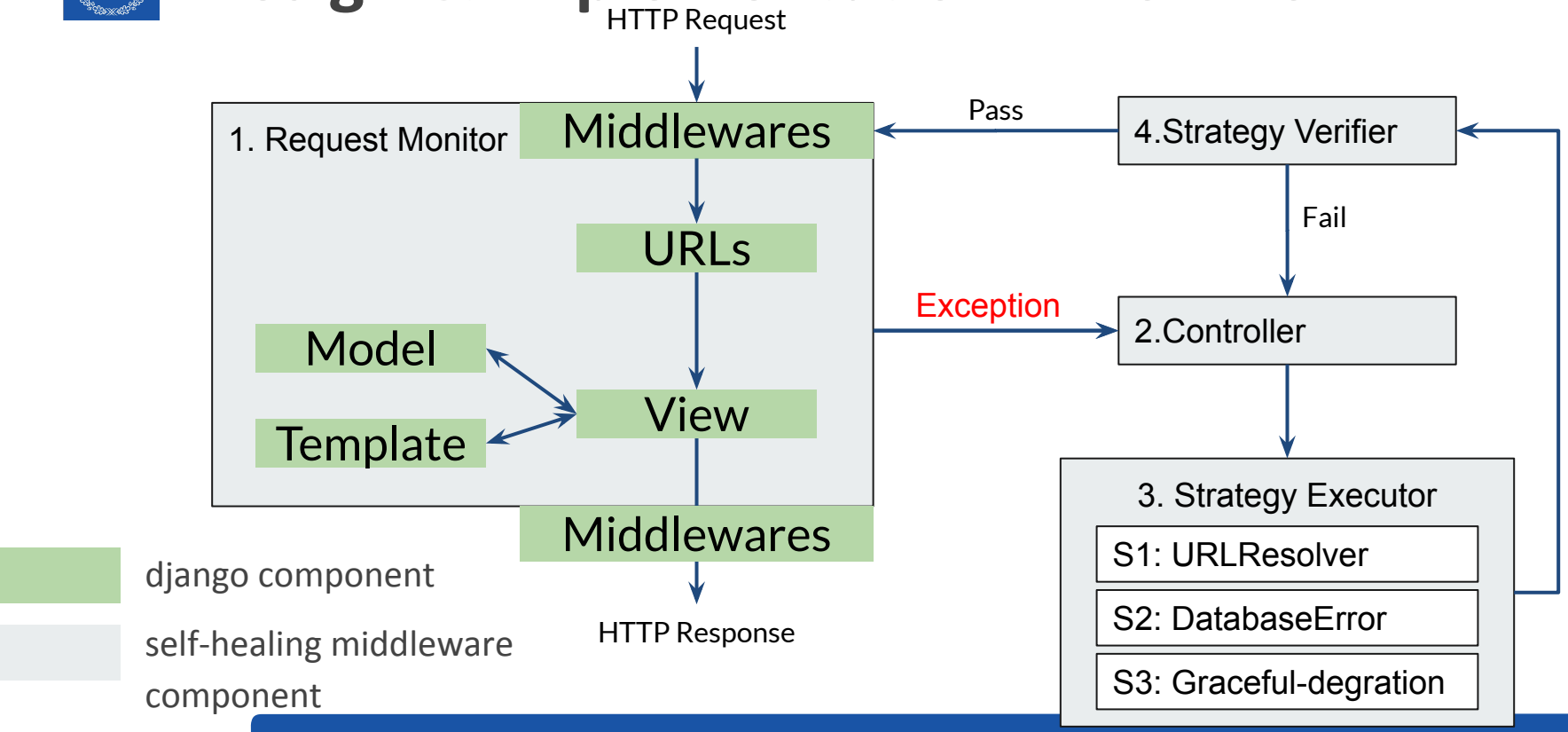
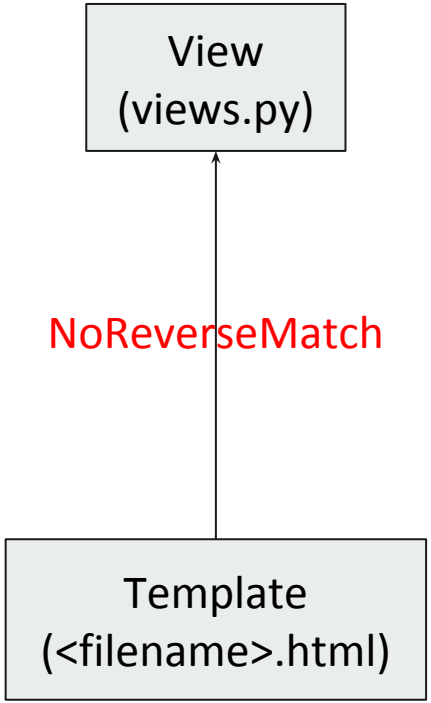


Design & Implementation - S1-URLResolver



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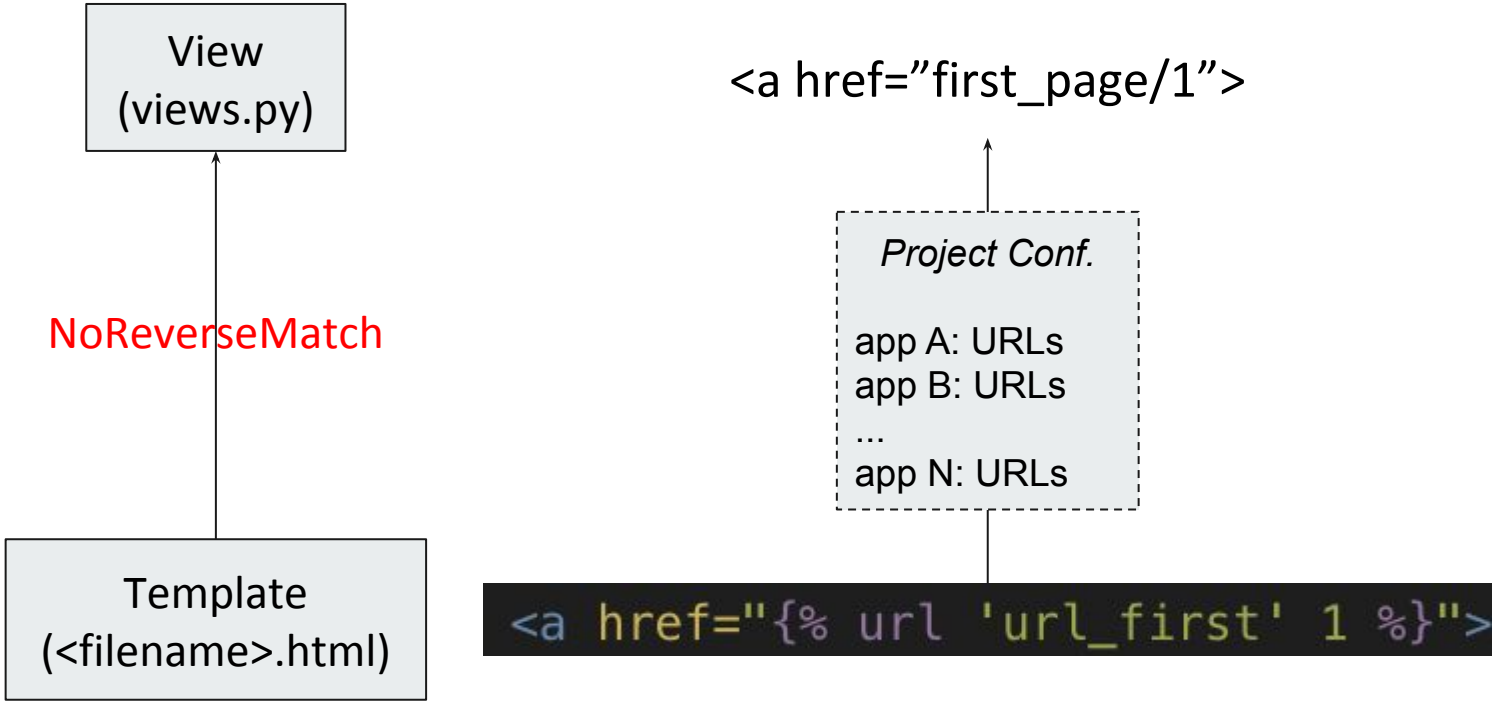

Design & Implementation - S1-URLResolver

Template Modification

Template (<filename>.html)

Configuration Modification

Project Conf.

app A: URLs
app B: URLs
...
app N: URLs

Design & Implementation - S2-DatabaseError

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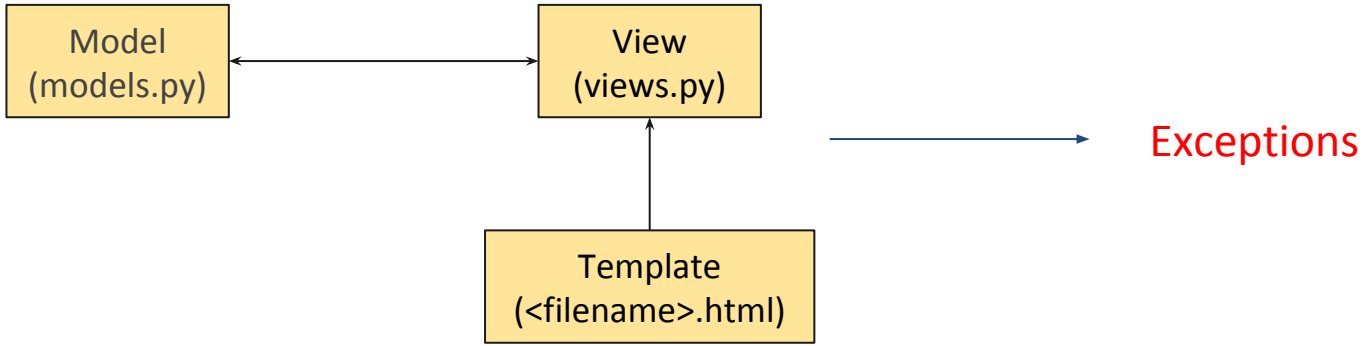
Name ***Unique key**	**Age** ***Cannot be null**
Peter	12
Kim	23

Name	**Age**
Peter	

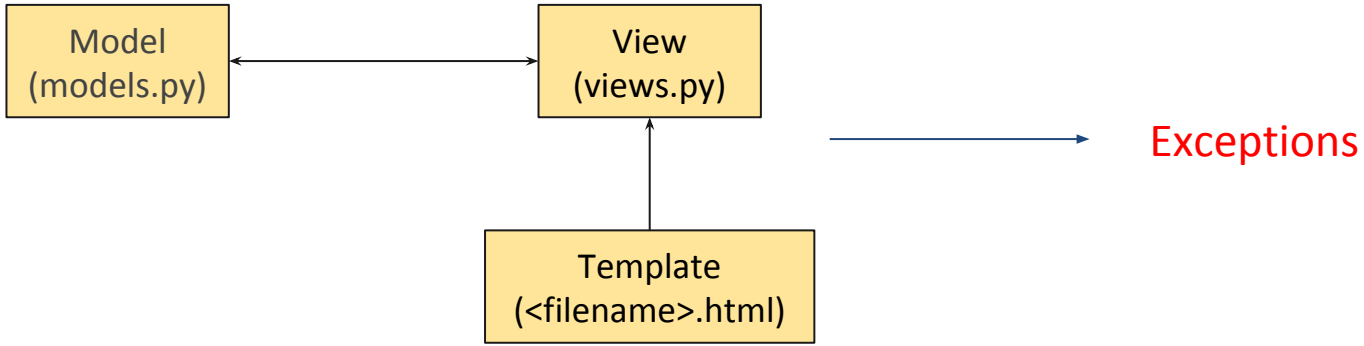
Design & Implementation - S2-DatabaseError

- Database migration
- Show error message page

Design & Impl. - S3-Graceful-degradation



Design & Impl. - S3-Graceful-degradation

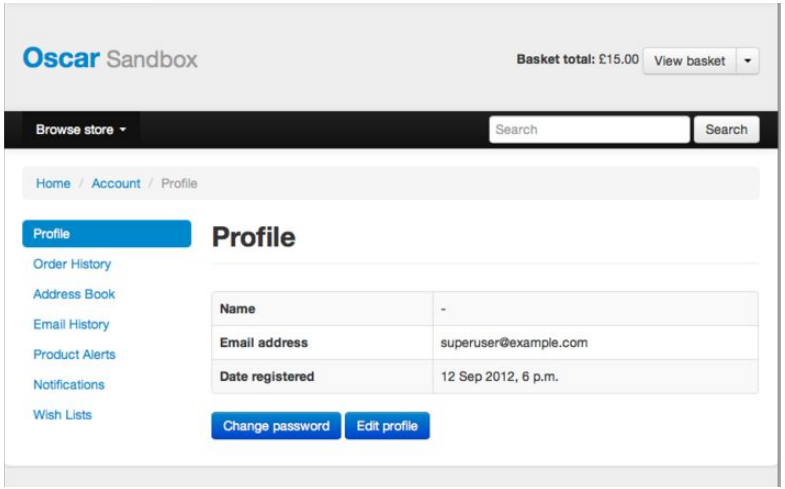


- Show home page
- Show last visited page
- Show error message page

Experiment - Projects

- blog-zinnia (1,897 stars)

- django-oscar (3,860 stars)



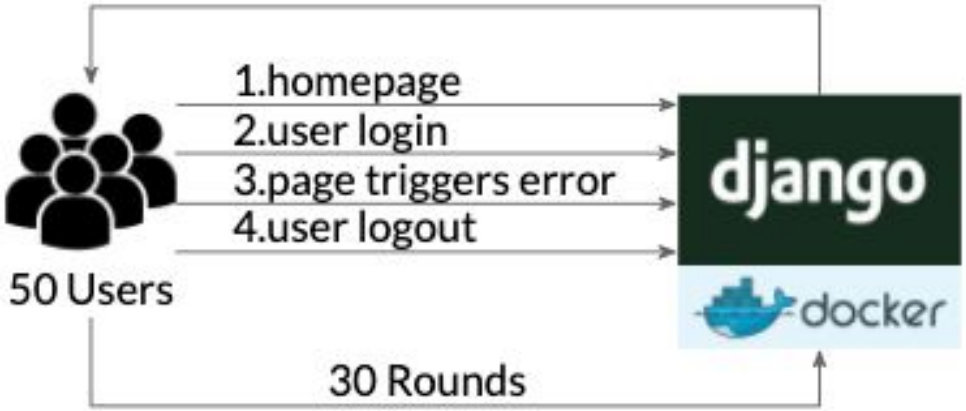
Experiment - Workload

- 50 Users
- 4 Action requests
  - home page
  - login
  - exception
  - logout
- 30 Rounds

Experiment - Workload

- Workload
  - 50 Users
  - 4 Requests
  - 30 Rounds
- 3 Experiments

- One experiment



Experiment - Metrics

Metrics	Indicator	Measured By
Effectiveness	Correctness	JMeter
Overhead	Response time	JMeter
	CPU Usage	cAdvisor
	Memory Usage	cAdvisor

cAdvisor

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Results - Correctness

SHM: self-healing middleware

Exception Type	Projects	Action Requests			
		Admin	**Login**	**Exception**	**Logout**
URL Resolver	blog-zinnia without SHM	100%	100%	0%	100%
DatabaseError	django-oscar without SHM	100%	29.65%	0%	88.34%

Results - Correctness

SHM: self-healing middleware

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	blog-zinnia with SHM	100%	100%	100%	100%
DatabaseError	django-oscar without SHM	100%	29.65%	0%	88.34%
	django-oscar with SHM	100%	27.11%	11.87%	88.73%

Results - Response Time (seconds)

SHM: self-healing middleware

Exception Type	Projects	Action Requests				
		Admin	**Login**	**Exception**	**Logout**	**Total Time**
URL Resolver	blog-zinnia without SHM	1.09	5.98	9.14	3.34	19.57
DatabaseError	django-oscar without SHM	3.74	8.02	2.28	10.79	24.83

Results - Response Time (seconds)

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		Admin	**Login**	**Exception**	**Logout**	**Total Time**
URL Resolver	blog-zinnia without SHM	1.09	5.98	9.14	3.34	19.57
	blog-zinnia with SHM	2.71	10.66	28.06	6.11	47.55
DatabaseError	django-oscar without SHM	3.74	8.02	2.28	10.79	24.83
	django-oscar with SHM	8.19	18.22	4.97	21.52	52.9

Results - CPU & Memory Usage

SHM: self-healing middleware

Exception	Projects	CPU (%)	Memory (%)
URL Resolver	blog-zinnia without SHM	64.5	10.31
	blog-zinnia with SHM	49.34	11.05
DatabaseError	django-oscar without SHM	73.23	11.37

Results - CPU & Memory Usage

SHM: self-healing middleware

Exception	Projects	CPU (%)	Memory (%)
URL Resolver	blog-zinnia without SHM	64.5	10.31
	blog-zinnia with SHM	49.34	11.05
DatabaseError	django-oscar without SHM	73.23	11.37
	django-oscar with SHM	99.58	26.76

Discussion - Research Questions

- RQ1: What are the common errors in the current Django web framework? Empirical study
- RQ2: How to design and implement self-healing strategies for Django web applications? Design & Implementation
- RQ3: How to evaluate the self-healing prototype with respect to effectiveness? Correctness
- RQ4: How to evaluate the self-healing prototype with respect to overhead? Resp. time, CPU, and memory usage

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Discussion - Limitation & Future Work

- Middleware position
- Self-healing strategies
- Correctness measurement

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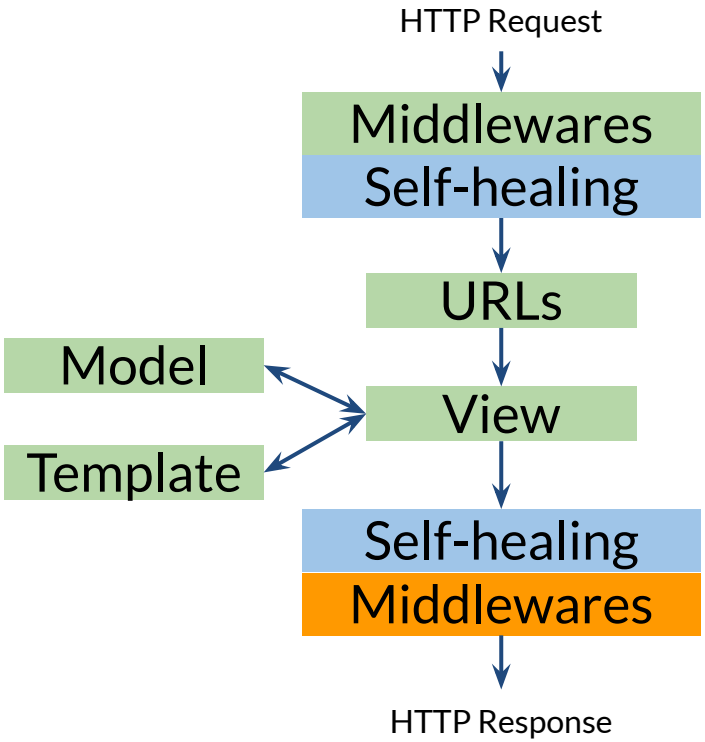

self-healing middleware

django components

cannot be caught

Conclusion

- First common Django errors
- First self-healing middleware for Django
- Open source