

# Automated Test Generation for REST APIs: No Time to Rest Yet

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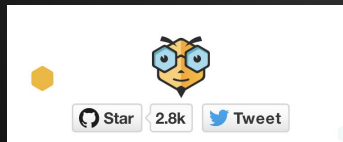
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# REST APIs are Widespread

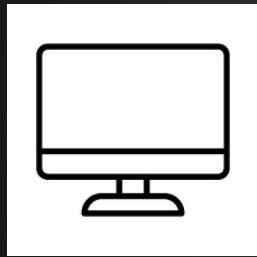


80% of APIs in the  
ProgrammableWeb repository  
are REST APIs

Modern web services using REST APIs



# What Are RESTful Services

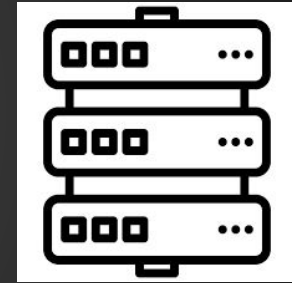


Client

Request



Response

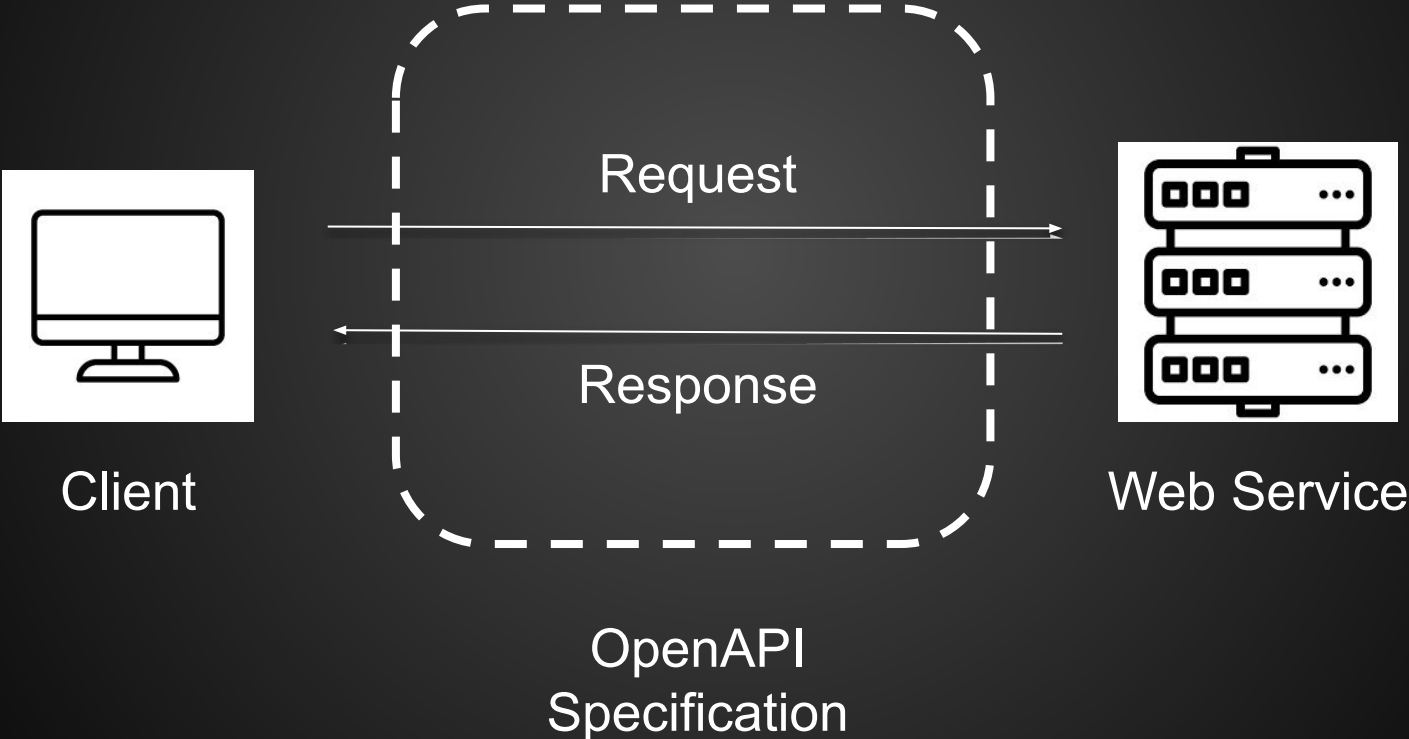


Web Service

# Resource Access Via REST APIs



# Resource Access Via REST APIs



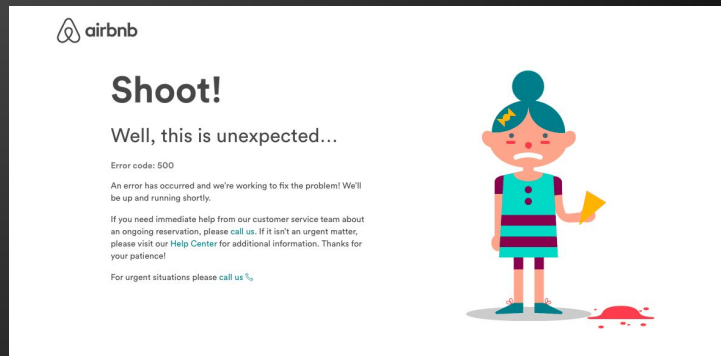
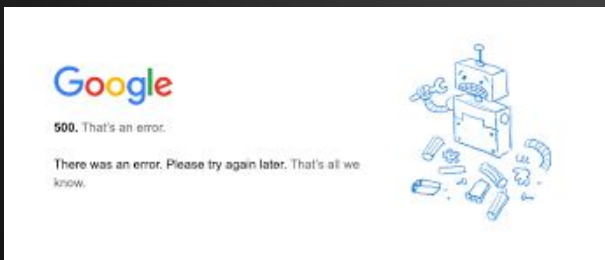
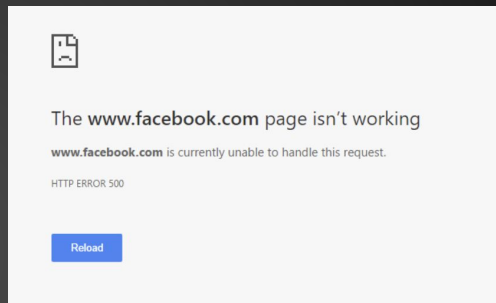
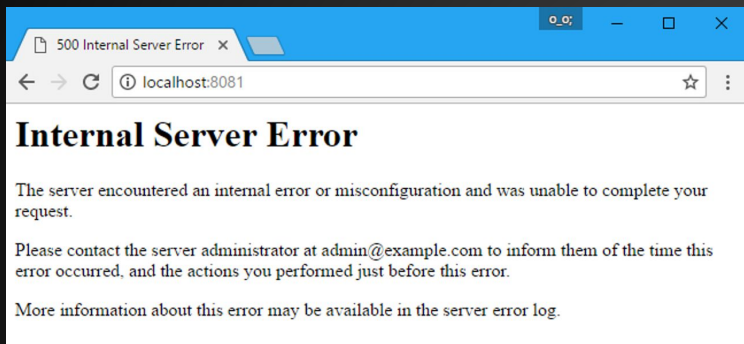
# OpenAPI Specification Example

```
1  "/products/{productName}": {           12    }],
2  "get": {                               13    "responses": {
3    "operationId":                       14      "200": {
4      "getProductByName",               15        "description":
5    "produces":                           16        "successful operation",
6      ["application/json"],             17        "schema": {
7    "parameters": [{                     18          "$ref":
8      "name": "productName",             19          "#/definitions/Product"
9      "in": "path",                       20        },
10     "required": true,                    21     "headers": {}
11     "type": "string"                     22   ]}}}]
```

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```

# REST API Failures





# REST API Testing

Automated REST API  
testing techniques



APIFuzzer

bBOXRT

Dredd

EvoMaster

RESTler

REStest

RestTestGen

Schemathesis

Tcases

...

## Problem

1. **Different** in many ways (types, strategies, oracles, etc.)
2. Evaluated on **different benchmarks** with **different metrics**
3. Hard to understand their **strengths** and **weaknesses**

# Our Empirical Study



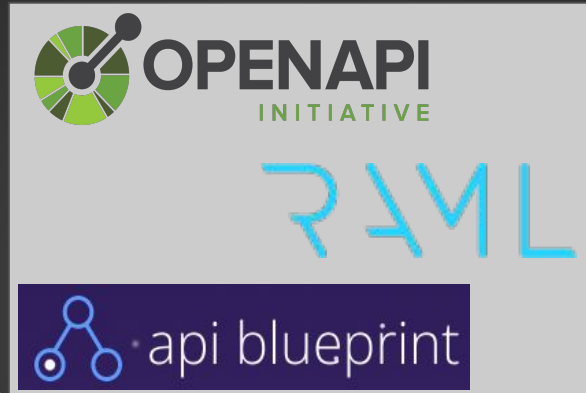
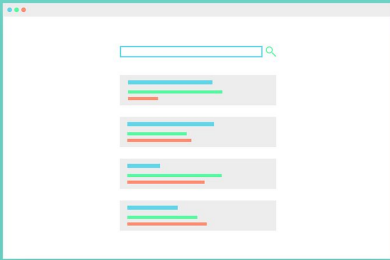
Compare state-of-the-art REST API testing tools in terms of **code coverage** and **bugs found** on a benchmark of **20 RESTful web services**



Analyze their **performance**, discuss **implications**, and present possible **improvements**

# Tools Selection

Keyword Search



RAML

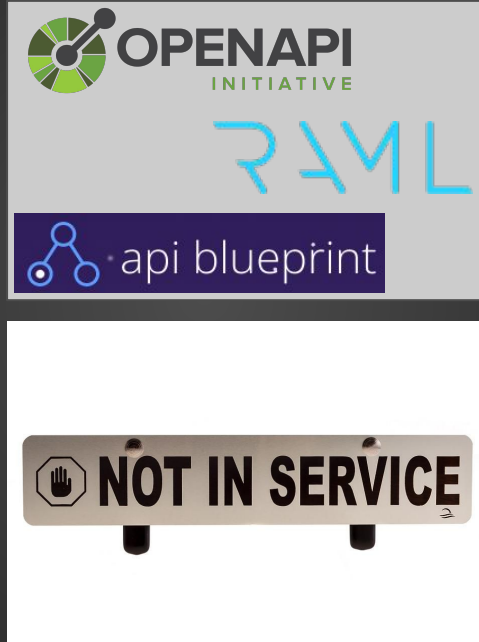


EvoMasterWB  
EvoMasterBB  
RESTler  
RestTestGen  
REStest  
Schemathesis  
Dredd  
Tcases  
bBOXRT  
APIFuzzer

# Services Selection



**bBOXRT**  
**EvoMaster**  
**REStest**



CWA-verification  
ERC-20 RESTful service  
Features-Service  
Genome Nexus  
Languagetool  
Market  
NCS  
News  
OCVN  
Person Controller  
Problem Controller  
Project tracking system  
ProxyPrint  
RESTful web service study  
Restcountries  
SCS  
Scout-API  
Spring boot sample app  
Spring-batch-rest  
User management



# Questions & Metrics



Q1: How much code coverage can the tools achieve?



Q2: How many error responses can the tools trigger?



Q3: What are the implications of our findings?

## Error Stack Trace

```
javax.servlet.ServletException: Something bad happened
    at com.example.myproject.OpenSessionInViewFilter.doFilter(OpenSessionInViewFilter.java:60)
    at org.mortbay.jetty.servlet.ServletHandler$CachedChain.doFilter(ServletHandler.java:1157)
    at com.example.myproject.ExceptionHandlerFilter.doFilter(ExceptionHandlerFilter.java:28)
    at org.mortbay.jetty.servlet.ServletHandler$CachedChain.doFilter(ServletHandler.java:1157)
    at com.example.myproject.OutputBufferFilter.doFilter(OutputBufferFilter.java:33)
    at org.mortbay.jetty.servlet.ServletHandler$CachedChain.doFilter(ServletHandler.java:1157)
    at org.mortbay.jetty.Server.handle(Server.java:326)
```

## Code Coverage



# Experiment Setup

- E2-standard-4 machines
- 2.2GHz Intel-Xeon processors and 16GB RAM
- 10 tools & 20 RESTful services
- Dependencies (e.g., DB and libraries)
- Clean up after each run
- 10 times run for one hour

# Results

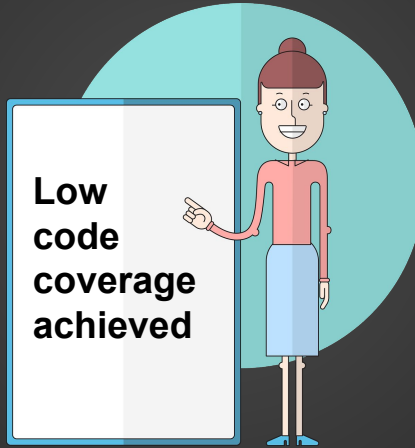
Tool	Line	Branch	Method	#500 (E/UFP/ULFP)
EvoMasterWB	52.76%	36.08%	52.86%	33.3 / 6.4 / 3.2
RESTler	35.44%	12.52%	40.03%	15.1 / 2.1 / 1.3
RestTestGen	40.86%	21.52%	42.31%	7.7 / 2 / 1
REStest	33.86%	18.26%	33.99%	7.2 / 1.9 / 1.1
bBOXRT	40.23%	22.20%	42.48%	9.5 / 2.1 / 1.3
Schemathesis	43.01%	25.29%	43.65%	14.2 / 2.8 / 2
Tcases	37.16%	16.29%	41.47%	18.5 / 3.5 / 2.1
Dredd	36.04%	13.80%	40.59%	6.9 / 1.5 / 0.9
EvoMasterBB	45.41%	28.21%	47.17%	16.4 / 3.3 / 1.8
APIFuzzer	32.19%	18.63%	33.77%	6.9 / 2.2 / 1.3



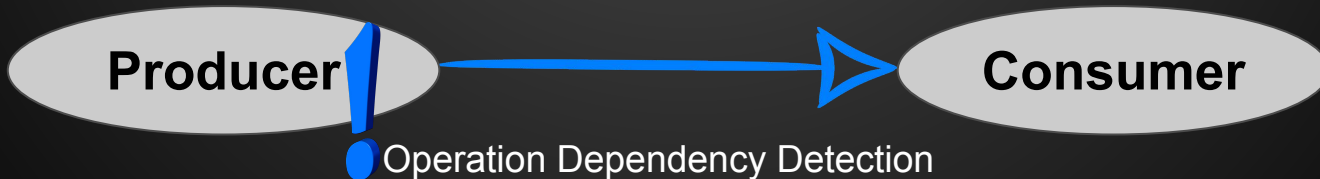
# RQ1: How Much Code Coverage Can the Tools Achieve?



! Mismatch between Specification and API



! Parameter Generation





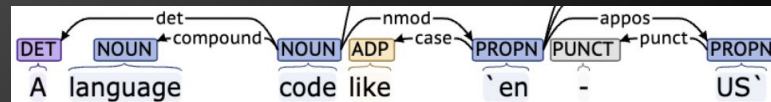
# RQ2: How Many Error Responses Can the Tools Trigger?

- WhiteBox vs BlackBox
- Parameter Generation Strategies
- Correlation
- Error Severity

# RQ3: What Are the Implications of Our Findings?



1. Better input parameter generation
2. Better support for stateful testing
3. Tools comparison



```
"name": "language",  
"in": "formData",  
"type": "string",  
"description": "A language code like `en-US`, `de-DE`, `fr`,  
or `auto` to guess the language automatically  
(see `preferredVariants` below). For languages with variants  
(English, German, Portuguese) spell checking will  
only be activated when you specify the variant,  
e.g. `en-GB` instead of just `en`.",  
"required": true
```

# Future Work

- Consider more REST services & testing tools
- Investigate the use of NLP-based techniques
- Extend our evaluation by using mutation
- Investigate the use of symbolic analysis