Load testing and functional testing with Taurus

Overview

Taurus is an open-source automation tool used for load and also functional testing.

Taurus acts as an abstraction layer on top of different load and functional tools, allowing users to easily maintain the YAML/JSON-based test scripts by storing them in the source control system.

Taurus can interact with JMeter, Gatling, Robot and other tools.

By using its CLI, Taurus can easily be integrated in the CI pipeline.

It can produce XML/CSV based reports or even Junit XML based reports. Reports can also be uploaded to Blazemeter where they can be analyzed in further extent.

Taurus provides a kind of SLA/SLO mechanism based on "pass/fail" criteria. Criteria can be defined based on typical load testing metrics (i.e. the "runtime criteria) and/or on the monitoring data obtained from the services running the target system. Thus, Taurus can be used as a way to extend JMeter, for example, and provide it advanced SLAs.

Requirements

- Taurus
- JMeter (installed automatically)
- Jenkins (optional)

Description

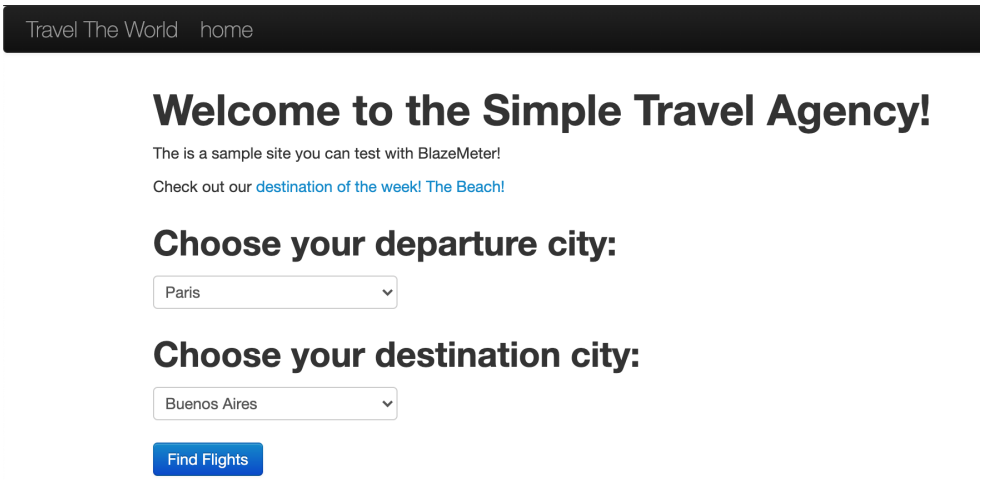
In the following example, we'll perform testing on a fictitious "Simple Travel Agency" site (kindly provided by BlazeMeter for demo purposes).

The overall approach to have visibility of the performance results in Xray will be as follows:

1. run Taurus in command line
2. generate multiple test reports
    a. standard results in CSV and XML formats
    b. custom JUnit XML report with additional info
3. submit results to Xray along with the previously generated report assets
    a. fill out the "Description" field of the corresponding created Test Execution issue with
        i. link to project/job in Jenkins
        ii. link to BlazeMeter report
        iii. summary results formatted as a table

Load testing example, with SLAs

In this example, we will load test the site.



The testing scenario exercises 10 users, with a ramp-up period of 40s, doing a (partial) reservation interaction: go to the site, and reserve a flight from Paris to Buenos Aires.

There are several "labels" (i.e. transactions), grouping one or more actions (i.e. HTTP requests). However, there are no explicit assertions.

The scenario itself and execution-related details are described in an YAML file.

execution.yml

```
---
execution:
- concurrency: 10
  hold-for: 2m
  ramp-up: 40s
  scenario: Thread Group
scenarios:
  Thread Group:
    requests:
    - label: blazedemo
      method: GET
      url: http://blazedemo.com/
    - body:
        fromPort: Paris
        toPort: Buenos Aires
      label: reserve
      method: POST
      url: http://blazedemo.com/reserve.php
```

Multiple reporting modules are configured to process the results. A custom module produces a JUnit XML report; this module is a customized variant over the standard junit-xml module.

passfail_config.yml

```
---
modules:
  custom-junit-xml:
    class: bitcoder.bzt.customreporting.JUnitXMLReporter

reporting:
- module: passfail
  criteria:
  - avg-rt>10ms for 7s, stop as failed
  - hits of reserve >10 for 13s, continue as failed
- module: custom-junit-xml
  filename: junit_report.xml
  data-source: pass-fail
  classname: bzt
- module: final-stats
  summary: true  # overall samples count and percent of failures
  percentiles: true  # display average times and percentiles
  summary-labels: true # provides list of sample labels, status, percentage of completed, avg time and errors
  failed-labels: true  # provides list of sample labels with failures
  test-duration: true  # provides test duration
  dump-xml: dump.xml
  dump-csv: dump.csv
- module: blazemeter
  report-name: Jenkins Build
  test: Taurus Demo
  project: Taurus
  upload-artifacts: true  # upload artifacts when test is finished
  browser-open: none  # can be "start", "end", "both", "none"
```

This modified custom-junit-xml module accepts one additional setting "classname" that can be used to customize the classname attribute on the target <testcase> elements of the XML report ; otherwise, "bzt" will be used. We can use to have an unique identifier such as "PurchaseUserPath".

The module also provides additional information that may be shown in Xray.

bitcoder/bzt/customreporting.py

```
"""
Basics of reporting capabilities

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distributed under the License is distributed on an "AS IS" BASIS,
WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
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limitations under the License.
"""
import copy
import csv
import locale
import os
import sys
import time
import pdb
from collections import Counter, OrderedDict
from datetime import datetime

from terminaltables import AsciiTable
```

```
from bzt import TaurusInternalException, TaurusConfigError
from bzt.engine import Reporter
from bzt.modules.aggregator import DataPoint, KPISet, AggregatorListener, ResultsProvider
from bzt.modules.blazemeter import BlazeMeterUploader, CloudProvisioning
from bzt.modules.functional import FunctionalAggregatorListener
from bzt.modules.passfail import PassFailStatus
from bzt.utils import etree, iteritems, get_full_path, is_windows

if is_windows():
    from terminaltables import AsciiTable as SingleTable
else:
    from terminaltables import SingleTable


class FinalStatus(Reporter, AggregatorListener, FunctionalAggregatorListener):
    """
    A reporter that prints short statistics on test end
    """

    def __init__(self):
        super(FinalStatus, self).__init__()
        self.last_sec = None
        self.cumulative_results = None
        self.start_time = time.time()  # default value
        self.end_time = time.time()
        self.first_ts = float("inf")
        self.last_ts = 0

    def startup(self):
        self.start_time = time.time()

    def prepare(self):
        super(FinalStatus, self).prepare()
        if isinstance(self.engine.aggregator, ResultsProvider):
            self.engine.aggregator.add_listener(self)
        elif self.engine.is_functional_mode():
            self.engine.aggregator.add_listener(self)

    def aggregated_second(self, data):
        """
        Just store the latest info

        :type data: bzt.modules.aggregator.DataPoint
        """
        self.first_ts = min(self.first_ts, data[DataPoint.TIMESTAMP])
        self.last_ts = max(self.last_ts, data[DataPoint.TIMESTAMP])
        self.last_sec = data

    def aggregated_results(self, results, cumulative_results):
        """
        Just store the latest info

        :type cumulative_results: bzt.modules.functional.ResultsTree
        :type results: bzt.modules.functional.ResultsTree
        """
        self.cumulative_results = cumulative_results

    def shutdown(self):
        self.end_time = time.time()

    def post_process(self):
        """
        Log basic stats
        """
        super(FinalStatus, self).post_process()

        if self.parameters.get("test-duration", True):
            self.__report_duration()

        if self.last_sec:
```

```
            summary_kpi = self.last_sec[DataPoint.CUMULATIVE][""]

            if self.parameters.get("summary", True):
                self.__report_samples_count(summary_kpi)
            if self.parameters.get("percentiles", True):
                self.__report_percentiles(summary_kpi)

            if self.parameters.get("summary-labels", True):
                self.__report_summary_labels(self.last_sec[DataPoint.CUMULATIVE])

            if self.parameters.get("failed-labels"):
                self.__report_failed_labels(self.last_sec[DataPoint.CUMULATIVE])

            if self.parameters.get("dump-xml"):
                self.__dump_xml(self.parameters.get("dump-xml"))

            if self.parameters.get("dump-csv"):
                self.__dump_csv(self.parameters.get("dump-csv"))
        elif self.cumulative_results:
            self.__report_summary()

            report_mode = self.parameters.get("report-tests", "failed")
            if report_mode == "failed":
                self.__report_failed_tests()
            else:
                self.__report_all_tests()

    def __plural(self, count, noun):
        return noun + 's' if count > 1 else noun

    def __report_all_tests(self):
        for test_suite in self.cumulative_results.test_suites():
            for case in self.cumulative_results.test_cases(test_suite):
                full_name = case.test_suite + "." + case.test_case
                self.log.info("Test %s - %s", full_name, case.status)
                print_trace = self.parameters.get("print-stacktrace", True)
                if print_trace and case.error_trace:
                    self.log.info("Stacktrace:\n%s", case.error_trace)

    def __report_failed_tests(self):
        for test_suite in self.cumulative_results.test_suites():
            for case in self.cumulative_results.test_cases(test_suite):
                if case.status in ("FAILED", "BROKEN"):
                    full_name = case.test_suite + "." + case.test_case
                    msg = "Test {test_case} failed: {error_msg}".format(test_case=full_name, error_msg=case.
error_msg)
                    if case.error_trace:
                        msg += "\n" + case.error_trace
                    self.log.warning(msg)

    def __report_summary(self):
        status_counter = Counter()
        for test_suite in self.cumulative_results.test_suites():
            for case in self.cumulative_results.test_cases(test_suite):
                status_counter[case.status] += 1

        # FIXME: it's actually not tests, but test cases
        total = sum(count for _, count in iteritems(status_counter))
        self.log.info("Total: %s %s", total, self.__plural(total, 'test'))

    def __report_samples_count(self, summary_kpi_set):
        """
        reports samples count
        """
        if summary_kpi_set[KPISet.SAMPLE_COUNT]:
            err_rate = 100 * summary_kpi_set[KPISet.FAILURES] / float(summary_kpi_set[KPISet.SAMPLE_COUNT])
            self.log.info("Samples count: %s, %.2f%% failures", summary_kpi_set[KPISet.SAMPLE_COUNT], err_rate)

    def __report_percentiles(self, summary_kpi_set):
        """
        reports percentiles
```

```
        """
        fmt = "Average times: total %.3f, latency %.3f, connect %.3f"
        self.log.info(fmt, summary_kpi_set[KPISet.AVG_RESP_TIME], summary_kpi_set[KPISet.AVG_LATENCY],
                      summary_kpi_set[KPISet.AVG_CONN_TIME])

        data = [("Percentile, %", "Resp. Time, s")]
        for key in sorted(summary_kpi_set[KPISet.PERCENTILES].keys(), key=float):
            data.append((float(key), summary_kpi_set[KPISet.PERCENTILES][key]))
            # self.log.info("Percentile %.1f%%: %.3f", )
        table = SingleTable(data) if sys.stdout.isatty() else AsciiTable(data)
        table.justify_columns[0] = 'right'
        table.justify_columns[1] = 'right'
        self.log.info("Percentiles:\n%s", table.table)

    def __report_failed_labels(self, cumulative):
        """
        reports failed labels
        """
        report_template = "%d failed samples: %s"
        sorted_labels = sorted(cumulative.keys())
        for sample_label in sorted_labels:
            if sample_label != "":
                failed_samples_count = cumulative[sample_label]['fail']
                if failed_samples_count:
                    self.log.info(report_template, failed_samples_count, sample_label)

    def __console_safe_encode(self, text):
        return text.encode(locale.getpreferredencoding(), errors='replace').decode('unicode_escape')

    def __get_sample_element(self, sample, label_name):
        failed_samples_count = sample['fail']
        success_samples_count = sample['succ']
        total_samples_count = failed_samples_count + success_samples_count
        assert total_samples_count > 0, "Total samples is zero for %s" % label_name
        success_samples_perc = (success_samples_count * 100) / total_samples_count

        errors = set()
        for err_desc in sample['errors']:
            errors.add(self.__console_safe_encode(err_desc["msg"]))

        return (
            self.__console_safe_encode(label_name),
            "FAIL" if failed_samples_count > 0 else "OK",
            "{0:.2f}%".format(round(success_samples_perc, 2)),
            "{0:.3f}".format(round(sample['avg_rt'], 3)),
            "\n".join(errors)
        )

    def __report_summary_labels(self, cumulative):
        data = [("label", "status", "succ", "avg_rt", "error")]
        justify = {0: "left", 1: "center", 2: "right", 3: "right", 4: "left"}

        sorted_labels = sorted(cumulative.keys())
        for sample_label in sorted_labels:
            if sample_label != "":
                data.append(self.__get_sample_element(cumulative[sample_label], sample_label))
        table = SingleTable(data) if sys.stdout.isatty() else AsciiTable(data)
        table.justify_columns = justify
        self.log.info("Request label stats:\n%s", table.table)

    def __report_duration(self):
        """
        asks executors start_time and end_time, provides time delta
        """
        date_start = datetime.fromtimestamp(int(self.start_time))
        date_end = datetime.fromtimestamp(int(self.end_time))
        self.log.info("Test duration: %s", date_end - date_start)

    def __dump_xml(self, filename):
        self.log.info("Dumping final status as XML: %s", filename)
        root = etree.Element("FinalStatus")
```

```
    if self.first_ts < float("inf") and self.last_ts > 0:
        duration_elem = etree.Element("TestDuration")
        duration_elem.text = str(round(float(self.last_ts - self.first_ts), 3))
        root.append(duration_elem)

    report_info = get_bza_report_info(self.engine, self.log)
    if report_info:
        link, _ = report_info[0]
        report_element = etree.Element("ReportURL")
        report_element.text = link
        root.append(report_element)
    if self.last_sec:
        for label, kpiset in iteritems(self.last_sec[DataPoint.CUMULATIVE]):
            root.append(self.__get_xml_summary(label, kpiset))

    with open(get_full_path(filename), 'wb') as fhd:
        tree = etree.ElementTree(root)
        tree.write(fhd, pretty_print=True, encoding="UTF-8", xml_declaration=True)

def __get_xml_summary(self, label, kpiset):
    elem = etree.Element("Group", label=label)
    for kpi_name, kpi_val in iteritems(kpiset):
        if kpi_name in (KPISet.ERRORS, KPISet.RESP_TIMES):
            continue

        if isinstance(kpi_val, dict):
            for param_name, param_val in iteritems(kpi_val):
                elem.append(self.__get_kpi_xml(kpi_name, param_val, param_name))
        else:
            elem.append(self.__get_kpi_xml(kpi_name, kpi_val))

    return elem

def __get_kpi_xml(self, kpi_name, kpi_val, param=None):
    kpi = etree.Element(kpi_name)
    kpi.attrib['value'] = self.__val_to_str(kpi_val)
    elm_name = etree.Element("name")
    elm_name.text = kpi_name
    if param is not None:
        kpi.attrib['param'] = self.__val_to_str(param)
        elm_name.text += "/" + param

    kpi.append(elm_name)

    elm_value = etree.Element("value")
    elm_value.text = self.__val_to_str(kpi_val)
    kpi.append(elm_value)

    return kpi

def __val_to_str(self, kpi_val):
    if isinstance(kpi_val, float):
        return '%.5f' % kpi_val
    elif isinstance(kpi_val, int):
        return '%d' % kpi_val
    elif isinstance(kpi_val, str):
        return kpi_val
    else:
        raise TaurusInternalException("Unhandled kpi type: %s" % type(kpi_val))

def __dump_csv(self, filename):
    self.log.info("Dumping final status as CSV: %s", filename)
    # FIXME: what if there's no last_sec
    with open(get_full_path(filename), 'wt') as fhd:
        fieldnames = self.__get_csv_dict('', self.last_sec[DataPoint.CUMULATIVE]['']).keys()
        writer = csv.DictWriter(fhd, fieldnames)
        writer.writeheader()
        for label, kpiset in iteritems(self.last_sec[DataPoint.CUMULATIVE]):
            writer.writerow(self.__get_csv_dict(label, kpiset))
```

```
    def __get_csv_dict(self, label, kpiset):
        kpi_copy = copy.deepcopy(kpiset)
        res = OrderedDict()
        res['label'] = label

        # sort label
        for key in sorted(kpi_copy.keys()):
            res[key] = kpi_copy[key]

        del res[KPISet.ERRORS]
        del res[KPISet.RESP_TIMES]
        del res[KPISet.RESP_CODES]
        del res[KPISet.PERCENTILES]

        percentiles = list(iteritems(kpiset[KPISet.PERCENTILES]))
        for level, val in sorted(percentiles, key=lambda lv: (float(lv[0]), lv[1])):
            res['perc_%s' % level] = val

        resp_codes = list(iteritems(kpiset[KPISet.RESP_CODES]))
        for rcd, val in sorted(resp_codes):
            res['rc_%s' % rcd] = val

        for key in res:
            if isinstance(res[key], float):
                res[key] = "%.5f" % res[key]

        return res


class JUnitXMLReporter(Reporter, AggregatorListener, FunctionalAggregatorListener):
    """
    A reporter that exports results in Jenkins JUnit XML format.
    """

    def __init__(self):
        super(JUnitXMLReporter, self).__init__()
        self.last_second = None
        self.report_file_path = None
        self.cumulative_results = None

    def prepare(self):
        if isinstance(self.engine.aggregator, ResultsProvider):
            self.engine.aggregator.add_listener(self)
        elif self.engine.is_functional_mode():
            self.engine.aggregator.add_listener(self)

    def aggregated_second(self, data):
        self.last_second = data

    def aggregated_results(self, _, cumulative_results):
        """
        :type cumulative_results: bzt.modules.functional.ResultsTree
        """
        self.cumulative_results = cumulative_results

    def post_process(self):
        """
        Get report data, generate xml report.
        """
        filename = self.parameters.get("filename", None)
        if not filename:
            filename = self.engine.create_artifact(XUnitFileWriter.REPORT_FILE_NAME, XUnitFileWriter.
REPORT_FILE_EXT)
        self.parameters["filename"] = filename  # reflect it in effective config

        #pdb.set_trace()
        if self.cumulative_results is None:
            test_data_source = self.parameters.get("data-source", "sample-labels")
            class_name = self.parameters.get("classname", "bzt")
            #pdb.set_trace()
```

```
        if test_data_source == "sample-labels":
            if not self.last_second:
                self.log.warning("No last second data to generate XUnit.xml")
            else:
                writer = XUnitFileWriter(self.engine, class_name)
                self.process_sample_labels(writer)
                writer.save_report(filename)
        elif test_data_source == "pass-fail":
            writer = XUnitFileWriter(self.engine, class_name)
            self.process_pass_fail(writer)
            writer.save_report(filename)
        else:
            raise TaurusConfigError("Unsupported data source: %s" % test_data_source)
    else:
        writer = XUnitFileWriter(self.engine, class_name)
        self.process_functional(writer)
        writer.save_report(filename)

    self.report_file_path = filename  # TODO: just for backward compatibility, remove later

def process_sample_labels(self, xunit):
    """
    :type xunit: XUnitFileWriter
    """
    xunit.report_test_suite('sample_labels')
    labels = self.last_second[DataPoint.CUMULATIVE]

    for key in sorted(labels.keys()):
        if key == "":  # skip total label
            continue

        errors = []
        for er_dict in labels[key][KPISet.ERRORS]:
            rc = str(er_dict["rc"])
            msg = str(er_dict["msg"])
            cnt = str(er_dict["cnt"])
            if er_dict["type"] == KPISet.ERRTYPE_ASSERT:
                err_element = etree.Element("failure", message=msg, type="Assertion Failure")
            else:
                err_element = etree.Element("error", message=msg, type="Error")
            err_desc = "%s\n(status code is %s)\n(total errors of this type: %s)" % (msg, rc, cnt)
            err_element.text = err_desc
            errors.append(err_element)

        #pdb.set_trace()
        duration = str(round(labels[key]['avg_rt'], 3))
        xunit.report_test_case('sample_labels', key, errors, duration)

def process_pass_fail(self, xunit):
    """
    :type xunit: XUnitFileWriter
    """
    xunit.report_test_suite('bzt_pass_fail')
    mods = self.engine.reporters + self.engine.services  # TODO: remove it after passfail is only reporter
    pass_fail_objects = [_x for _x in mods if isinstance(_x, PassFailStatus)]
    self.log.debug("Processing passfail objects: %s", pass_fail_objects)
    fail_criteria = []

    for pf_obj in pass_fail_objects:
        if pf_obj.criteria:
            for _fc in pf_obj.criteria:
                fail_criteria.append(_fc)

    for fc_obj in fail_criteria:
        if 'label' in fc_obj.config:
            data = (fc_obj.config['subject'], fc_obj.config['label'], fc_obj.config['condition'],
                    fc_obj.config['threshold'])
            tpl = "%s of %s%s%s"
        else:
            data = (fc_obj.config['subject'], fc_obj.config['condition'], fc_obj.config['threshold'])
            tpl = "%s%s%s"
```

```
            if fc_obj.config['timeframe']:
                tpl += " for %s"
                data += (fc_obj.config['timeframe'],)
            disp_name = tpl % data

            if fc_obj.is_triggered and fc_obj.fail:
                error = etree.Element("error", message=str(fc_obj), type="pass/fail criteria triggered")
                error.text = str(fc_obj)
                errors = [error]
            else:
                errors = ()

            #pdb.set_trace()
            # fc_obj.__dict__
            # fc_obj.label
            xunit.report_test_case('bzt_pass_fail', disp_name, errors)

    def process_functional(self, xunit):
        for suite_name, samples in iteritems(self.cumulative_results):
            duration = max(s.start_time for s in samples) - min(s.start_time for s in samples)
            duration += max(samples, key=lambda s: s.start_time).duration
            attrs = {
                "name": suite_name,
                "tests": str(len(samples)),
                "errors": str(len([sample for sample in samples if sample.status == "BROKEN"])),
                "skipped": str(len([sample for sample in samples if sample.status == "SKIPPED"])),
                "failures": str(len([sample for sample in samples if sample.status == "FAILED"])),
                "time": str(round(duration, 3)),
                # TODO: "timestamp" attribute
            }
            xunit.add_test_suite(suite_name, attributes=attrs)
            for sample in samples:
                attrs = {
                    "classname": sample.test_suite,
                    "name": sample.test_case,
                    "time": str(round(sample.duration, 3))
                }
                children = []
                if sample.status == "BROKEN":
                    error = etree.Element("error", type=sample.error_msg)
                    if sample.error_trace:
                        error.text = sample.error_trace
                    children.append(error)
                elif sample.status == "FAILED":
                    failure = etree.Element("failure", message=sample.error_msg)
                    if sample.error_trace:
                        failure.text = sample.error_trace
                    children.append(failure)
                elif sample.status == "SKIPPED":
                    skipped = etree.Element("skipped")
                    children.append(skipped)
                xunit.add_test_case(suite_name, attributes=attrs, children=children)


def get_bza_report_info(engine, log):
    """
    :return: [(url, test), (url, test), ...]
    """
    result = []
    if isinstance(engine.provisioning, CloudProvisioning):
        cloud_prov = engine.provisioning
        test_name = cloud_prov.settings.get("test")
        report_url = cloud_prov.results_url
        result.append((report_url, test_name if test_name else report_url))
    else:
        bza_reporters = [_x for _x in engine.reporters if isinstance(_x, BlazeMeterUploader)]
        for bza_reporter in bza_reporters:
            if bza_reporter.results_url:
                test_name = bza_reporter.parameters.get("test")
                report_url = bza_reporter.results_url
                result.append((report_url, test_name if test_name else report_url))
```

```
        if len(result) > 1:
            log.warning("More than one blazemeter reporter found")
    return result


class XUnitFileWriter(object):
    REPORT_FILE_NAME = "xunit"
    REPORT_FILE_EXT = ".xml"

    def __init__(self, engine, class_name):
        """
        :type engine: bzt.engine.Engine
        """
        super(XUnitFileWriter, self).__init__()
        self.engine = engine
        self.log = engine.log.getChild(self.__class__.__name__)
        self.test_suites = OrderedDict()
        bza_report_info = get_bza_report_info(engine, self.log)
        self.class_name = class_name  #bza_report_info[0][1] if bza_report_info else "bzt-" + str(self.
__hash__())
        self.report_urls = ["BlazeMeter report link: %s\n" % info_item[0] for info_item in bza_report_info]

    def save_report(self, fname):
        """
        :type fname: str
        """
        try:
            if os.path.exists(fname):
                self.log.warning("File %s already exists, it will be overwritten", fname)
            else:
                dirname = os.path.dirname(fname)
                if dirname and not os.path.exists(dirname):
                    os.makedirs(dirname)

            testsuites = etree.Element("testsuites")
            for _, suite in iteritems(self.test_suites):
                testsuites.append(suite)
            etree_obj = etree.ElementTree(testsuites)

            self.log.info("Writing JUnit XML report into: %s", fname)
            with open(get_full_path(fname), 'wb') as _fds:
                etree_obj.write(_fds, xml_declaration=True, encoding="UTF-8", pretty_print=True)
        except BaseException:
            raise TaurusInternalException("Cannot create file %s" % fname)

    def report_test_suite(self, suite_name):
        """
        :type suite_name: str
        :type children: list[lxml.etree.Element]
        """
        self.add_test_suite(suite_name, attributes={"name": suite_name, "package_name": "bzt"})

    def report_test_case(self, suite_name, case_name, children=None, duration=None):
        """
        :type suite_name: str
        :type case_name: str
        :type children: list[lxml.etree.Element]
        """
        children = children or []
        if self.report_urls:
            system_out = etree.Element("system-out")
            system_out.text = "".join(self.report_urls)
            children.insert(0, system_out)
        if duration is not None:
            self.add_test_case(suite_name, attributes={"classname": self.class_name, "name": case_name, "time":
duration}, children=children)
        else:
            self.add_test_case(suite_name, attributes={"classname": self.class_name, "name": case_name},
children=children)
```

```
def add_test_suite(self, suite_name, attributes=None, children=()):
    attributes = attributes or {}

    suite = etree.Element("testsuite", **attributes)

    for child in children:
        suite.append(child)

    if not suite_name in self.test_suites:
        self.test_suites[suite_name] = suite

def add_test_case(self, suite_name, attributes=None, children=()):
    attributes = attributes or {}

    case = etree.Element("testcase", **attributes)

    for child in children:
        case.append(child)

    self.test_suites[suite_name].append(case)
```

Test scenarios can be run using the command line **`bzt`** tool.

We'll use Jenkins as our CI tool and we'll configure a freestyle project for performing our load testing.

Please note

If we aim to send the reports to BlazeMeter, we need to configure the API token used by Taurus' `bzt`. Instead of hard-coding this in Taurus configuration files, it can be set on the Jenkins user' home settings (more info here).

~/.bzt-rc

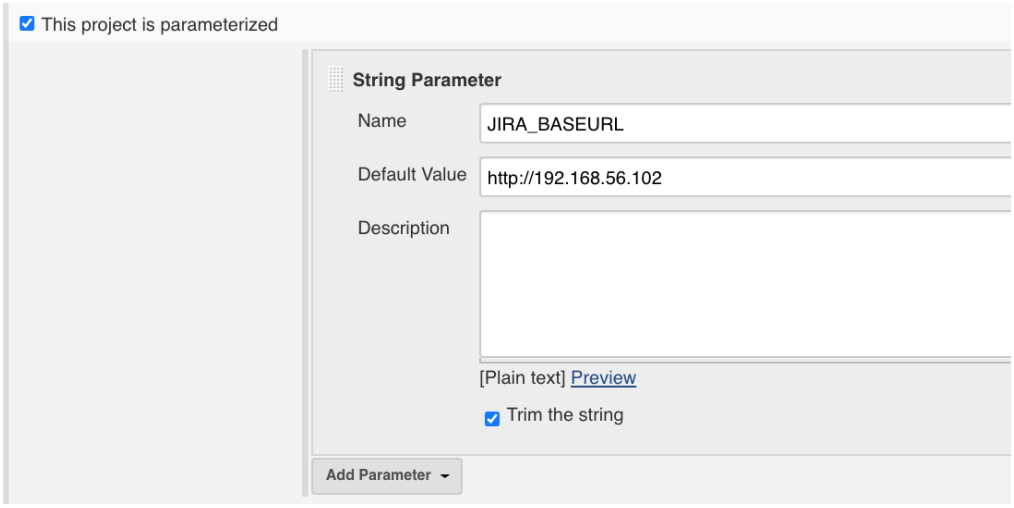
```
# BlazeMeter reporting settings
#modules:
#  blazemeter:
#    token: <key id>:<key secret>  # API id and API secret joined with ':'


modules:
  blazemeter:
    token: 22321b40xxxxxx:d1d3abcb97xxxxxxxxxxxxxxxxxxxxxxxxxxxx
    public-report: true
```

Setup: checking out the JMeter project and setup of auxiliary variables

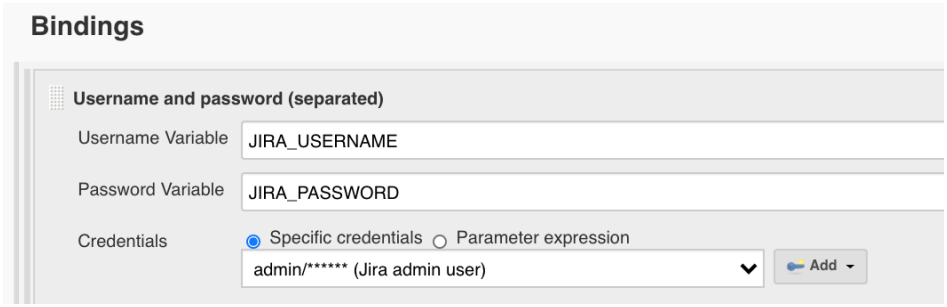
We need to setup some variables related to the Jira instance to be able to attach some files to the Test Execution issue later on, if we want to, using the `attach_files_to_issue.sh` shell script.

These are somehow redundant with the Xray instance configuration but are necessary if we wish to expose them.

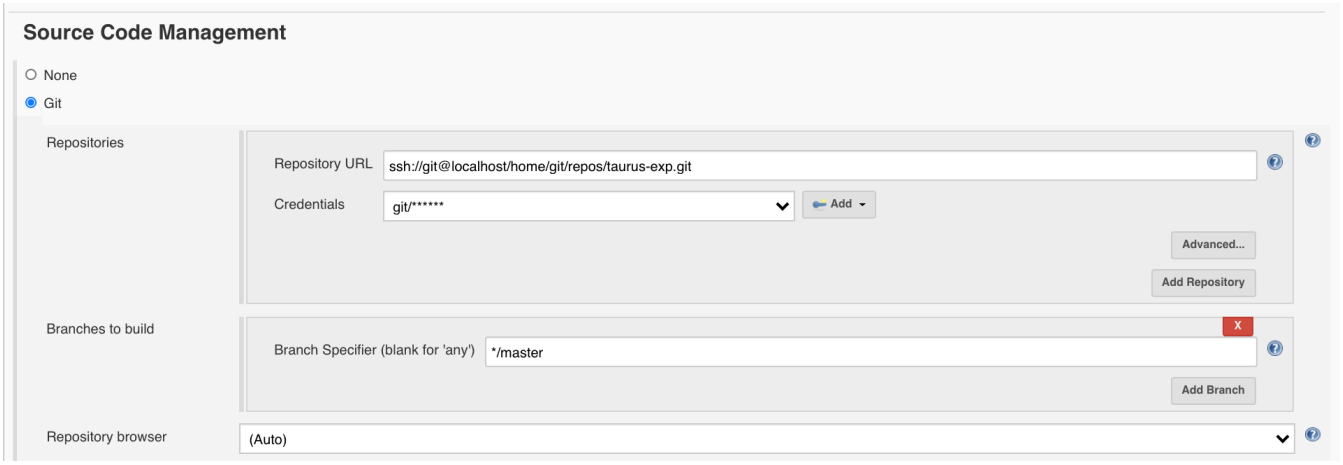
We start by defining one variable for the Jira server base URL as build pararameter.



Using the Credentials Binding plugin, we will populate two variables for the Jira instance's username and password; these will be, in turn, obtained from the credentials already stored and linked to the Xray instance configuration in Jenkins.



The "code" will be checked out from our source code versioning system (e.g. Git), which contain the Taurus configuration files along with some additional scripts.



Configuring the Build steps

The "build" is composed of several steps, starting with the one that runs Taurus.

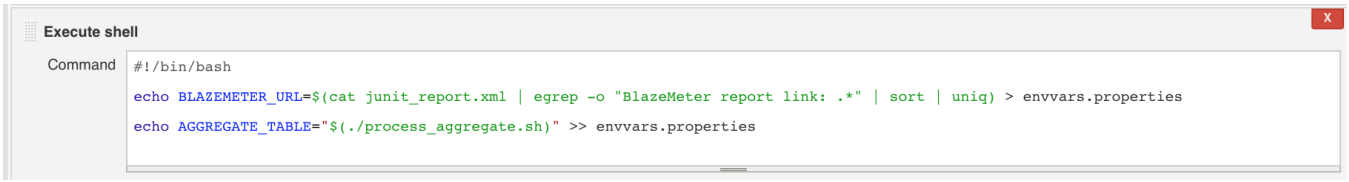
Here we may decide to enforce the build step as successful, as shown in the screenshot, or let it fail or not depending on the load testing results. The latter would require to define the additional build steps as post-actions though.

We'll store the artifact inside the directory `artifacts`. We'll also customize the report name in BlazeMeter so that it contains the Jenkins build number.

./run3.sh

```
#!/bin/bash
bzt -v -o settings.artifacts-dir=artifacts  examples/3/execution.yml examples/3/passfail_config.yml -o modules.
blazemeter.report-name="Jenkins Build ${BUILD_NUMBER}"
```

Optionally, we'll add two build steps to store the tabular aggregate report in an environment variable (e.g. AGGREGATE_TABLE) as a string. This requires the Environment Injector plugin.



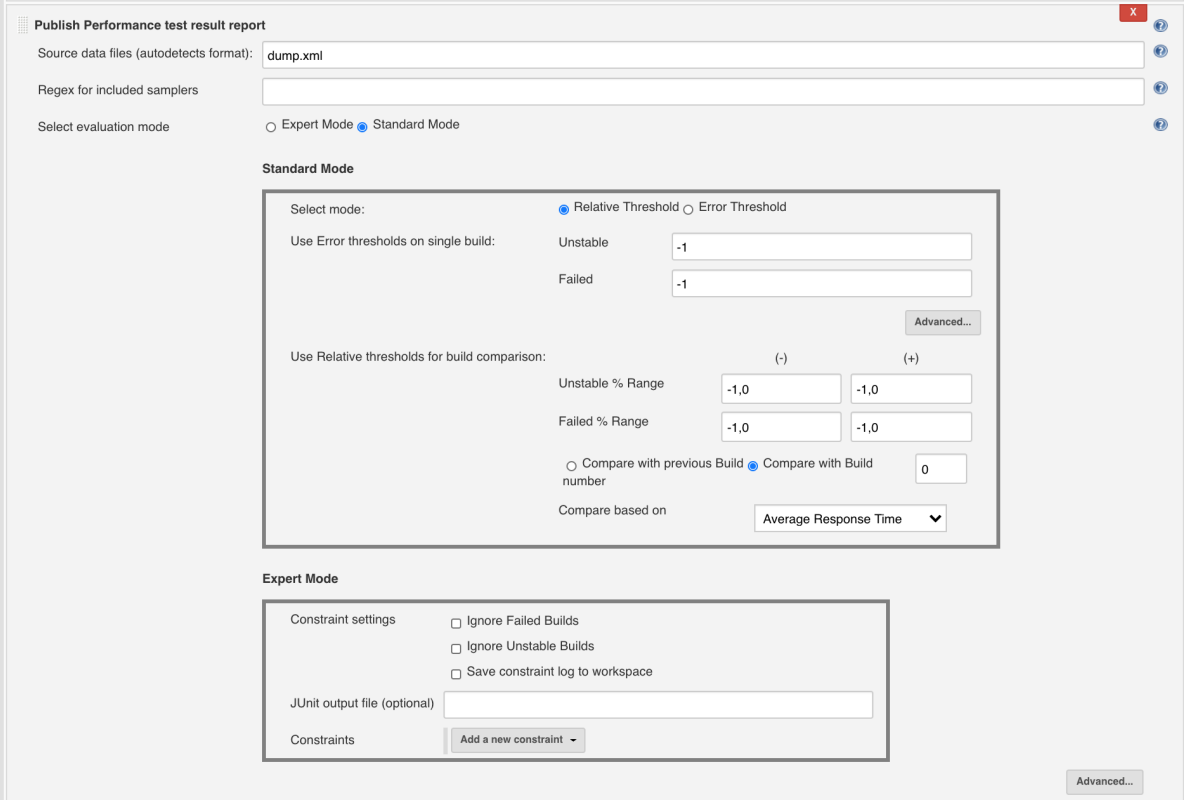
./process_aggregate.sh

```
#!/bin/bash

cat dump.csv  |sed -e 's/^,/TOTAL,/g' | tr "," "|" | sed -e 's/^/|/' | sed -e 's/\r$/|\\\\n\\/' | sed -e '1 s/|
/||/g'
```

Configuring the Post-build actions

Bonus tip!

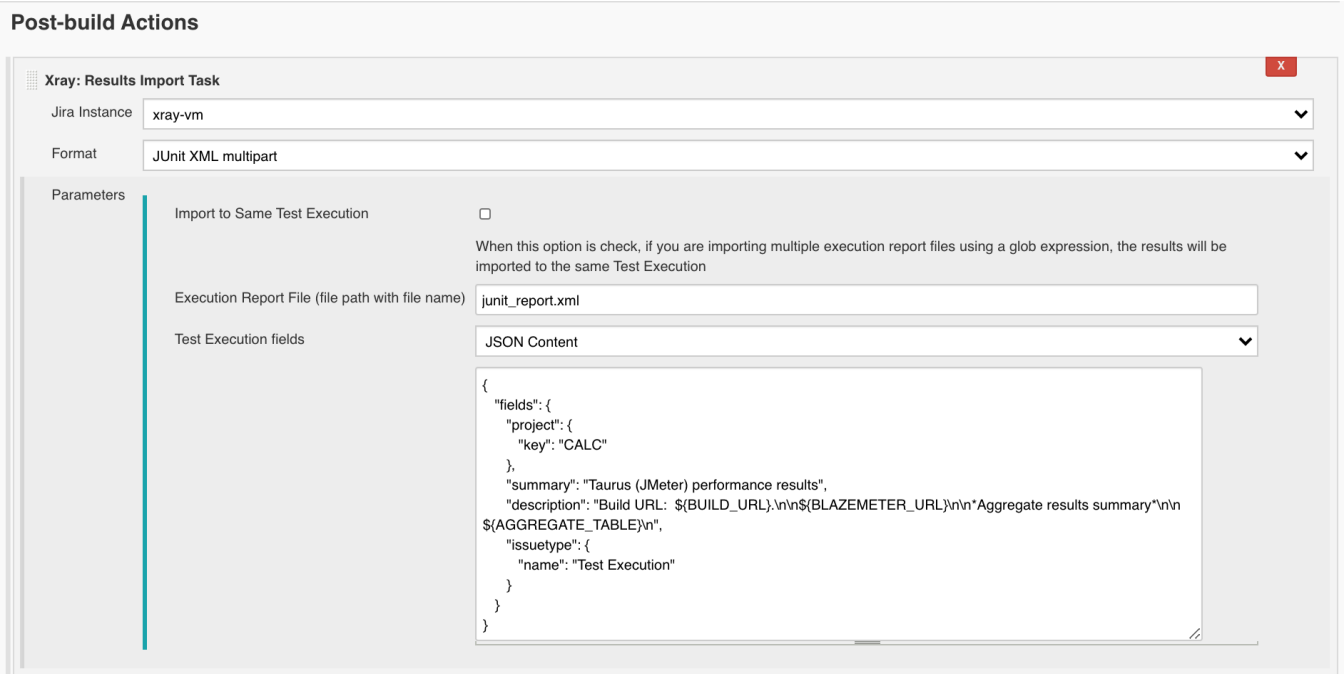
The Jenkins' Performance plugin can optionally be used to create some trend charts in Jenkins and also as means to mark the build as failed or unstable depending on absolute or relative thresholds.



Test results can be submitted to Xray either by using a command line tool (e.g. `curl`) or by using a specific CI plugin which in our case will be the "Xray – Test Management for Jira Plugin".

We could choose the "JUnit XML" as the format in the "Xray: Results Import Task", that would be simpler to setup.

However, if we use the "JUnit XML multipart" format, we can further customize the Test Execution issue. We'll use this as means to provide a link to the Jenkins build along with a link to more in-depth details at BlazeMeter site. We may also provide the aggregate report table stored previously as an environment variable.



If using this format, you'll need to provide the Test Execution's issue type name (or the id) and the project key.

Test Execution fields (JSON content) - example1

```
{
   "fields": {
      "project": {
         "key": "CALC"
      },
      "summary": "Taurus (JMeter) performance results",
      "description": "Build URL:  ${BUILD_URL}.\n\n${BLAZEMETER_URL}\n\n*Aggregate results summary*\n\n
${AGGREGATE_TABLE}\n",
      "issuetype": {
         "name": "Test Execution"
      }
   }
}
```

You may also specify the Test Plan, Revision and Test Environments fields but you'll need to obtain their custom field ID from Jira's administration. Note that these IDs are specific to each Jira instance. In the following example, "customfield_10033" corresponds to the Revision CF, "customfield_11805" to the Test Environments CF and "customfield_11807" to the Test Plan CF.

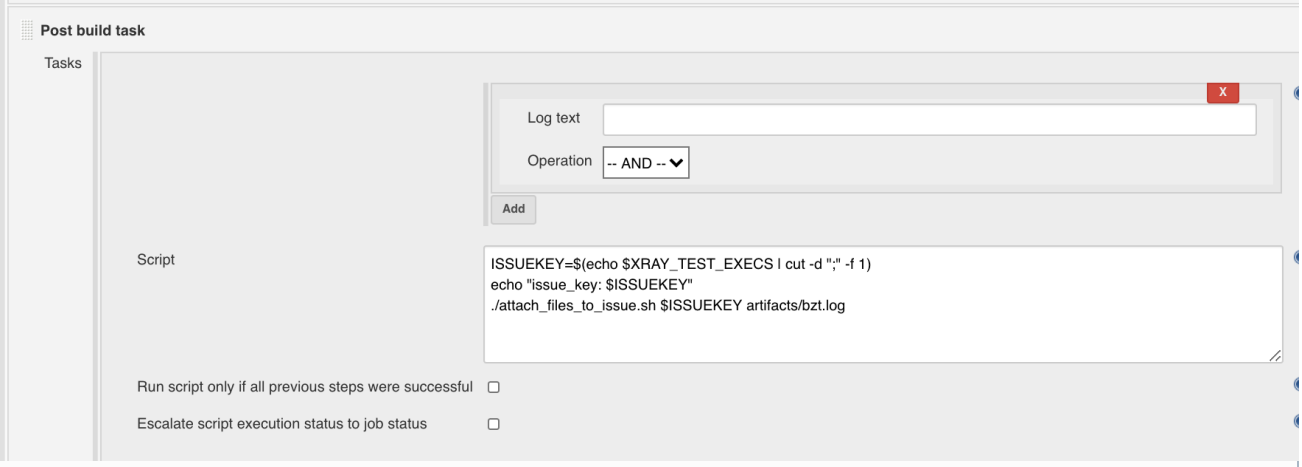
Test Execution fields (JSON content) - example2

```
{
   "fields": {
      "project": {
         "key": "CALC"
      },
      "summary": "Taurus (JMeter) performance results",
      "description": "Build URL:  ${BUILD_URL}.\n\n${BLAZEMETER_URL}\n\n*Aggregate results summary*\n\n
${AGGREGATE_TABLE}\n",
      "issuetype": {
         "name": "Test Execution"
      },
      "customfield_10033": "123",
          "customfield_11805" : [
            "staging"
      ],
      "customfield_11807": [
         "CALC-1200"
      ]

   }
}
```

Bonus tip!

You may also attach some files (e.g. logs, reports) to the created Test Execution issue.

The Jenkins plugin exports the XRAY_TEST_EXECS variable containing the issue key of the Test Execution that was created.

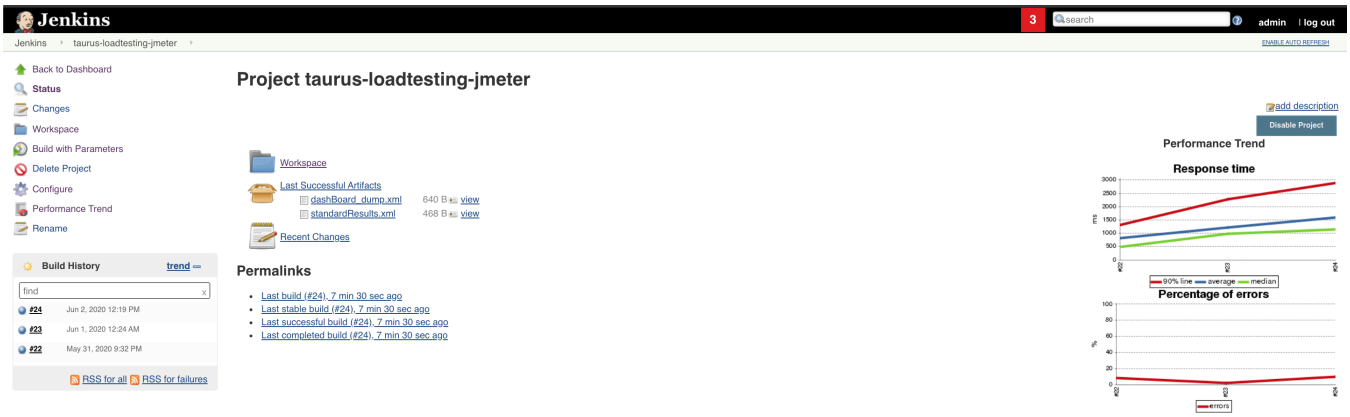


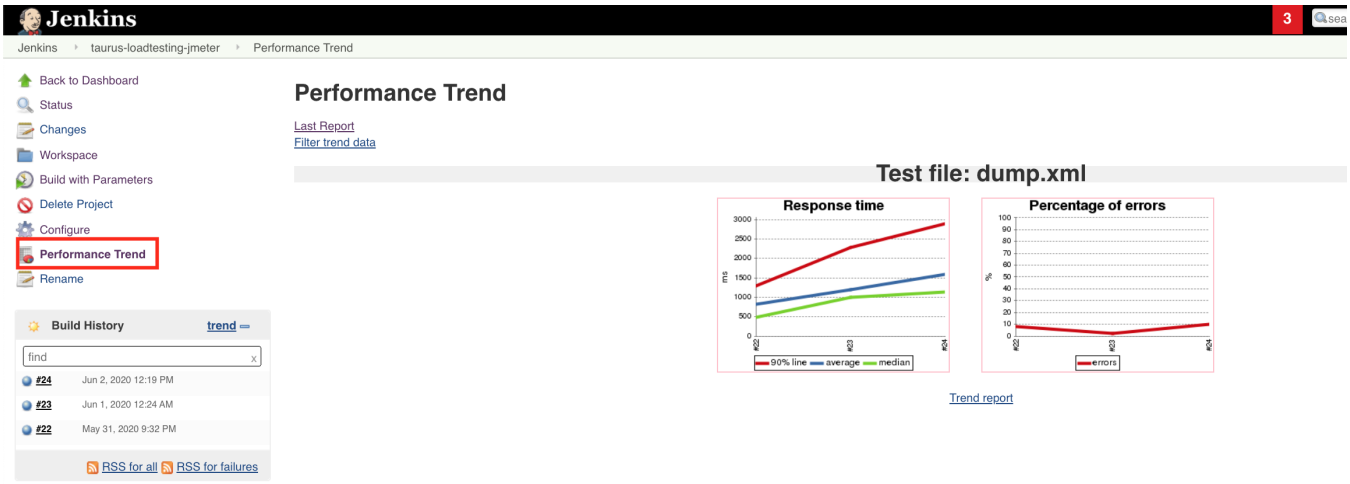
For the time being, the Jenkins plugin can't upload other files; however, we can make a basic shell script (e.g. `attach_files_to_issue.sh`) for that.

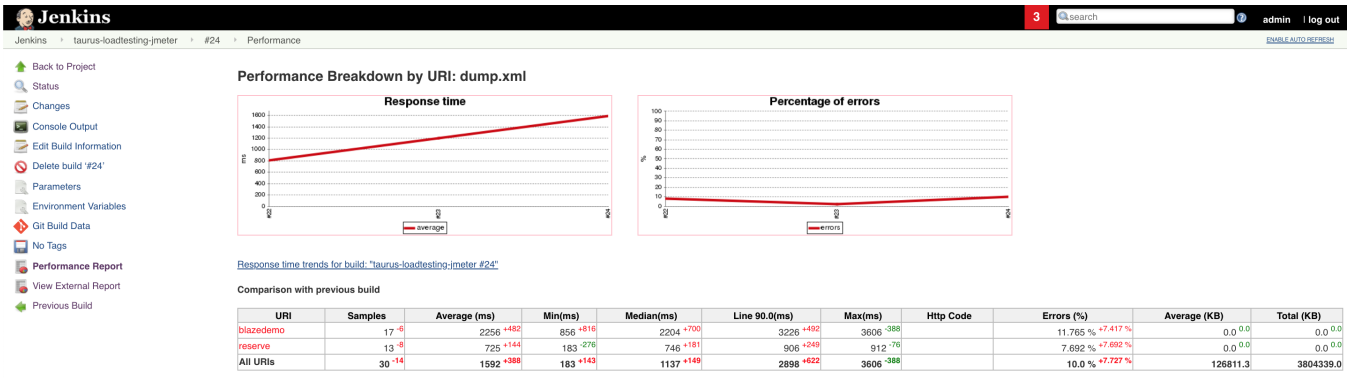
attach_files_to_issue.sh

```
#!/bin/bash

BASEURL=${JIRA_BASEURL:-http://yourjiraserver.example.com}
USERNAME=${JIRA_USERNAME:-admin}
PASSWORD=${JIRA_PASSWORD:-admin}

ISSUEKEY=$1

for file in "${@:2}"
do
 curl -D- -u $USERNAME:$PASSWORD -X POST -H "X-Atlassian-Token: nocheck" -F "file=@$file" $BASEURL/rest
/api/2/issue/$ISSUEKEY/attachments
done
```

After running Jenkins job, some performance information will be directly avilable in Jenkins; this is provided by the Performance plugin (if you've previously configured it as mentioned earlier), either on the project page or on the build page.



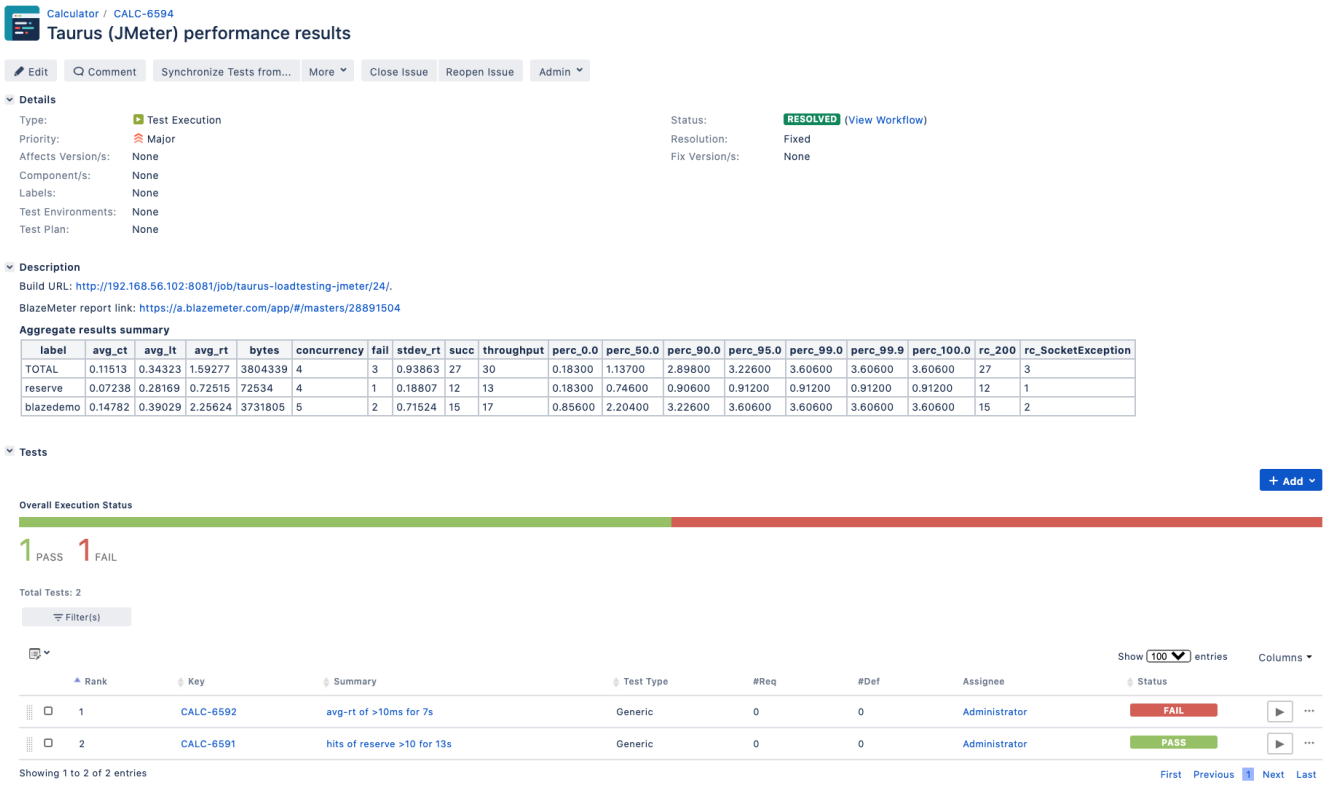




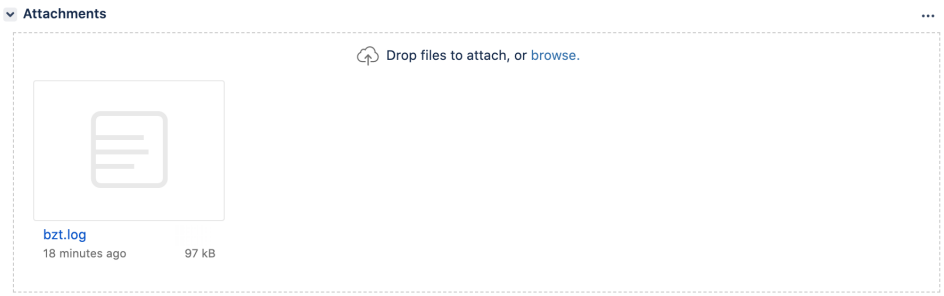
URI	Samples	Average (ms)	Min(ms)	Median(ms)	Line 90.0(ms)	Max(ms)	Http Code	Errors (%)	Average (KB)	Total (KB)
blazedemo	17 -6	2256 +482	856 +816	2204 +700	3226 +492	3606 -388		11.765 % +7.417 %	0.0 0.0	0.0 0.0
reserve	13 -8	725 +144	183 -276	746 +181	906 +249	912 -76		7.692 % +7.692 %	0.0 0.0	0.0 0.0
All URIs	**30 -14**	**1592 +388**	**183 +143**	**1137 +149**	**2898 +622**	**3606 -388**		**10.0 % +7.727 %**	**126811.3**	**3804339.0**

As we submitted the processed test results to Xray (e.g. junit_report.xml), we can now track them in Jira.

A Test Execution will be created containing a summary of results along with some useful links to access additional information in Jenkins.



The attachments section on the Test Execution issue provide direct access to some reports and also to a zipped file containing the dashboard report generated by JMeter.

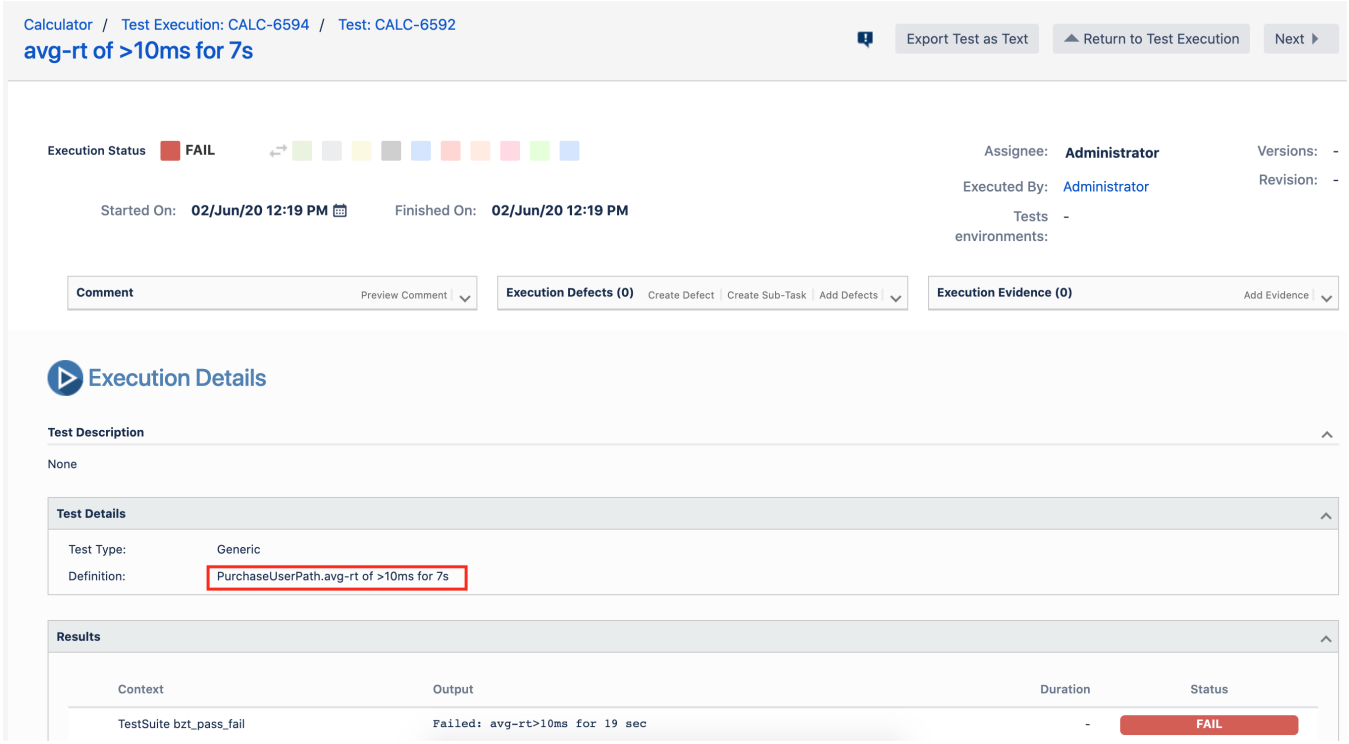


Unstructured (i.e. "generic) Test issues will be auto-provisioned (unless they already exist), one per each SLA criteria defined in the `passfail` module configuration. The "Generic Definition" field acts as the unique test identifier for subsequent imports and is composed by a prefix along with the criteria (e.g. "PurchaseUserPath.avg-rt of >10ms for 7s", "bzt.avg-rt of >10ms for 7s").

If `classname` configuration has been specified in the `custom-junit-xml` module, it will be used as the prefix; otherwise "bzt" will be used.

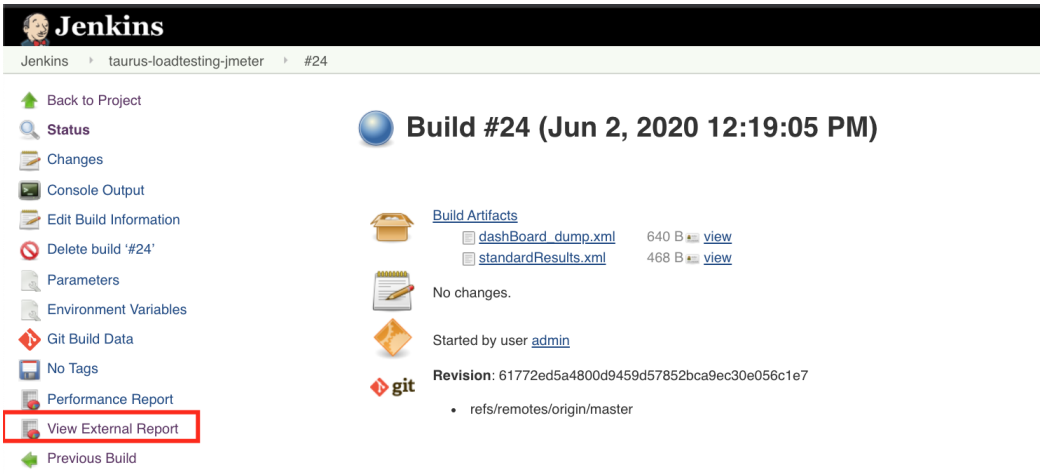
The execution details of a specific Test Run show whether the pass/fail criteria (i.e. our SLA) passed or not.

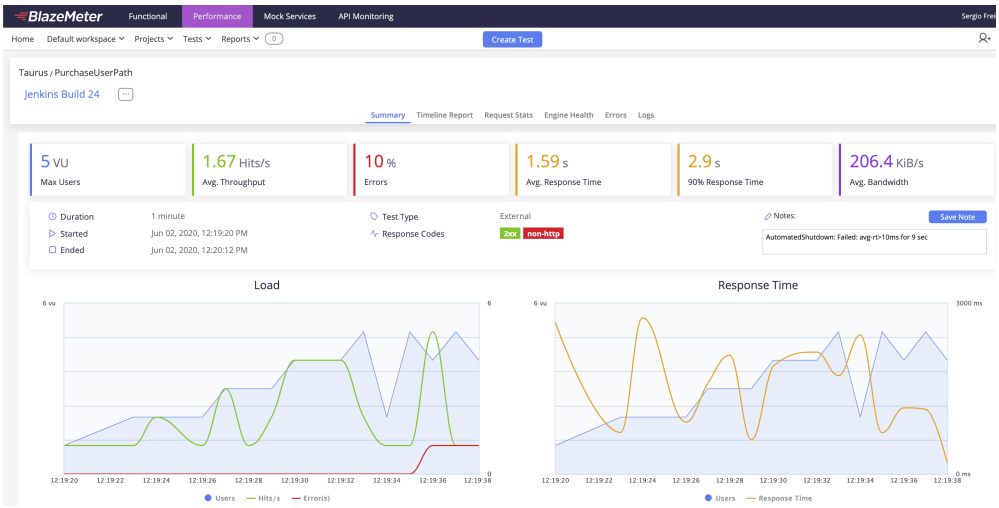
The following screenshot showcases the details of a failed criterium (e.g. average response-time greater than 10ms for 19 seconds).

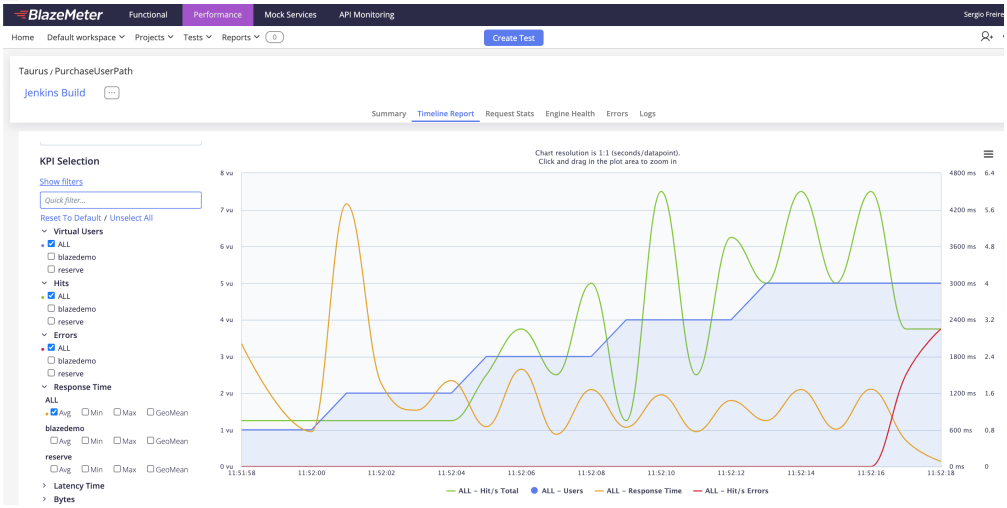


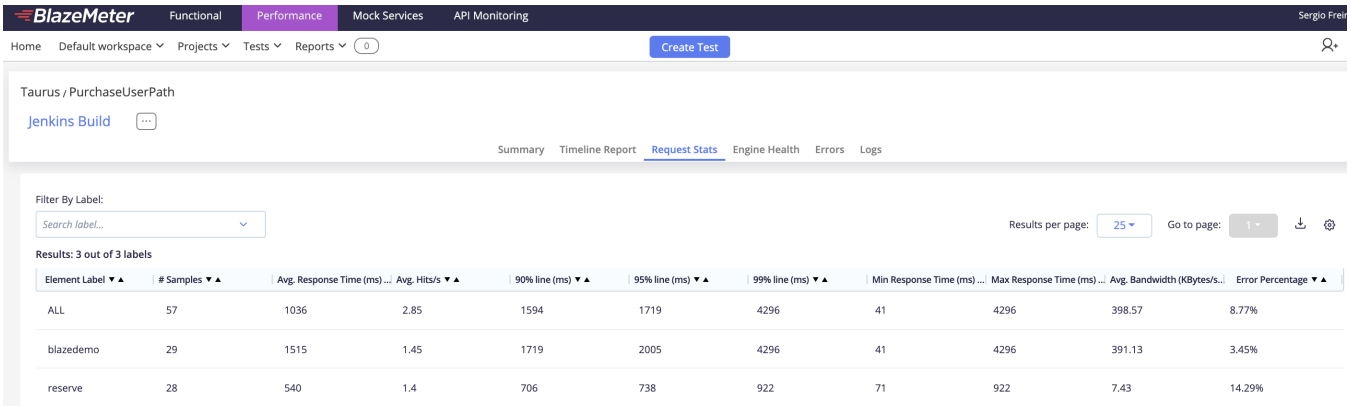
Results can be further analyzed on BlazeMeter site (if you've previously configured the "blazemeter" reporter).

You can access the report by using a specific link within the Jenkins build screen, or by using the link provided inside the Test Execution's description field in Xray.





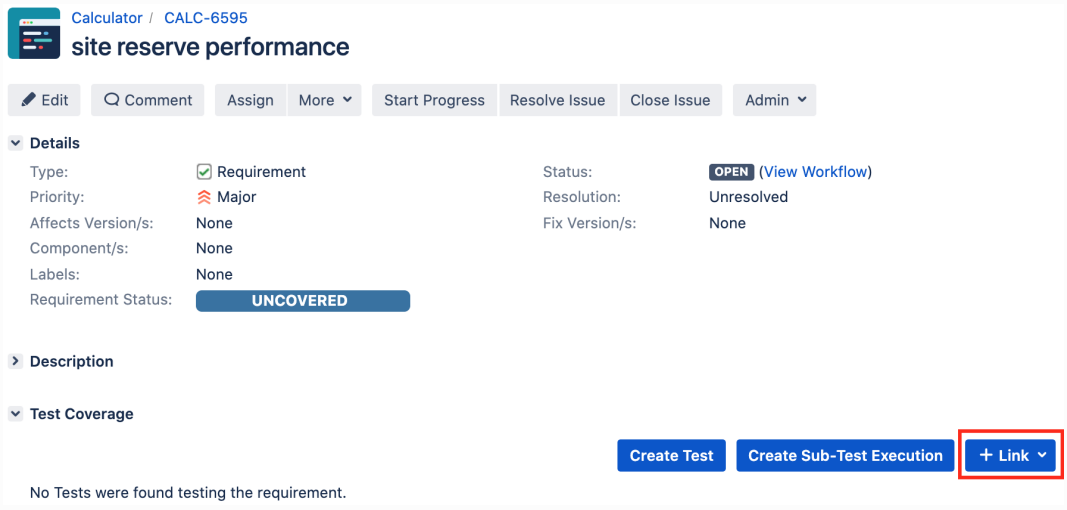


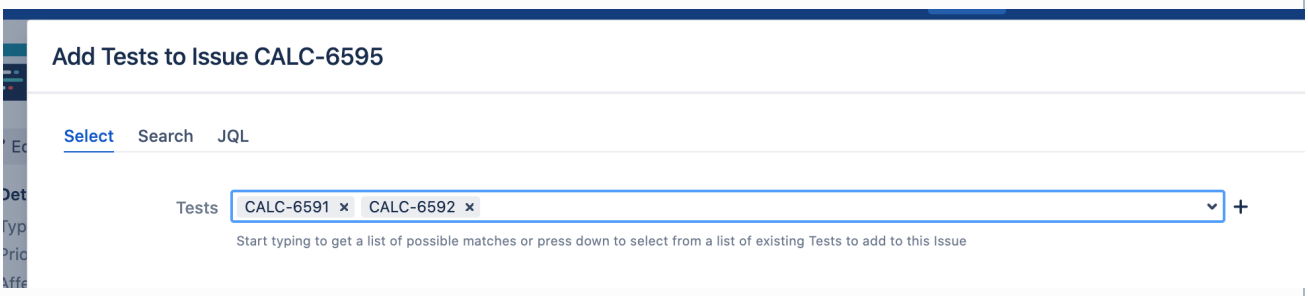


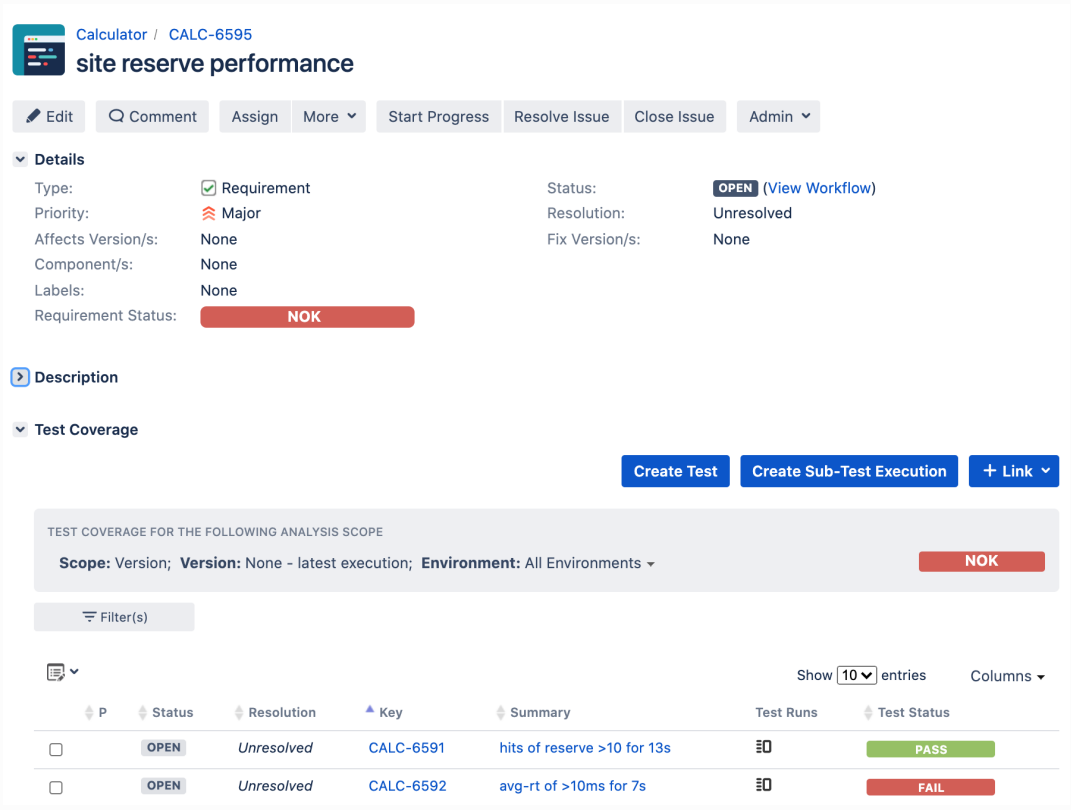
Element Label	# Samples	Avg. Response Time (ms)	Avg. Hits/s	90% line (ms)	95% line (ms)	99% line (ms)	Min Response Time (ms)	Max Response Time (ms)	Avg. Bandwidth (KBytes/s)	Error Percentage
ALL	57	1036	2.85	1594	1719	4296	41	4296	398.57	8.77%
blazedemo	29	1515	1.45	1719	2005	4296	41	4296	391.13	3.45%
reserve	28	540	1.4	706	738	922	71	922	7.43	14.29%

Bonus tip!

After Tests are auto-provisioned in Xray, they can be manually linked (i.e. cover) to a performance-related requirement/user story issue. This will provide you the ability to track coverage directly on the requirement issue.







Load testing example, without SLAs

This example is similar to the previous one (please have a look at it first), except that we wont define SLAs using the pass-fail module.

execution.yml

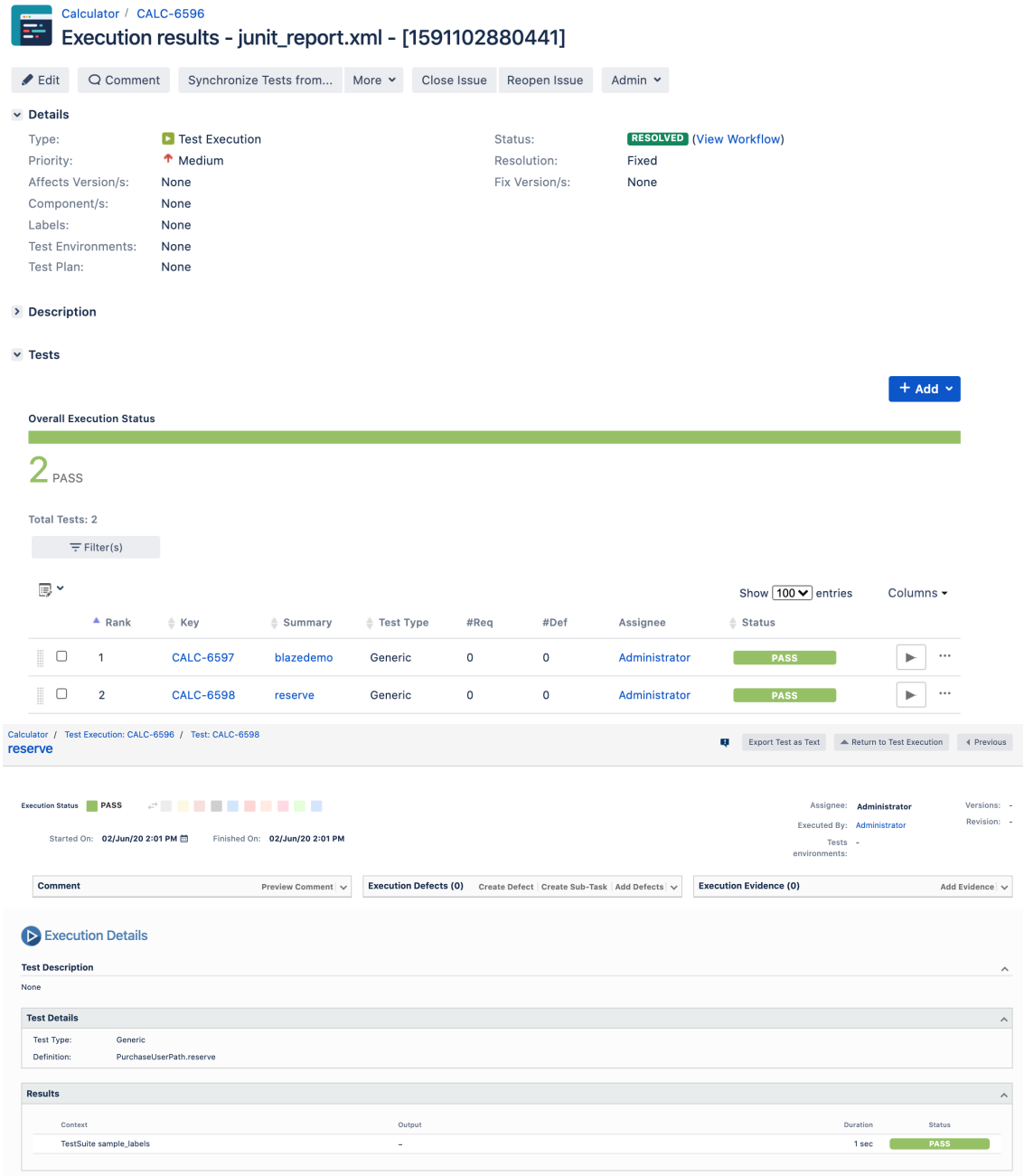
```
---
execution:
- concurrency: 10
  hold-for: 2m
  ramp-up: 40s
  scenario: Thread Group
scenarios:
  Thread Group:
    requests:
    - label: blazedemo
      method: GET
      url: http://blazedemo.com/
    - body:
        fromPort: Paris
        toPort: Buenos Aires
      label: reserve
      method: POST
      url: http://blazedemo.com/reserve.php
```

Multiple reporting modules are configured to process the results. A custom module (see code in the previous example) produces a JUnit XML report; this module is a customized variant over the standard junit-xml module.

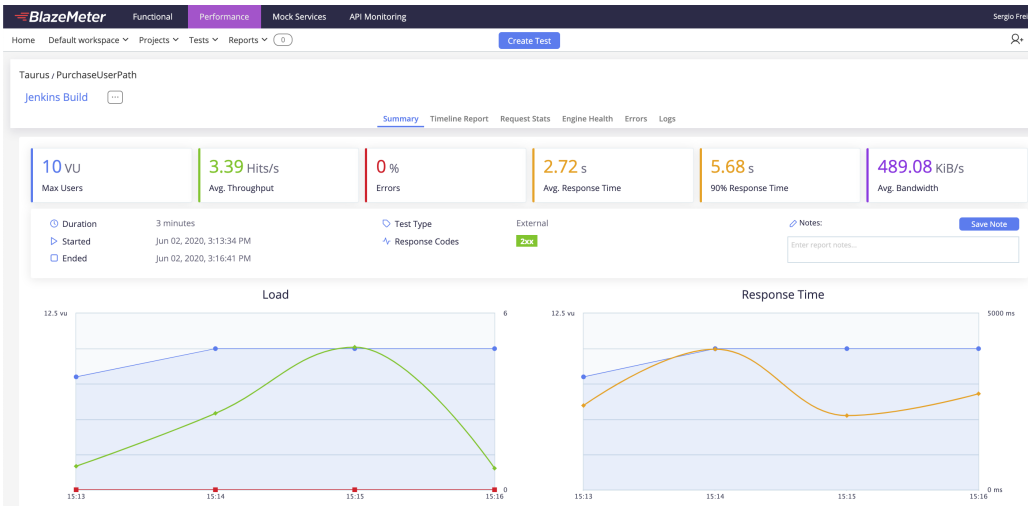
modules_config.yml

```
---
modules:
  custom-junit-xml:
    class: bitcoder.bzt.customreporting.JUnitXMLReporter

reporting:
- module: custom-junit-xml
  filename: junit_report.xml
  data-source: sample-labels
  classname: PurchaseUserPath
- module: final-stats
  summary: true  # overall samples count and percent of failures
  percentiles: true  # display average times and percentiles
  summary-labels: true # provides list of sample labels, status, percentage of completed, avg time and errors
  failed-labels: true  # provides list of sample labels with failures
  test-duration: true  # provides test duration
  dump-xml: dump.xml
  dump-csv: dump.csv
- module: blazemeter
  report-name: Jenkins Build
  test: Taurus Demo
  project: Taurus
  upload-artifacts: true  # upload artifacts when test is finished
  browser-open: none  # can be "start", "end", "both", "none"
```

Upon submission to Xray (e.g. junit_report.xml), each labeled request is converted to an unstructured (i.e. Generic) Test, uniquely identified by a prefix (e.g. PurchaseUserPath) along with the label.



Detailed reports can be analyzed in BlazeMeter site.



Functional testing example

Taurus can also be used for functional testing. Taurus can execute Selenium-based tests directly or invoke other test automation frameworks (e.g. JUnit) to run these type of tests.

To assist you writing U/Selenium test scritpts, you may use a specific Chrome extension that is able of generation a YAML configuration file Taurus friendly.

This file can then be further customized to your needs (e.g. for adding assertions).

functional_selenium.yml

```
modules:
  custom-junit-xml:
    class: bitcoder.bzt.customreporting.JUnitXMLReporter
  selenium:
    remote: https://22321b4098ad5b2e7b2060ee:
d1d3abcb97d59125619277ced5d7bf9a000263c672301d998d7cd00515a8aa1531b7be72@a.blazemeter.com/api/v4/grid/wd/hub
    capabilities:
      blazemeter.testName: Purchase test
      blazemeter.projectId: 634491
      blazemeter.locationId: US East (Virginia) - Functional GUI Test
  custom-junit-xml:
    class: bitcoder.bzt.customreporting.JUnitXMLReporter


execution:
- executor: selenium
  scenario: full_purchase_user_path
  iterations: 1
  capabilities:
    browserName: chrome

- executor: selenium
  scenario: full_purchase_user_path
  iterations: 1
  capabilities:
    browserName: firefox

scenarios:
  full_purchase_user_path:
    generate-flow-markers: true
    headless: false
    timeout: 60s
    think-time: 0s
    requests:
    - label: Open Travel Agency site
      actions:
```

```
      - go(http://blazedemo.com/)
      - assertTitle(BlazeDemo)
    - label: select From
      actions:
      - selectByName(fromPort): "Portland"
      - clickByName(fromPort)
      - assertTitle(BlazeDemo)
    - label: select To
      actions:
      - selectByName(toPort): "Dublin"
      - clickByName(toPort)
    - label: click Find
      actions:
      - clickByCSS(input.btn.btn-primary)
      - assertTitle(BlazeDemo - reserve)
    - label: click Choose
      actions:
      - clickByXPath(((//input[@value='Choose This Flight'])[3])
      - assertTitle(BlazeDemo Purchase)
    - label: enter Name
      actions:
      - clickByID(inputName)
      - typeByID(inputName): "John"
    - label: enter City
      actions:
      - clickByID(city)
      - typeByID(city): "Madrid"
    - label: click Purchase
      actions:
      - clickByCSS(input.btn.btn-primary)
      - assertTitle(BlazeDemo Confirmation)
      assert:
      - contains:
        - 'Thank you for your purchase today!'
        subject: body

reporting:
- module: final-stats
  summary: true  # overall samples count and percent of failures
  percentiles: true  # display average times and percentiles
  summary-labels: true # provides list of sample labels, status, percentage of completed, avg time and errors
  failed-labels: true  # provides list of sample labels with failures
  test-duration: true  # provides test duration
  dump-xml: dump.xml
  dump-csv: dump.csv
- module: custom-junit-xml
  filename: junit_report.xml
  data-source: sample-labels # sample-labels, pass-fail
- module: blazemeter
  report-name: full purchase user path
  test: Taurus Demo
  project: Taurus
  upload-artifacts: true  # upload artifacts when test is finished
  browser-open: none  # can be "start", "end", "both", "none"
```

```
17:13:07 INFO: Average times: total 7.157, latency 0.000, connect 0.000
17:13:07 INFO: Percentiles:
```

Percentile, %	Resp. Time, s
0.0	4.552
50.0	5.5
90.0	10.696
95.0	11.248
99.0	11.248
99.9	11.248
100.0	11.248

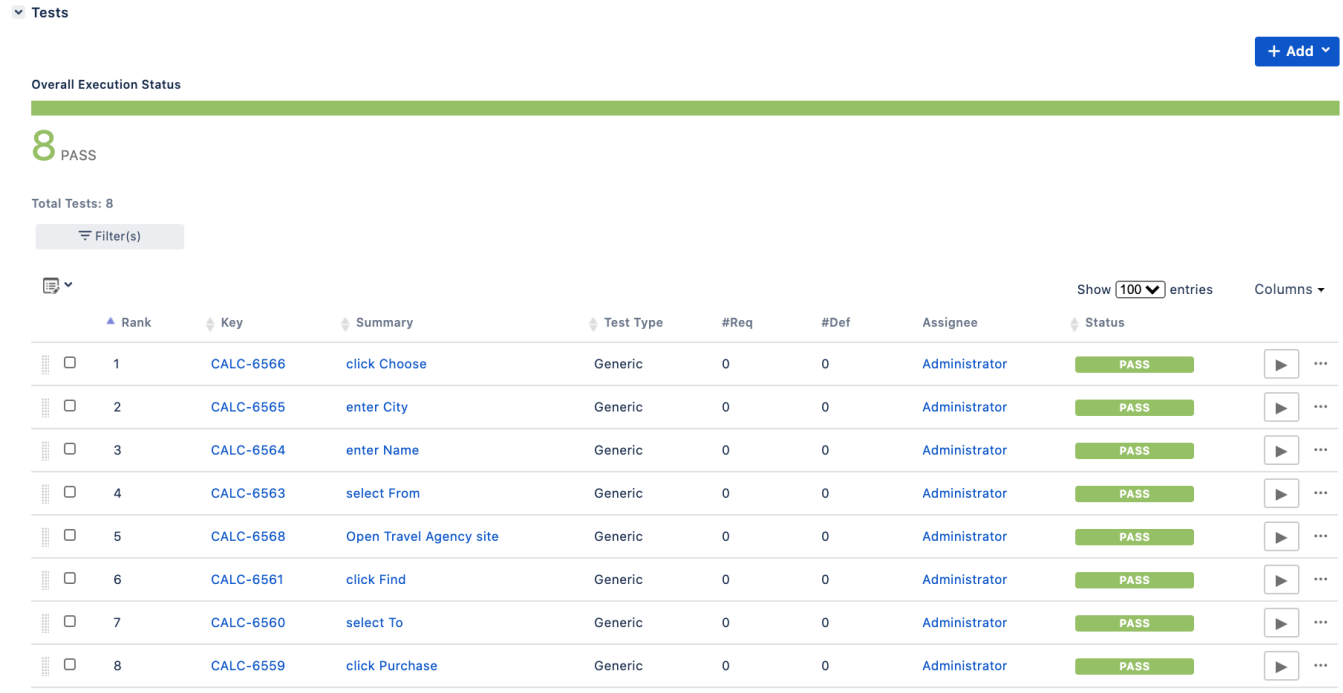
```
17:13:07 INFO: Request label stats:
```

label	status	succ	avg_rt	error
Open Travel Agency site	OK	100.00%	4.634	
click Choose	OK	100.00%	4.935	
click Find	OK	100.00%	4.732	
click Purchase	OK	100.00%	5.441	
enter City	OK	100.00%	8.183	
enter Name	OK	100.00%	8.184	
select From	OK	100.00%	10.974	
select To	OK	100.00%	10.169	

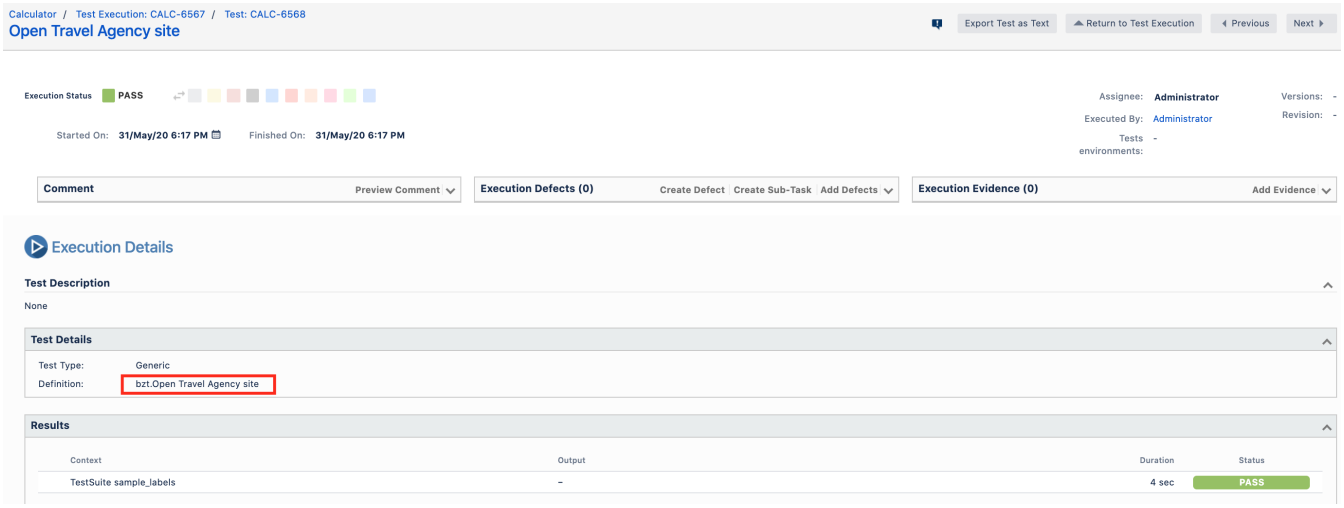
```
17:13:07 INFO: Dumping final status as XML: dump.xml
17:13:07 INFO: Dumping final status as CSV: dump.csv
17:13:07 WARNING: File junit_report.xml already exists, it will be overwritten
17:13:07 INFO: Writing JUnit XML report into: junit_report.xml
17:13:07 INFO: Sending remaining KPI data to server...
17:13:09 INFO: Uploading all artifacts as artifacts.zip ...
17:13:10 INFO: Uploading /Users/smsf/exps/taurus1/2020-06-01_17-11-35.146669/bzt.log
17:13:11 INFO: Ending data feeding...
17:13:12 INFO: Online report link: https://a.blazemeter.com/app/#/masters/28873337
```

After test is run, a JUnit XML report is produced (e.g. junit_report.xml). This can be submitted to Xray.

An unstructured (i.e. Generic) Test will be created per each action.



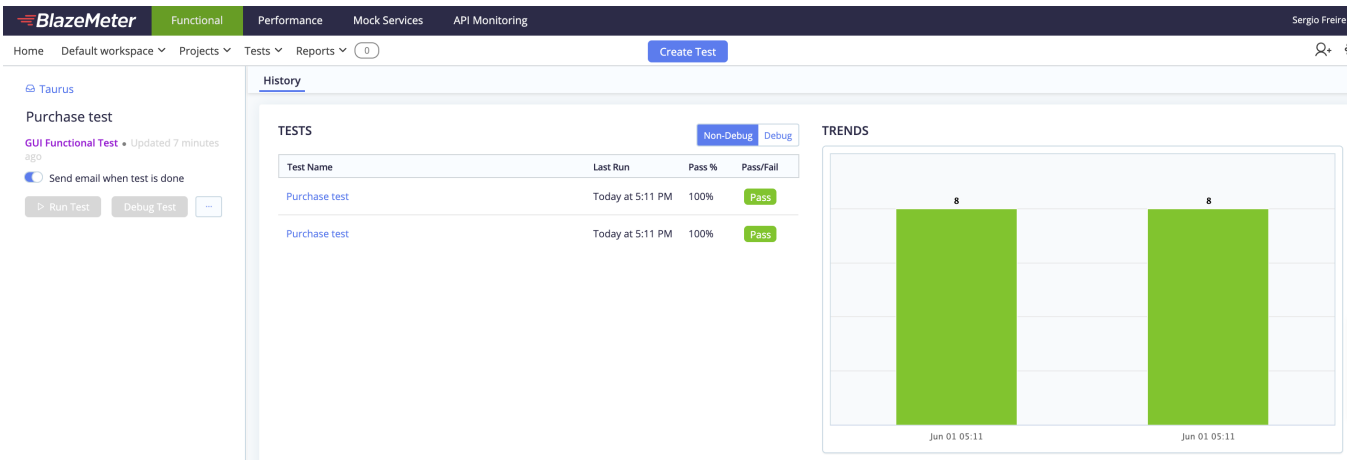
The unique identifier for the Test (i.e. the value of the Generic definition field) is composed by a prefix along with the label.



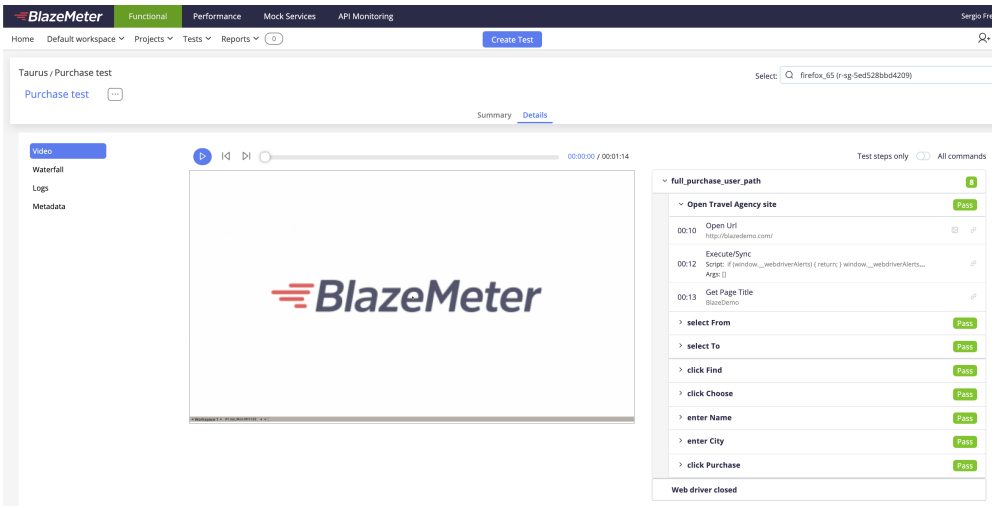
Results can be further analyzed in BlazeMeter' site.

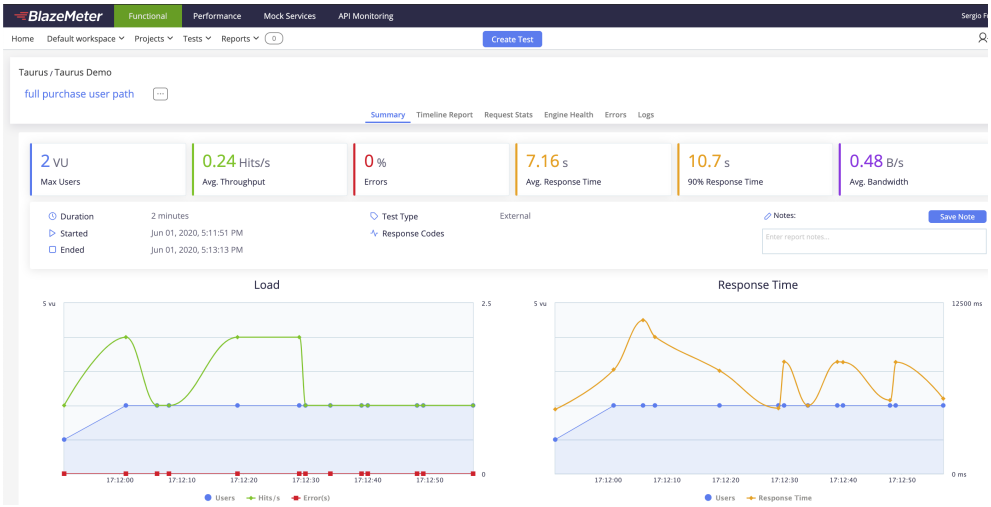
> **Please note**
>
> Unless you run your tests in BlazeMeter using the remote webdriver, test results will appear under the Performance section and you won't be able to see action level pass/fail information.
>
> Please check the Selenium Executor and the Apiritif Executor documentation.

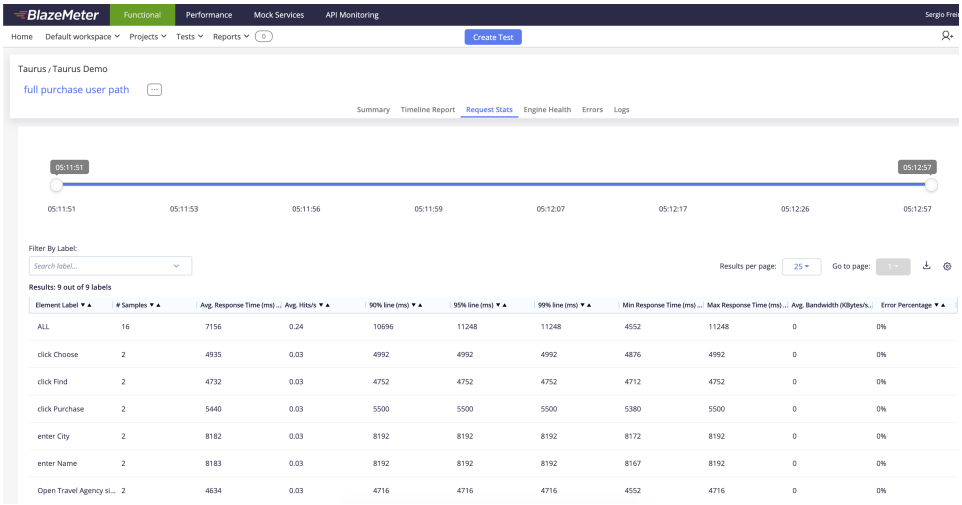
Our test was run against two different browsers, thus we can see the two distinct results.



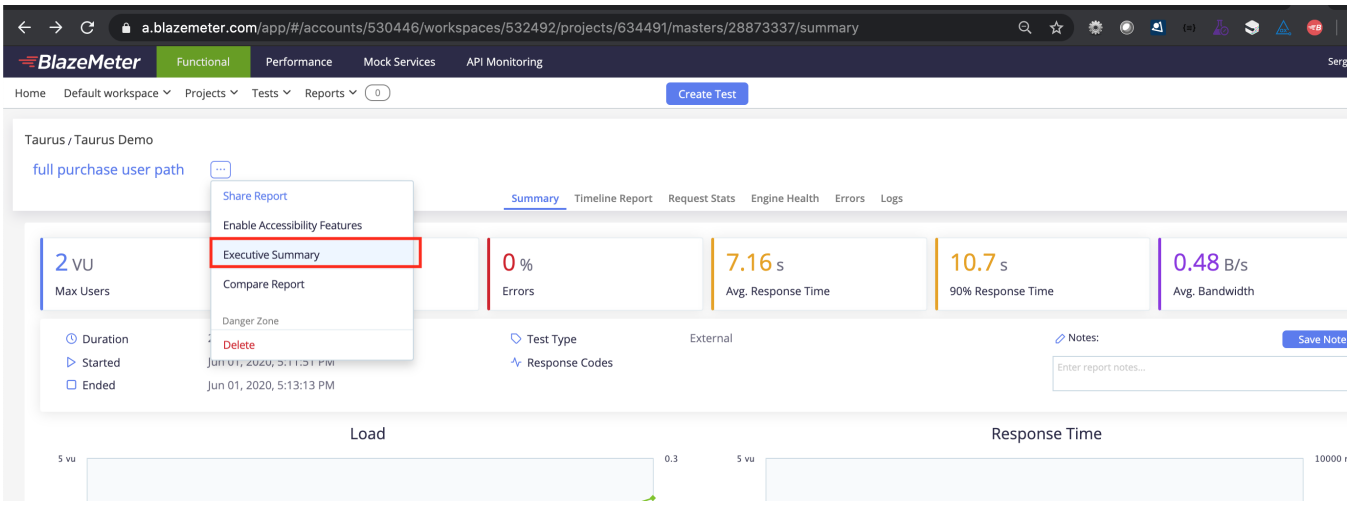
On each test result, it is possible to evaluate the step/group of actions (i.e. label) result along with the inner actions. It's also possible to watch a recording of the test session.

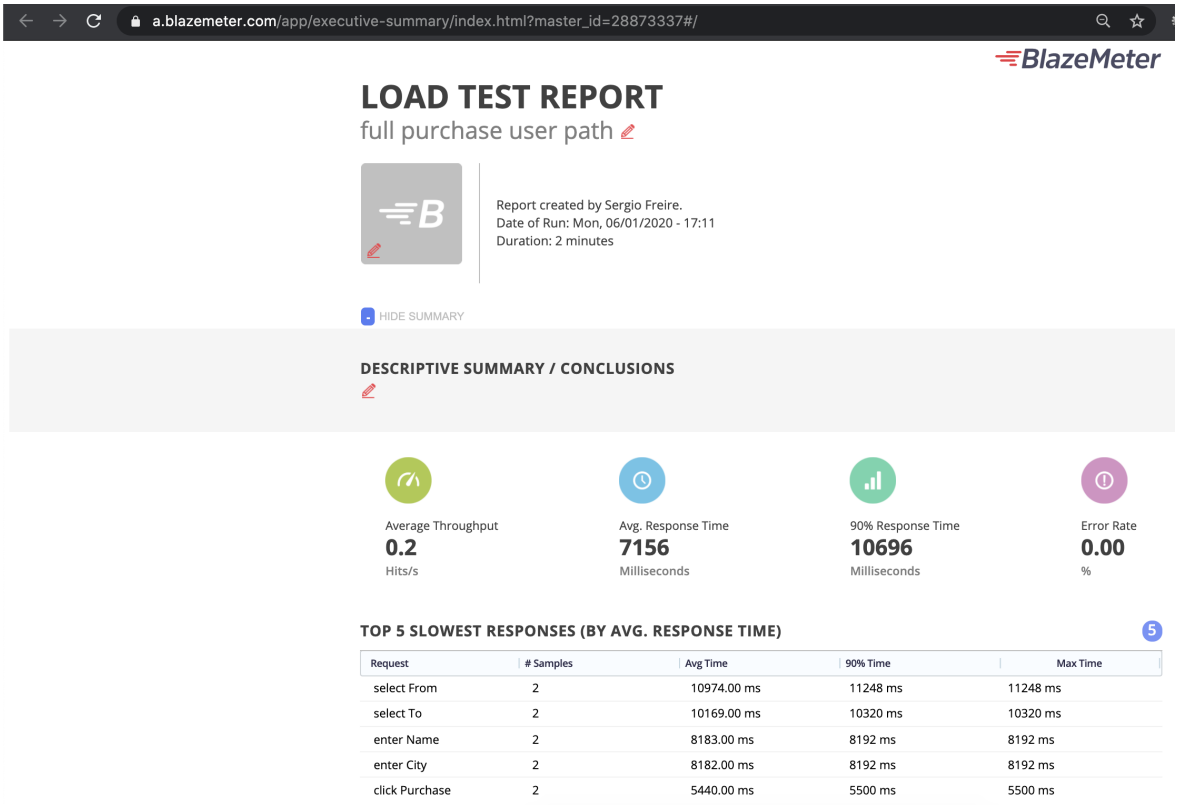






It's also possible to access an execute summary report.

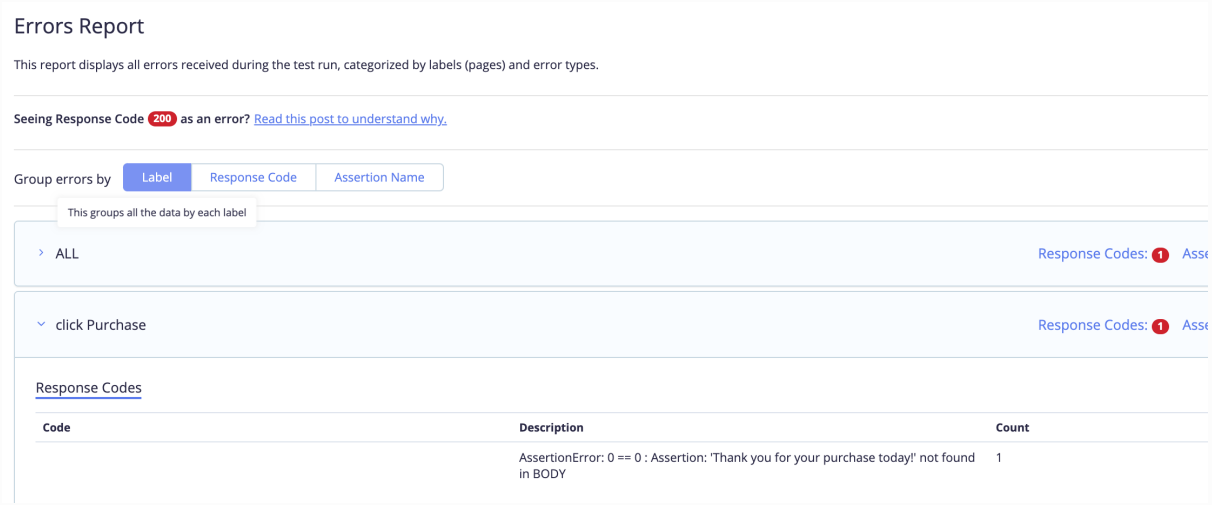




Request	# Samples	Avg Time	90% Time	Max Time
select From	2	10974.00 ms	11248 ms	11248 ms
select To	2	10169.00 ms	10320 ms	10320 ms
enter Name	2	8183.00 ms	8192 ms	8192 ms
enter City	2	8182.00 ms	8192 ms	8192 ms
click Purchase	2	5440.00 ms	5500 ms	5500 ms

Please note

Assertion errors can be tracked in the Errors Report section of the overall test results.



Room for improvement

- abstract the whole Taurus test as a single Test
- use Robot Framework XML report instead of JUnit to provide more granular details
- provide the possibility of linking test(s) to an existing requirement in Xray

References

- https://github.com/Blazemeter/taurus
- https://gettaurus.org/
- https://gettaurus.org/docs/PassFail/
- https://gettaurus.org/learn/
- https://gettaurus.org/docs/JMeter/#Assertions
- https://gettaurus.org/kb/SeleniumActions/
- https://chrome.google.com/webstore/detail/blazemeter-the-continuous/mbopgmdnpcbohhpnfglgohlbhfongabi?hl=en
- https://gettaurus.org/kb/Reporting/
- https://www.blazemeter.com/blog/how-to-perform-local-GUI-functional-test-through-Taurus
- https://gettaurus.org/docs/BlazemeterReporter/