

UNIVERSITY OF MANNHEIM

USING TEST SHEETS FOR REAL TIME TESTING IN THE CASE OF FIGO GMBH

Master Thesis

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Abstract

- 2-3 sentences - current state of art
- 1-2 sentences - contribution to improvement
- 1-2 sentences - specific result of the paper and main idea behind it
- 1 sentences - how result is demonstrated and defend

While providing of simple way for test description is a hot topic in software development. There is no software developed for a realization of Test Sheet concept, pragmatic way of defining tests which lays between two extreme paradigms FIT and hard coded test definitions.

This paper describes processes of design and implementation of the Test Sheets' concept together with integration of the product to business processes of figo GmbH for a real-time testing/validation of internet banking web pages.

Result of this research is following: developed conventions for Test Sheets definitions in particular use case, implemented interpreter from Test Sheets to executable JavaScript code.

Conventions and the code listing of main module together with example of executable JavaScript file are provided as well as statistics regarding improvement of user experience and overall system fault prevention improvements.

Some feedback from Bianca and Sebastian + statistics regarding user experience improvement

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1. Introduction

- What precisely did I answer

what question did I answer

why should the reader care

what larger question does this address

- What is my result

What new knowledge have I contributed that reader can use elsewhere

What previous work do I build on

What precisely and in detail my new result

- Why should the reader believe in my result

What standard was used to evaluate the claim

What concrete evidence shows that my result satisfies my claim

Relevance of the topic and the necessity for scientific investigation: No researches found regarding semi automated tests generation for web page verification.

Practical and theoretical value of the topic: Implementation of engine for Test Sheets with application of software design and development practices.

Motives for choosing a particular topic: Necessity of tests defined by non-developers for figo for a real-time testing (will be provided later)

Research problem and why it is worthwhile studying - definition of convention for test sheets definition, usage of test sheets for testing of asynchronous systems in a real-time.

Research objectives - design and development of software for translation of test sheets in to executable java script for testing asynchronous calls to external system.

Structure of the thesis : A paragraph indicating the main Contribution of each chapter and how do they relate to the main body of the study Limitations of the

study

2. figo GmbH

2.1. General Information

The figo GmbH's mission is to "build the backbone of next generation financial services"[9], company was founded in 2012 and has its headquarter in Hamburg. Total Equity Funding: \$778.660 in 3 Rounds from 7 Investors (November 3, 2015). Currently, the API is fully functional in Germany and partly in Austria.[5][6]

figo Connect API was created to accelerate innovation in the FinTech area and to allow figo's partners to offer products with real added value. It enables developers, startups and even banks to connect to every financial service provider. These partners can access every bank account (current, savings, loan, securities, ...), credit card, eWallet and other financial services like PayPal through one single REST-API. [19][9][22]

Functions available through API:[7]

- Create, Read, Update, Delete Bank account(s);
- Read, Update, Delete Bank account(s) transactions;
- Create, Read, Update, Delete Bank account(s) standing orders;
- Create, Read, Update, Delete Bank account(s) direct debits;
- Read, Update Bank account(s) securities;
- Create, Read, Update, Delete Bank payment(s);

List of partners of figo API with their use-cases: http://figo.io/use_cases.html

2.2. IT infrastructure

Information technology infrastructure of figo GmbH has two parts related to the external connections. **API Server** - implements interfaces to figo's customers

and partners for accessing banking information and services. **Banking Server** - implements connection to banks via three possible communication channels. This particular part lays in scope of this research as a part where implemented system is running. Below provided description introduces basic concepts of Banking Service Architecture. For more information regarding IT infrastructure please use (pics with arch scheme attached)

2.2.1. Banking Server Architecture

Custom-API. Introduction of Directive on Payment Services (PSD) and PSD2 by European Commission in European Union and initiatives of Government in United Kingdom regarding provision of API by Banks and its standardization obligated with providing of online access points to their services.[13][14][2] Some of the banks already implemented Application Program Interfaces to access their services. Some of which provide full functionality while some only partial. Within the Single European Payment Area acceptance of directive by European Bank Authority scheduled within 2017 year. [4] All this APIs vary in their structure and functionality, and connection process lays out of the scope of this research.

Moreover some of the banks implements standardized programmable entry point.

HBCI+/FinTS - bank-independent protocol for online banking, developed and used by German banks. Home Banking Computer Interface (HBCI) was originally designed by the two German banking groups Sparkasse and Volksbanken und Raiffeisenbanken and German higher-level associations as the Bundesverband deutscher Banken e.V.. The result of this effort was an open protocol specification, which is publicly available. The standardisation effort was necessary to replace the huge number of deprecated homemade software clients and servers (some of them still using BTX emulation). While IFX (Interactive Financial Exchange), OFX (Open Financial Exchange) and SET are tailored for the North American market, HBCI is designed to meet the requirements of the European market.[8]

Features[8]:

- Support for online-banking using PIN/TAN one time passwords.

- Support for online-banking with SWIFT.
- DES and RSA encryption and signatures.
- Making use of XML and SOAP for data-exchange, encryption and signatures.
- Implemented on top of HTTP, HTTPS and SMTP as communication layer.
- Multibanking: The software clients are designed to support accounts on multiple banking companies.
- Platform Independency: The specification allows software development for various types of clients.
- Storage of the encryption keys on an external physical device (smart card) for improved security.
- Possibility to use so called "Secoder" smart card readers to allow the user to cross check the transaction data on a secure device before signing it to uncover manipulations caused by malware. To use Secoder the bank as well as the home banking software have to support the Secoder protocol extension of FinTS

Low level vocabulary for message communication is defined by ISO20022 for more information please have a look to <https://www.iso20022.org/>

Web-Banking Engine. Since not all of the banks provide API nor HBCI figo uses web scraping technology (implemented within Web-Banking Engine) to access account's information and perform interaction with internet banking web page. From the banks perspective interaction completely looks like directly with user, while user does not feel the difference between interaction via Custom-API or HBCI or Web-Banking Engine.

In a same time this is the most sensitive part from the developer's perspective since every change to the bank's web page can leads to failure of the specific scripts. The critical part to recognize such significant for scraping changes before any user's interaction and notify a developer regarding part of the script which failed. Exactly for this purpose testing scripts generated from Test Sheets are used as a (demon task/crown job) in real time fashion with recording unexpected behavior to the general log and notification of the developer (email/slack).

Next chapter provides general information regarding web scraping and high-level description of scraping tool used by figo GmbH.

2.2.2. Web scraping

”Web scraping (web harvesting or web data extraction) is a computer software technique of extracting information from websites. Usually, such software programs simulate human exploration of the World Wide Web by either implementing low-level Hypertext Transfer Protocol (HTTP), or embedding a fully-fledged web browser, such as Mozilla Firefox.

Web scraping is the process of automatically collecting information from the World Wide Web. It is a field with active developments sharing a common goal with the semantic web vision, an ambitious initiative that still requires breakthroughs in text processing, semantic understanding, artificial intelligence and human-computer interactions. Current web scraping solutions range from the ad-hoc, requiring human effort, to fully automated systems that are able to convert entire web sites into structured information, with limitations.” [20]

”The Document Object Model is a platform- and language-neutral interface that will allow programs and scripts to dynamically access and update the content, structure and style of documents.” [18]

2.2.3. CasperJS

[3] CasperJS is an open source navigation scripting & testing utility written in JavaScript for the PhantomJS WebKit headless browser and SlimerJS (Gecko). It eases the process of defining a full navigation scenario and provides useful high-level functions, methods & syntactic sugar for doing common tasks such as:

- defining & ordering browsing navigation steps
- filling & submitting forms
- clicking & following links
- capturing screenshots of a page (or part of it)
- testing remote DOM

- logging events
- downloading resources, including binary ones
- writing functional test suites, saving results as JUnit XML
- scraping Web contents

3. Testing

”Software testing has grown as an important technique to evaluate and help to improve software quality. Numerous techniques and tools have appeared in the last decade, ranging from static analysis to automatic test generation and application. One can argue that software is the dominant part of an embedded system, either as a final product (executable code) or during its development lifecycle (system modeling in specific languages and computation models). In both cases, software must be thoroughly verified to ensure product quality and reliability. One can observe a growing number of academic and industrial works on the topic of embedded SW testing in the last four or five years, and this seems to be a good time for reflection: how exactly is embedded software testing different from traditional software testing? Is it an engineering or computer science problem? Does it need extra support from platform developers? What is the role of the SW engineer and of the designer in developing a high-quality software-based embedded application? Many authors suggest that, on top of the ordinary software testing challenges, software usage in an embedded application brings additional issues that must be dealt with: the variety of possible target platforms, the different computational models involved during the design, faster time-to-market and even more instable and complex specifications, platform-dependent constraints (power, memory, and resources availability), etc. On the other hand, current platforms are more and more powerful, and the specificities of the embedded application can help to reduce the search space during test generation: application domains, strong code reuse paradigm, use of less advanced programming language resources, and common availability of system models subject to or already verified with respect to specific properties, for instance. Furthermore, a major part of the so-called embedded software does not depend directly on hardware, and one can argue that only a small percentage really needs to be tested together with the target platform, and this test is part of the platform design, not the system design. ”[28]

Introduction of Agile and Extreme development paradigms with increased requirements for control over the existing code, its reuse and maintenance lifted requirements for tests and their quality to the new level and shifted responsibility regarding testing process from software engineers to people without development background. This led to new requirements for testing definition and representation tools since old tools like JUnit have high entry level for test engineers and requires its users to have an ability to write and read an executable code in a corresponding programming language.

”Tests are as important to the health of a project as the production code is. Perhaps they are even more important, because tests preserve and enhance the flexibility, maintainability, and reusability of the production code. ”[33]

”The ideas and techniques of software testing have become essential knowledge for all software developers”[23]

Testing is responsible for at least 30% of the cost in a software project.[26]

NIST 2002 report, “The Economic Impacts of Inadequate Infrastructure for Software Testing” claimed that - inadequate software testing costs the US alone between \$22 and \$59 billion annually. [25]

Huge losses due to web application failures Financial services : \$6.5 million per hour (just in USA!) Credit card sales applications : \$2.4 million per hour (in USA) [25]

3.1. Test Driven Development

Test Driven Development is a software development paradigm which combines test-first development and refactoring. This means that programmers first define test and only after write code to fulfill test requirements, both code and test maintained by developers. This reduces amount of redundant code and improves developers’ confidence during refactoring process. Refactoring in TDD requires developer before introducing new feature first ask question the existing design fits best for implementation of new functionality.[10] [24]

”Consider the following three laws: 1)First Law You may not write production code until you have written a failing unit test. 2)Second Law You may not

write more of a unit test than is sufficient to fail, and not compiling is failing.
3)Third Law You may not write more production code than is sufficient to pass the currently failing test.

These three laws lock you into a cycle that is perhaps thirty seconds long. The tests and the production code are written together, with the tests just a few seconds ahead of the production code. If we work this way, we will write dozens of tests every day, hundreds of tests every month, and thousands of tests every year. If we work this way, those tests will cover virtually all of our production code. The sheer bulk of those tests, which can rival the size of the production code itself, can present a daunting management problem.[33]

Pros. As a result you will always be improving the quality of your design, thereby making it easier to work with in the future.[10] Excelent fault isolation. Support by big variety of test frameworks [31] Tests can replace code documentation at certain level of abstraction [33]

Cons. Very hard to perform TDD without testing framework. [31] Also [31] states among the limitations of TDD is its bottom-up nature which provides little oportunity for elegant design. In contrast [10] cites Robert C Martin with following words: "The act of writing a unit test is more an act of design than of verification. It is also more an act of documentation than of verification. The act of writing a unit test closes a remarkable number of feedback loops, the least of which is the one pertaining to verification of function" For the same bottom-up approach [31] claims that some of the faults can be tracked only by data flow testing.

3.2. Requirements for tests (F. I. R. S. T.)

Fast. Tests should be fast. They should run quickly. When tests run slow, you won't want to run them frequently. If you don't run them frequently, you won't find problems early enough to fix them easily. You won't feel as free to clean up the code. Eventually the code will begin to rot.[33]

Independent. Tests should not depend on each other. One test should not set up the conditions for the next test. You should be able to run each test independently and run the tests in any order you like. When tests depend on each other, then the first one to fail causes a cascade of downstream failures, making diagnosis difficult and hiding downstream defects.[33]

Repeatable. Tests should be repeatable in any environment. You should be able to run the tests in the production environment, in the QA environment, and on your laptop while riding home on the train without a network. If your tests aren't repeatable in any environment, then you'll always have an excuse for why they fail. You'll also find yourself unable to run the tests when the environment isn't available.[33]

Self-Validating. The tests should have a boolean output. Either they pass or fail. You should not have to read through a log file to tell whether the tests pass. You should not have to manually compare two different text files to see whether the tests pass. If the tests aren't self-validating, then failure can become subjective and running the tests can require a long manual evaluation.[33]

Timely. The tests need to be written in a timely fashion. Unit tests should be written just before the production code that makes them pass. If you write tests after the production code, then you may find the production code to be hard to test. You may decide that some production code is too hard to test. You may not design the production code to be testable.[33]

3.3. Dependability [32]

Dependability is defined as the trustworthiness of a computer system such that reliance can justifiably be placed on the service it delivers. The service delivered by a system is its behaviour as it is perceptible by its users(s); a user is another system (human or physical) with the former.

Depending on applications intended for the system, a different emphasis may be put on the various facets of dependability, that is dependability can be viewed

according to different, but complementary properties which enable the attributes of dependability to be defined:

- *The readiness for usage* leads to **availability**
- *The continuity of service* leads to **reliability**
- *The nonoccurrence of catastrophic consequences on the environment* leads to **safety**
- *The nonoccurrence of unauthorized disclosure of information* leads to **confidentiality**
- *The nonoccurrence of improper information* leads to **integrity**
- *The ability to undergo repairs and evolutions* leads to **maintainability**

3.4. Real Time Testing

"Real-time software is a software that drives a computer which interacts with functioning external devices or objects. It is called real-time because the software actions control activities that are occurring in an ongoing process." [30] (MORE SHOULD BE ADDED)

3.5. Reliability testing

"Reliability is the probability that a system, or a system component, will deliver its intended functionality and quality for a specified period of "time", and under specified conditions, given that the system was functioning properly at the start of this "time" period. For example, this may be the probability that a real-time system will give specified functional and timing performance for the duration of a ten hour mission when used in the way and for the purpose intended. Since, software reliability will depend on how software is used, software usage information is an important part of reliability evaluation. This includes information on the environment in which software is used, as well as the information on the actual frequency of usage of different functions (or operations, or features) that the system offers. The usage information is quantified through operational profiles." [34]

4. Test Sheets

”Software testing is an important aspect of modern software development. Testing is performed to ensure that a product or component meets the requirements of all stakeholders. Just as the requirements themselves tests can vary widely in their nature. Some tests check whether executing certain code paths results in a correct state or answer while others may check whether a certain code path delivers its results in a specified amount of time.

However writing and evaluating tests is often not much different from programming itself. Tests are usually written in a formal programming language such as Java/JUnit. This necessitates that in order to create a test and understand its results knowledge of a formal programming language is required. This is a significant barrier of entry for stakeholders without a background in IT even though they may be interested in the tests themselves. Even without deep IT knowledge a stakeholder may still be interested in how well a product performs with regard to her requirements.

Visual test representations such as the UML Testing Profile try to lower the barrier of entry into testing. However most of the time these visualizations are only partial descriptions of the tests and so do not contain all the desired information for evaluation.

The Software Engineering group has started to develop a new representation for tests called Test Sheets. The goal is to create a way to define tests which combines the power and completeness of formal programming language with a representation that is easy to understand and work with even for people with little IT knowledge. This is achieved by representing a test in tabular form as a spreadsheet. Rows in a Test Sheet represent operations being executed while the columns represent input parameters and expected results. The actual content of a cell can be made dependent on other cells by addressing them via their location. This works in a way similar to existing spreadsheet software such as Microsoft Excel. After executing a test the cells for each expected result is colored according

to the result of the test. A successful test causes cells to become green while failed tests are indicated by red cells.”[15]

4.1. Basic Test Sheets

”A Test Sheet consists of a name and a class being tested. Each row after that represents one method call. The first column identifies the object being tested while the second column indicates which method is being called on said object. [...] Input parameters are specified in the columns following the method name up to the invocation line. Right after the invocation line the expected return values can be specified.”[16]

4.2. High Order, Parameterized Test Sheets

”The actual value used for Parameterized Test Sheets is specified by a Higher-Order Test Sheet as in the example below. The Higher-Order Test Sheet references the Parameterized Test Sheet as the ‘class’ being tested. On said pseudo-class it invokes the pseudo-method test followed the by the value to be used as parameter. ?C in the Parameterized Test Sheet is replaced by the value defined the third column (column C) for each execution. It is also possible to use more than one parameter. These are defined in the Higher-Order Test Sheet in subsequent columns (D, E, F, etc.) and referenced in the Parameterized Test Sheet via ?D, ?E, ?F, etc”[17]

5. NodeJS

”As an asynchronous event driven framework, Node.js is designed to build scalable network applications. Node is similar in design to and influenced by systems like Ruby’s Event Machine or Python’s Twisted. Node takes the event model a bit further, it presents the event loop as a language construct instead of as a library.” [1]

”Node.js is considered by many as a game-changer—the biggest shift of the decade in web development.[...]

First, Node.js applications are written in JavaScript, the language of the web, the only programming language supported natively by a majority of web browsers. [...]

The second revolutionizing factor is its single-threaded, asynchronous architecture. Besides obvious advantages from a performance and scalability point of view, this characteristic changed the way developers approach concurrency and parallelism. [...]

The last and most important aspect of Node.js lies in its ecosystem: the npm package manager, its constantly growing database of modules, its enthusiastic and helpful community, and most importantly, its very own culture based on simplicity, pragmatism, and extreme modularity. ”[27]

”JavaScript (JS) is a lightweight, interpreted, programming language with first-class functions. Most well-known as the scripting language for Web pages, many non-browser environments use it such as node.js and Apache CouchDB. JS is a prototype-based, multi-paradigm, dynamic scripting language, supporting object-oriented, imperative, and functional programming styles.”[12]

Non blocking I/O A set of bindings responsible for wrapping and exposing libuv and other low-level functionality to JavaScript.[27]

Non blocking I/O in NodeJS is provided by libuv[1][27]. Which is ”libuv is a multi-platform support library with a focus on asynchronous I/O. It was primar-

ily developed for use by Node.js, but it's also used by Luvit, Julia, pyuv, and others.” [21]

libuv properties[11]:

- Abstract operations, not events
- Support different nonblocking I/O models
- Focus on embeddability and perfomace

Node core A core JavaScript library (called node-core) that implements the high-level Node.js API.

V8/Chakra the JavaScript engine originally developed by Google for the Chrome browser/ Microsoft for IE 9 browser” [27]

Event handling NodeJS asynchronous nature provided by event handler which is an implementation of reactor pattern. Here is the description of process lifecycle[27]:

1. The application generates a new I/O operation by submitting a request to the Event Demultiplexer. The application also specifies a handler, which will be invoked when the operation completes. Submitting a new request to the Event Demultiplexer is a non-blocking call and it immediately returns the control back to the application.
2. When a set of I/O operations completes, the Event Demultiplexer pushes the new events into the Event Queue.
3. At this point, the Event Loop iterates over the items of the Event Queue.
4. For each event, the associated handler is invoked.
5. The handler, which is part of the application code, will give back the control to the Event Loop when its execution completes. However, new asynchronous operations might be requested during the execution of the handler, causing new operations to be inserted in the Event Demultiplexer, before the control is given back to the Event Loop.
6. When all the items in the Event Queue are processed, the loop will block again on the Event Demultiplexer which will then trigger another cycle.

Approaches for asynchronous information flow handling

- *Continuation Passing*. Definition and call of a function within function which performs asynchronous operation
- *Callbacks*. Passing as last input parameter function with specific signature for input parameters (error, data), which performs operation/error handling over returned data after it was obtained.
- *Async*. JavaScript library which gives an opportunity to write asynchronous functions execution in chain or parallel form within single information flow.
- *Promises*. Function can return promise object which can be resolved or rejected in a later time when its particular method will be called by other function.
- *Streams*. Piping asynchronous functions one to another. Result of first will be pushed to next stream whenever it is available, or pulled by the next stream whenever it is necessary (depends from stream mode)
- *Fibers*. Feature of ECMA6 standard which requires all asynchronous methods to have synchronous analogs.
- *Generators*. Type of constructor introduced in ECMA6 which returns iterator value. Which will iterate through the code unless it will reach yield method which will wait for return value without blocking event loop.

6. Contributions

For particular implementation of Test Sheets paradigm were developed conventions described below.

6.1. Requirements analysis

This section describes and analyses requirements differences defined by Test Sheets concept and introduced by figo GmbH.

Test Sheets were originally designed for test definitions of OOP languages. And all available examples describes tests definitions for Java Classes. While figo GmbH case requires implementation of tests for nodeJS/casperJS, which are based on JavaScript - Object Oriented, imperative, Functional Oriented programming language with asynchronous information flow. Moreover figo GmbH requires input of test results to be recorded in to LogStash logs database. The execution requirements from figo GmbH are such that tests defined via Test Sheets should be automatically executed in a time manner (every 2 mins or so), while normal software testing is performed on demand. The figo's requirement for comparison is such that while defining a Test Sheet user should be able to select from two types of comparison: 1) Strict comparison - complete comparison of objects including both properties' structure and their values. 2) Not-Strict comparison - scheme comparison of objects.

(Probably should go to different section) Scraping scripts implement callback based approach for handling asynchronous data flow. This provides an opportunity to perform result comparison within the custom callback defined on a implementation stage. Standard convention for callback definitions limitates number of input parameters of a callback (error, data), while comparison requires compare data parameter with expected outputs from Test Sheet. The opportunity to resolve this issue lays in a JavaScript's support of functions as a class citizens, the function implementation of module for comparison and report: module

exports function which invoked with single parameters (expected_output) / (+ script name) and returns function which is used as a callback for scrapping script, this callback function performs comparison and writes its result to TestSheet or logstash depending on environment in which the program was executed

6.2. Conventions

Following conventions should be followed for Test Sheet passed verification.

General:

- Number of columns within one TS should not exceed 26 columns (from A to Z);
- Invocation delimiters must be allocated within single column the (aligned to the longest row);
- References to the columns with expected returns columns will take as value actual return value obtained from method execution;
- Files extensions should be .xlsx

Basic Test Sheets

- A1 cell(optional) - description of the test case;
- A2 cell - module under testing with an extension (.js);
- A3..n - name of the class/object under the test;
- B3..n - name of the method from representative class (same row) under the test;
- C2..n to Invocation Column - input parameters for representative method (same row) under the test;
- Invocation Column - the column for separation of input values from expected output value(s) filled with — (pipe)(for comparison by scheme and data types) —— (two pipes)(for deep comparison - by scheme, data types and values) as a cells values until the last line which includes objects under tests;

- Expected Return - column(s) after invocation line.

Parameterized and Higher-Order Test Sheets Lower order test sheets can belong to Basic or Non-Linear types of Test Sheets and respectively follow conventions, with next additional option:

- Input and/or output cells can contain parameters `?[B-Z]+` which represent the value of cells within the representative column of Higher-Order Test Sheet
- Rows 1 and 2 should follow conventions for Basic Test Sheet;
- Cells starting from second row inside of `[B-Z]` columns should contain values which will replace parameters inside of Parameterized Test Sheet.

6.3. Use Case

definition (possibly in tabular form)

- Test Sheets defined by users (clients or employees without development background).
- Tests themselves will be applied for identification of layout changes on a target page before any interaction will appear to avoid errors and minimize the time of scripts correction.

Execution stages:

- Automated transformation of Test Sheets into JavaScript tests;
- Scheduled task for running tests on web pages;
- Developer notification regarding failing test.

The program run by user

6.4. Architecture

This system implements Pipe-and-Filter Architecture. [29] [27]

”In a pipe-and-filter style architecture, the computations components are called filters and they act as transducers that take input, transform it according to one or more algorithms, and then output the result to communications conduit. The input and outputs conduits are called pipes.

The filters must be independent components. [...] The classic example of pipe-and-filter architectural style is the Unix shell[...]” [29].

6.5. Design and Implementation

Consists of two streams Reader and Writer both streams are in object mode.

The system’s information workflow described with following explanatory Test Sheet:

	A	B	C	D	E	F
1	get Accounts					
2	BankAustria					
3	BankAustria	login	<credentials object>	<pin object>		{...}
4	BankAustria	getAccounts	<credentials object>			{...}

6.5.1. Reader

On a lower level Reader stream consists of two combined streams (streams combination pattern used);

First stream takes input as a directory and returns list of absolute paths to all files within provided directory (including nested folders); Second stream accepts output of a first stream and for all .xlsx files obtains its schema invoking function from schema_maker library and as an output returns object with absolute path to the Test Sheet file with file content returned by reading with object returned by reading file (object pool pattern) with *xlsx* library (<https://www.npmjs.com/package/xlsx>) and schema created by schema_maker library.

Schema structure for example Test Sheet:

- pathToFile: 'absolute/path/to/test/sheet/file';
- testsheet: { < object returned by xlsx library >};
- schema:

```
description: 'get Accounts',  
moduleUnderTest: 'BankAustria',  
objectsUnderTest: ['A3', 'A4'],  
methodsUnderTest: ['B3', 'B4'],  
inputs: ['C3', 'C4', 'D3'],  
outputs: ['F3', 'F4'],  
invocations: ['E3', 'E4'],
```

Correspondence to design principles:

- Closing - stream is closed over file extension, schema_maker - object structure returned by *xlsx* library;
- Code to Interface - stream obtains and returns values via standard stream interface, call to file system made via standard nodeJS File System stream interface;
- Do not Repeat Yourself - no code duplication;
- Single Responsibility Principle - can be changed only due to the change of input type;
- Open Close Principle - new pipes can be added in a single place;
- Liscov Substitution Principle - no inherited objects used;
- Interface Segregation Principle - no dependency on redundant methods;
- Dependency Inversion Principle - higher level module index.js does not depend on current library
- Least Knowledge Principle - communication to interfaces and invocation of used library;
- Loose Coupling Principle - standard interfaces;

6.5.2. Writer

7. Implementierung

Zusammen mit dem Betreuer werden use-cases entwickelt anhand deren die Software programmiert werden soll. Diese dienen auch als Bewertungsgrundlage.

Die allgemein empfohlene Verzeichnisstruktur eines Projektes sieht wie folgt aus:

- projektname
 - bin
 - doc
 - lib
 - src

Die zu erstellende Software soll im package `de.uni_mannheim.informatik.swt.projektname` unter `src` liegen.

Bei der Programmierung sollte durchgängig die englische Sprache verwendet werden. Hierzu zählen insbesondere Kommentare im Quellcode, Namen von Funktionen, Variable, Menüpunkte im Benutzerinterface, kurze Hilfestellungen und Ausgaben von Programmen.

Der Code sollte mit Hilfe von `lstinputlisting` formatiert und ausgegeben werden, wie in folgendem Beispiel:

```
package de.uni_mannheim.informatik.swt.projektname;  
  
import javax.servlet.http.HttpServletRequest;  
  
5 import de.unimannheim.wifo3.cobana.action.ActionForm;  
import de.unimannheim.wifo3.cobana.action.ActionMapping;  
  
public class GuestbookForm extends ActionForm {  
    private String name = null;
```

```
10    private String message = null;

    public GuestbookForm() {

15    public String getName() {
        return this.name;
    }
    public void setName(String name) {
        this.name = name;
20    }

    public String getMessage() {
        return this.message;
    }
25    public void setMessage(String message) {
        this.message = message;
    }

    public void reset(ActionMapping mapping, HttpServletRequest
        request) {
30        setName(null);
        setMessage(null);
    }

}
```

Listing 7.1: GuestbookForm.java

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Appendix

A. First class of appendices

A.1. Some appendix

This is a sample appendix entry.

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