

SMARTron Software Requirements Specification

Version 1.0

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Table of Contents

Mission Statement	2
1 Introduction	2
1.1 Purpose	2
1.2 Scope	2
1.3 Definitions, acronyms, and abbreviations	2
1.4 References	3
1.5 Overview	3
2 Overall Description	4
2.1 Product Perspective	4
2.1.1 User interfaces	4
2.1.2 Hardware interfaces	4
2.1.3 Software interfaces	4
2.1.4 Communications interfaces	4
2.1.5 Software and libraries utilized	4
3 Specific Requirements	6
3.1 Functions	6
3.1.1 Automatic Scantron Analysis	6
3.1.2 Computing Statistics	6
3.1.3 Data Recording	7
3.1.4 Web App	7
3.2 Use Cases	8
3.3 Use Case Diagrams	20
3.4 Sequence Diagrams	22
3.5 Exception Sequence Diagrams	33
Appendix A: 200 Question Scantron Sheet	43
Appendix B: Sample Results	45
Appendix C: Entity-Relationship Diagram	51

Mission Statement

Creating a headless bubble sheet analyzer that comes with a companion website which allows managing exams that have previously been scanned.

1 Introduction

1.1 Purpose

The purpose of this document is to give a detailed description of the requirements for the SMARTron software. It will illustrate the purpose and complete specifications for the development of the system. It will also explain the constraints, interfaces and interactions with other external applications. This document is primarily intended to be proposed to a stakeholder for its approval and a reference for developing the first version of the system for the development team.

1.2 Scope

SMARTron will be an automatic grading program maintaining compatibility with existing 200-answer bubble sheets used by SUNY Oswego. The program will allow the user to maintain a familiar workflow of scanning bubble sheets and receiving an email containing the results. This will be accomplished by a headless bubble sheet analysis program that receives emails containing an answer key and student bubble sheets from any scanner, and emails results to the user.

SMARTron will also include a web app providing benefits over the current automatic grading workflow. Scanned exams are associated with a user's LakerNet ID, and they can log in to the web app to view and edit scanned exams. The web app will provide functionality to make corrections to answer keys and rename exams. Users will also have the option to create an answer key in-app and generate a custom bubble sheet compatible with the analysis program.

1.3 Definitions, acronyms, and abbreviations

Term	Definition
<i>User</i>	An individual who utilizes the system
<i>Bubble sheet</i>	A paper form that contains fields for answering multiple choice questions with a fixed layout

SMARTron Software Requirements Specification v1.0

<i>PC</i>	Personal Computer
<i>SMARTron Engine</i>	The headless application that receives and processes bubble sheets and emails results
<i>SMARTron Web App</i>	The online application that provides the user interface for viewing and correcting scanned exams
<i>SMARTron Mail Client</i>	An email address associated with the SMARTron application
<i>LakerNet ID</i>	The username/identification a user will provide, specific to SUNY Oswego
<i>Credentials</i>	The user's username/identification and password that they will use to log into the SMARTron Web App
<i>Login</i>	The action required from a user to be able to access the SMARTron Web App
<i>SRS</i>	Software Requirements Specification
<i>QMR</i>	Quality Management Report
<i>CSV file</i>	A comma-separated value text file used to store and format tabular data
<i>Grade</i>	The process done by the SMARTron Engine that calculates the points earned on an exam sheet
<i>Statistics</i>	Measurable numerical information pertaining to a student's calculated grades
<i>Results</i>	A student's grades and statistics from a selected exam
<i>SMARTron Database</i>	The collection of information stored by the SMARTron application

1.4 References

1.5 Overview

2 Overall Description

2.1 Product Perspective

2.1.1 User interfaces

The user will interact with a physical bubble sheet and a web-based client that allows for re-execution of the program with different inputs.

2.1.2 Hardware interfaces

The user will have access to and utilize a faculty scanner. There he will be able to scan all bubble sheets including the answer key without leaving his building. The user's PC is where he will interact with the email containing all data and statistics from the test results.

2.1.3 Software interfaces

The user will be able to utilize his existing Oswego email, which is a Google account, to initiate scanning the hard copy bubble sheets as well as receive the test results upon completion of the analysis by the program. The user will also be interacting with the SMARTron software in order to access results, create and edit answer keys. Microsoft Excel is the other software that the user wants to synchronize with SMARTron. Once the results have been emailed to the user, they should have the ability to upload/copy the results into a current Excel spreadsheet.

2.1.4 Communications interfaces

Computer
Email
Scanner

2.1.5 Software and libraries utilized

Team Requirements:

1. plantUML at www.plantuml.com for use case diagrams
2. www.draw.io for sequence diagrams

Team Engine:

1. Python (Version 3.7.2)
2. Java (Version 8)
3. OpenCV (Version 4.0.0.21)
4. NumPy (1.16.1)
5. Jython (Version TBD)
6. Numba 0.42.0

Team Usability:

1. Axure (Version 8.1.0) for creating wireframes
2. www.qualtrics.com for creating surveys

Team GUI

1. Javascript (Version 9)
2. ReactJS (Version 16.8.3)
3. HTML
4. CSS
5. Recharts library for React
6. react-google-login library for React

Team Database-Networking:

1. MySQL (Version TBD)

Team Quality Assurance:

1. www.github.com for project collaboration and documentation
2. Spock - Java testing tool to allow for writing unit and mock tests
3. Travis CI - Continuous integration tool to help automate pull requests and help with code reviews
4. Pytest - Python testing tool to allow for writing JUnit and mock tests
5. Gradle - A system to build Java projects and automatically run Spock tests
6. Selenium - Website testing software

3 Specific Requirements

3.1 Functions

3.1.1 Automatic Scantron Analysis

FR-1: The SMARTron Engine shall load a PDF file of scanned bubble sheets received via email.

FR-2: The SMARTron Engine shall extract the images of bubble sheets from the received PDF

FR-3: The SMARTron Engine shall process each image.

FR-3.1: The SMARTron Engine shall convert the image to greyscale.

FR-3.2: The SMARTron Engine shall apply gaussian blur to the image.

FR-3.3: The SMARTron Engine shall create a copy of the image with the canny filter.

FR-3.4: The SMARTron Engine shall apply inverted threshold to original image.

FR-3.5: The SMARTron Engine shall find all edges on the canny image copy.

FR-3.6: The SMARTron Engine shall filter through all edges and detect circles.

FR-3.7: The SMARTron Engine shall sort the circles in rows and columns.

FR-3.8: The SMARTron Engine shall find question circle groups.

FR-3.9: The SMARTron Engine shall find name circle groups.

FR-3.10: The SMARTron Engine shall find date, ID, sex, and grade circle groups.

FR-3.11: The SMARTron Engine shall iterate through all groups recording the darkest circle.

FR-3.12: The SMARTron Engine shall store records of all detected fields.

3.1.2 Computing Statistics

FR-4: The SMARTron Engine shall compute the following statistics for a graded exam:

1. Mean score in both percentage and points
2. Median score in both percentage and points
3. Quartiles in points
4. Frequency of each response for each question
5. Lowest score
6. Highest score

7. Range of scores
8. Standard deviation of scores
9. Variation of scores
10. KR-20 reliability
11. KR-21 reliability
12. Coefficient (Cronbach) alpha reliability

FR-5: The SMARTron Engine shall request raw test data from the SMARTron Database when recomputing the statistics in FR-4.

3.1.3 Data Recording

FR-6: The SMARTron Engine shall create a blank CSV file.

FR-7: The SMARTron Engine shall produce columns in the CSV file for student name, ID, and score.

FR-8: The SMARTron Engine shall create rows in the CSV file for each student bubble sheet associated with the exam.

FR-9: The SMARTron Engine shall send an email to the address associated user containing the generated CSV file and the statistics computed in FR-4.

FR-10: The SMARTron Engine shall send the raw test data to the SMARTron Database.

3.1.4 Web App

FR-11: The SMARTron Web App shall allow the user to create a new test.

FR-12: The SMARTron Web App shall allow the user to specify a name and number of questions for a test.

FR-13: The SMARTron Web App shall generate a unique 5-letter code associated with a newly created test.

3.2 Use Cases

Use Case UC-1	Automatically Grade Exam
Related Use Cases	UC-2, UC-3, UC-4, UC-5, UC-6, UC-7
Initiating Actor	User
Actor's Goal	Receive an email containing student grades and overall statistics for an exam.
Participating Actors	Scanner, SMARTron Engine, SMARTron Database, SMARTron Mail Client
Preconditions	The user has a set of filled-in bubble sheets with one filled in as an answer key. The user has access to a scanner that can send emails. The SMARTron Engine and Database are running.
Postconditions	The user has received an email with exam grades and statistics.

	Flow of Events for Main Success Scenario
1.	The user scans the filled-in bubble sheets with a scanner configured to send emails to the SMARTron system.
2.	The scanner emails the scanned bubble sheets to the SMARTron Mail Client.
3.	The SMARTron Mail Client extracts the attachment containing the scanned bubble sheets and passes them to the SMARTron Engine.
4.	The SMARTron Engine processes the bubble sheets to determine student grades.
5.	The SMARTron Engine records bubble sheet data in the SMARTron Database.
6.	The SMARTron Engine computes statistics for the exam.
7.	The SMARTron Engine creates a CSV file containing student grades.
8.	The SMARTron Mail Client sends an email containing the computed statistics and generated CSV file to the user.

Use Case UC-2	Extract Emailed Bubble Sheets
Related Use Cases	UC-1
Initiating Actor	SMARTron Mail Client
Actor's Goal	Extract a file containing scanned bubble sheets and send it to the SMARTron Engine
Participating Actors	Scanner, SMARTron Mail Client, SMARTron Engine, SMARTron Database
Preconditions	An email containing scanned bubble sheets has been sent to the SMARTron Mail Client's email address.
Postconditions	The SMARTron Mail Client has sent a file containing scanned bubble sheets to the SMARTron Engine.

	Flow of Events for Main Success Scenario
1.	The SMARTron Mail Client receives an email containing scanned bubble sheets as a PDF file or a set of supported image files.
2.	The SMARTron Mail Client extracts file attachments from the email.
3.	If every file is in a format supported by the SMARTron Engine, the files are sent to the SMARTron Engine.

Use Case UC-3	Extract Answer Data
Related Use Cases	UC-1, UC-2
Initiating Actor	SMARTron Engine
Actor's Goal	Extract all data contained on each bubble sheet.
Participating Actors	SMARTron Engine, SMARTron Database
Preconditions	The SMARTron Engine has a file or set of files containing images of bubble sheets.
Postconditions	The bubble sheet data has been extracted and stored in the SMARTron Database.

	Flow of Events for Main Success Scenario
1.	The SMARTron Engine applies filters to the image to remove irrelevant details and ease circle recognition.
2.	The SMARTron Engine determines the positions of filled circles on the bubble sheet.
3.	The SMARTron image translates circle positions into an array containing sets of filled circles for each field.
4.	The SMARTron Engine repeats steps 1 through 3 for each bubble sheet in the set.
5.	The SMARTron Engine marks one bubble sheet as the answer key.
6.	The SMARTron Engine sends the extracted bubble sheet data to the SMARTron Database.

Use Case UC-4	Assign Student Grades
Related Use Cases	UC-1, UC-2, UC-3
Initiating Actor	SMARTron Engine
Actor's Goal	Calculate a grade for each bubble sheet in a given exam.
Participating Actors	SMARTron Engine
Preconditions	The SMARTron Engine has bubble sheet data for an answer key and a set of student bubble sheets.
Postconditions	The SMARTron Engine has calculated a grade for each student bubble sheet.

	Flow of Events for Main Success Scenario
1.	The SMARTron Engine iterates through each answer on a student bubble sheet, assigning the appropriate points based on the answer key and the point value of the question.
2.	The SMARTron Engine stores the total points for the bubble sheet and associates the score with the name and Student ID read from the bubble sheet.
3.	The SMARTron Engine repeats steps 1 and 2 for each bubble sheet in the set.

Use Case UC-5	Compute Statistics
Related Use Cases	UC-1, UC-3, UC-4
Initiating Actor	SMARTron Engine
Actor's Goal	Compute the necessary statistics for an exam
Participating Actors	SMARTron Engine
Preconditions	The SMARTron Engine has a set of bubble sheet data and a set of student grades
Postconditions	The SMARTron Engine has computed all required statistics.

	Flow of Events for Main Success Scenario
1.	The SMARTron Engine computes necessary overall statistics (See Appendix B).
2.	The SMARTron Engine computes an item analysis for each exam item (See Appendix B).
3.	The SMARTron Engine computes item statistics for each exam item (See Appendix B).
4.	The SMARTron Engine stores the computed statistics.

Use Case UC-6	Create CSV File
Related Use Cases	UC-4
Initiating Actor	SMARTron Engine
Actor's Goal	Create a CSV file containing student grades for an exam.
Participating Actors	SMARTron Engine
Preconditions	The SMARTron Engine has a set of student grades.
Postconditions	The SMARTron Engine has generated a CSV spreadsheet of student grades.

	Flow of Events for Main Success Scenario
1.	The SMARTron Engine creates a blank CSV file.
2.	The SMARTron Engine creates columns for student name, student ID, and score.
3.	The SMARTron Engine fills each row with the corresponding data from an item in the set of student grades.
4.	The SMARTron Engine saves the generated CSV file.

Use Case UC-7	Send Email to User
Related Use Cases	UC-1, UC-5, UC-6
Initiating Actor	SMARTron Mail Client
Actor's Goal	Send an email containing student grades and overall statistics for an exam to the user.
Participating Actors	SMARTron Engine, SMARTron Mail Client, User
Preconditions	The SMARTron Engine has computed grades and statistics for an exam.
Postconditions	The SMARTron Mail Client has sent an email containing exam grades and statistics to the user.

	Flow of Events for Main Success Scenario
1.	The SMARTron Mail Client generates HTML displaying the computed statistics for the exam.
2.	The SMARTron Mail Client creates an email containing the statistics HTML.
3.	The SMARTron Mail Client adds the generated CSV file as an attachment to the email.
4.	The SMARTron Mail Client sends the generated email to the email address associated with the user.

Use Case UC-8	Login to SMARTron Web App
Related Use Cases	UC-9, UC-10
Initiating Actor	User
Actor's Goal	Access the SMARTron Web App
Participating Actors	SMARTron Web App
Preconditions	The user must have an existing LakerApps account.
Postconditions	The user has access to the features of the SMARTron Web App.

	Flow of Events for Main Success Scenario
1.	The user opens the SMARTron Web app in their web browser
2.	The user is prompted to log into the SMARTron Web app
3.	The user enters their proper credentials (LakerNet ID and password)
4.	The user is redirected to the SMARTron Web app dashboard

Use Case UC-9	Edit Answer Key
Related Use Cases	UC-4, UC-5, UC-8
Initiating Actor	User
Actor's Goal	Edit an existing answer key.
Participating Actors	SMARTron Web App.
Preconditions	There must be an existing account on SMARTron, and there must be an existing answer key to edit
Postconditions	The exam is reanalyzed according to the new answer key

	Flow of Events for Main Success Scenario
1.	The user logs into the SMARTron Web app.
2.	The user navigates to the exam they wish to change.
3.	The user makes their desired changes to the answer key.
4.	The user saves the changes to the answer key.
5.	The associated exams are re-graded according to UC-4

Use Case UC-10	Generate Custom Bubble Sheet
Related Use Cases	UC-8
Initiating Actor	User
Actor's Goal	Create a custom bubble sheet for a multiple-choice test.
Participating Actors	SMARTron Web App
Preconditions	The user must be logged into the SMARTron Web App.
Postconditions	A custom exam sheet is generated for future use.

	Flow of Events for Main Success Scenario
1.	The user navigates to the “create exam sheet” page in the SMARTron Web App.
2.	The user customizes a bubble sheet.
3.	The user downloads a PDF of the custom bubble sheet.

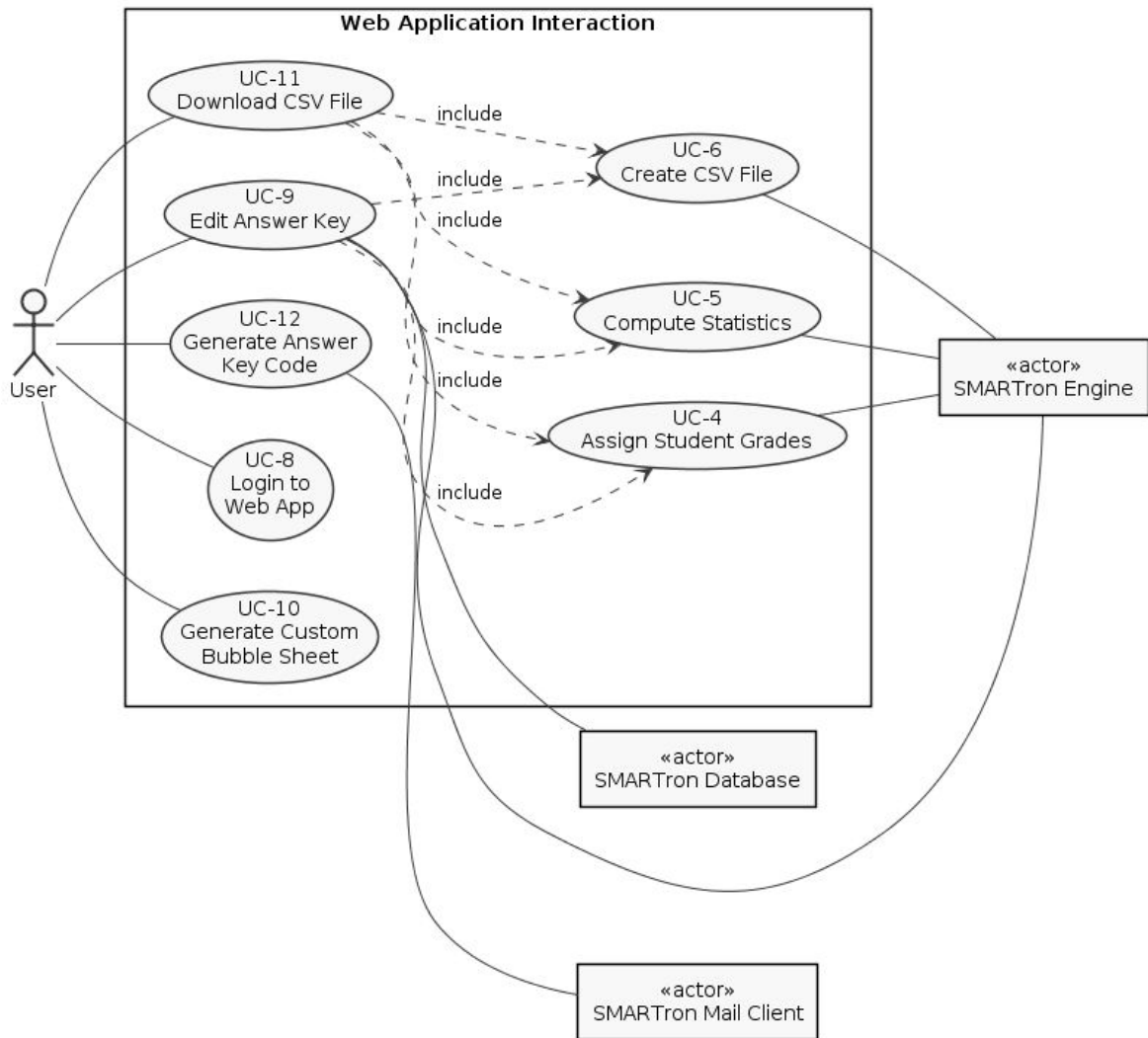
Use Case UC-11	Download CSV File
Related Use Cases	UC-6, UC-8
Initiating Actor	User
Actor's Goal	Download from the SMARTron Web App a CSV file containing student grades for an exam.
Participating Actors	SMARTron Web App
Preconditions	The user must be logged into the SMARTron Web App. There must be an existing CSV file of student grades
Postconditions	The user has a downloaded copy of the CSV file available on their local device.

	Flow of Events for Main Success Scenario
1.	The user navigates to the exam for which they wish to download the CSV file
2.	The user selects the option to download the CSV file
3.	The user is prompted to save the CSV file
4.	Upon selection of “save file”, the CSV file is downloaded to the user’s device

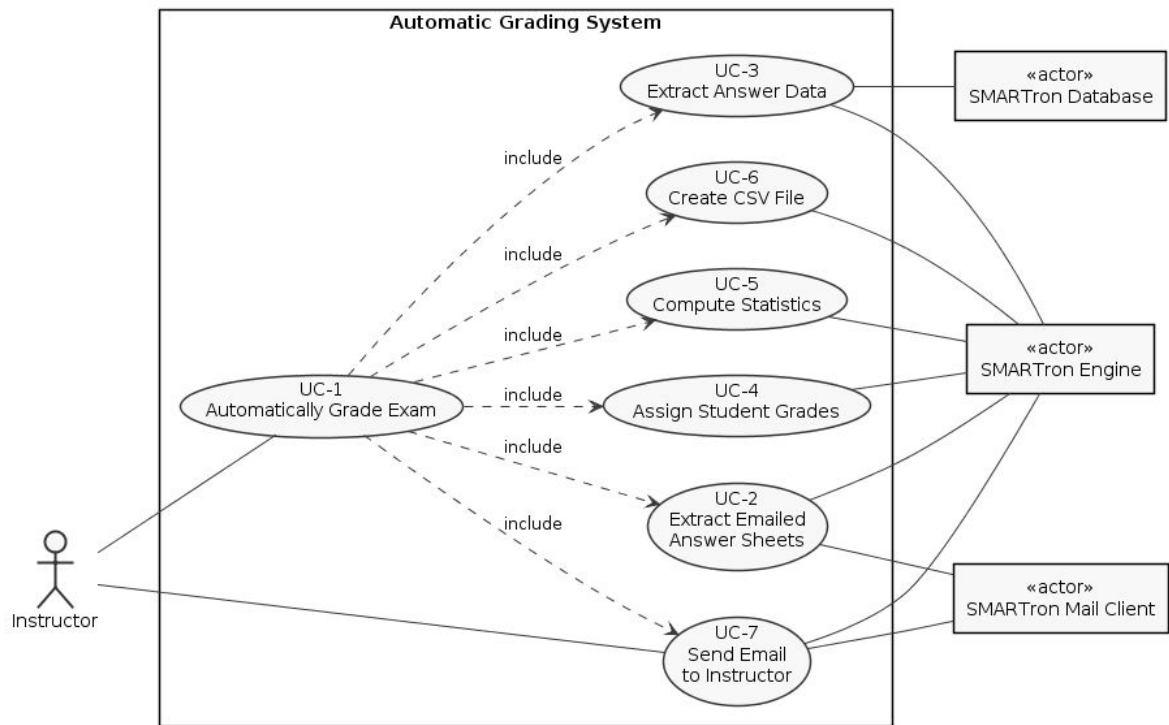
Use Case UC-12	Generate Answer Key Code
Related Use Cases	UC-9
Initiating Actor	User
Actor's Goal	To obtain a unique 5 character code to be used to identify an answer key for a set of bubble sheet exams to be scanned.
Participating Actors	SMARTron Web App, SMARTron Mail Client
Preconditions	The user must be logged into the SMARTron Web App.
Postconditions	The user is given a 5 character code to be used on an answer key of a set of bubble sheet exams.

	Flow of Events for Main Success Scenario
1.	The user navigates to the “initiate scan” page in the SMARTron Web App.
2.	The user is prompted to input the desired name of the exam and the number of questions on the exam.
3.	The user inputs the exam’s name and the number of questions.
4.	The user clicks the “generate code” button.
5.	An 5 character code is displayed to the user in the SMARTron Web App.
6.	The 5 character code, the name of the exam, and the number of questions on the exam are emailed to the user via the SMARTron Mail Client.

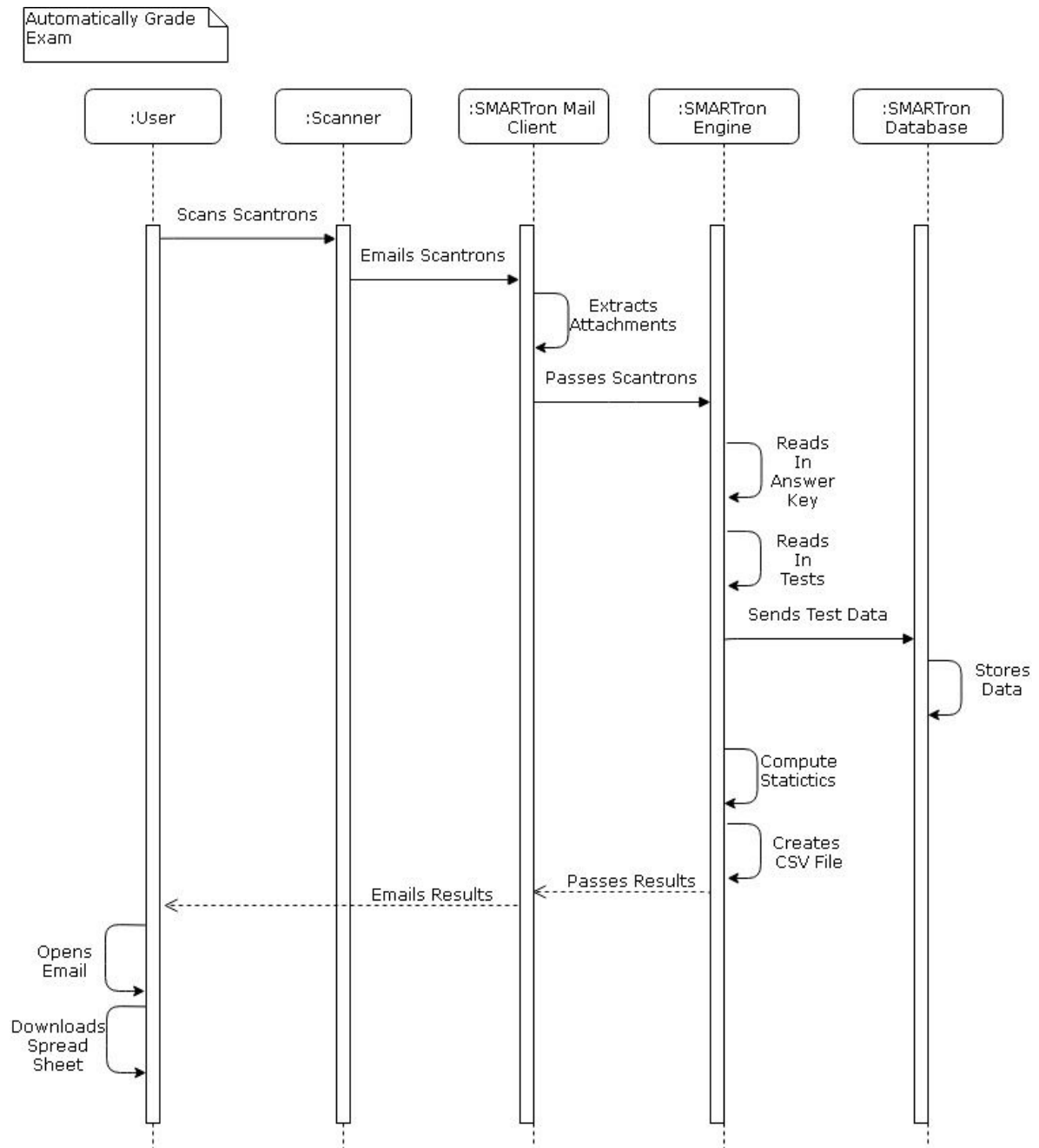
3.3 Use Case Diagrams

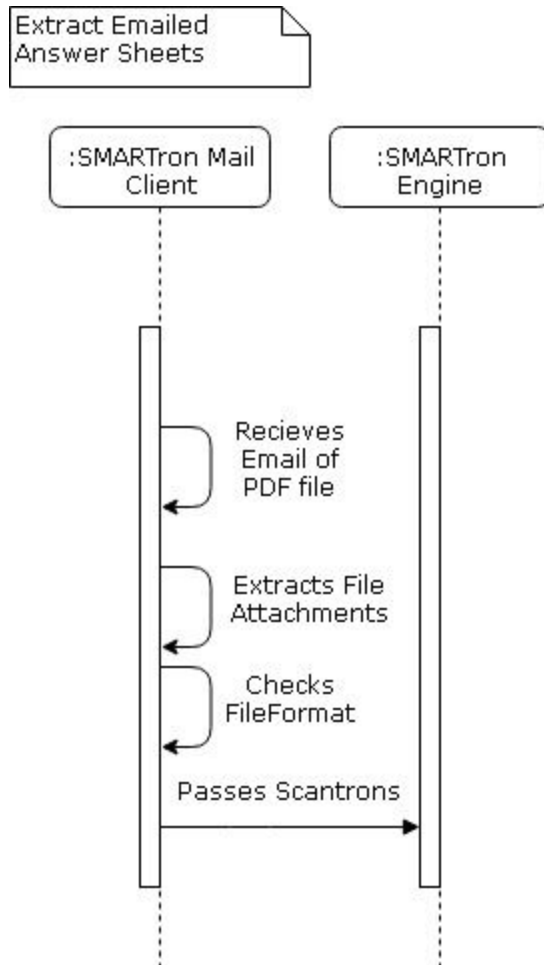


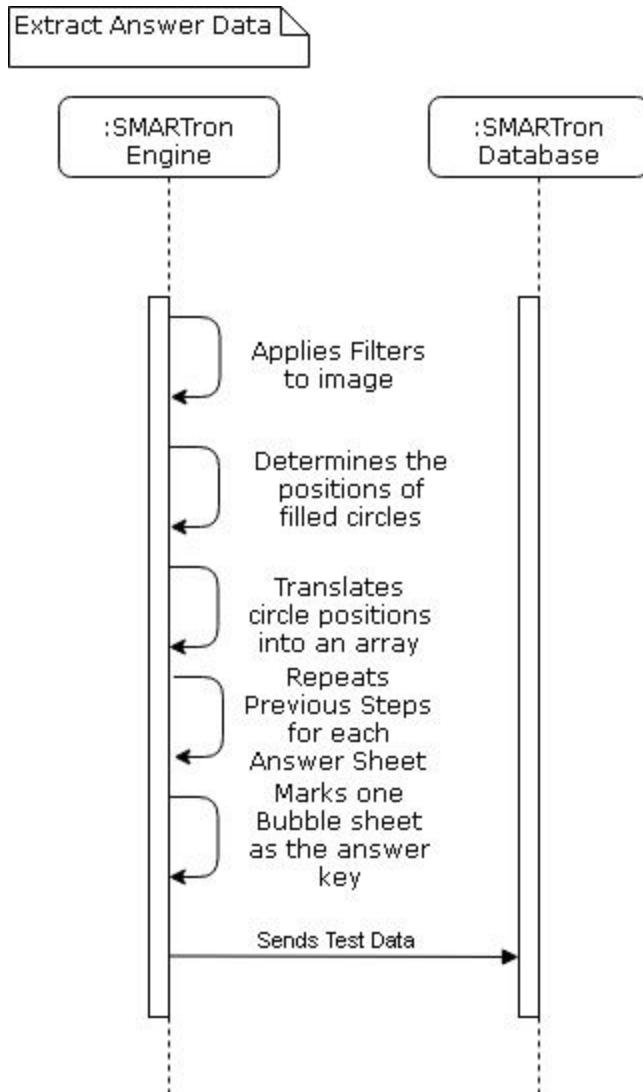
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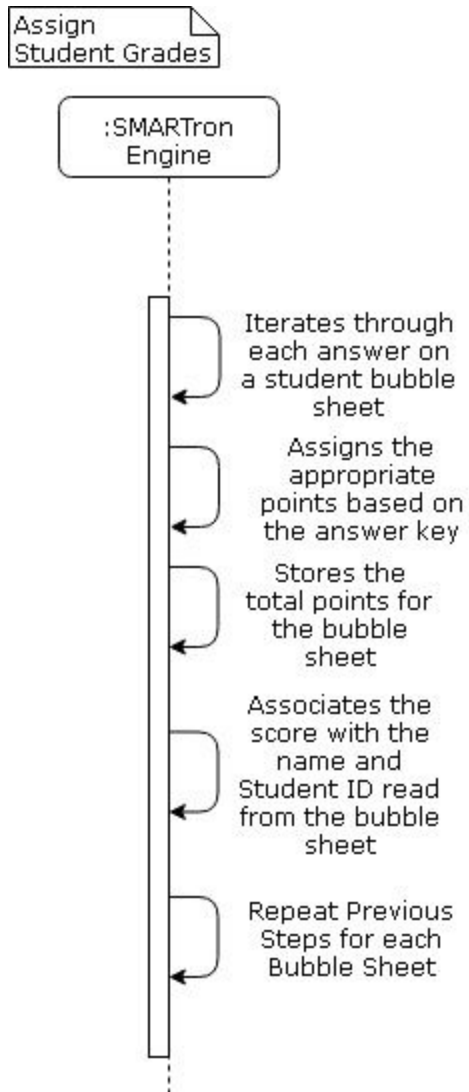


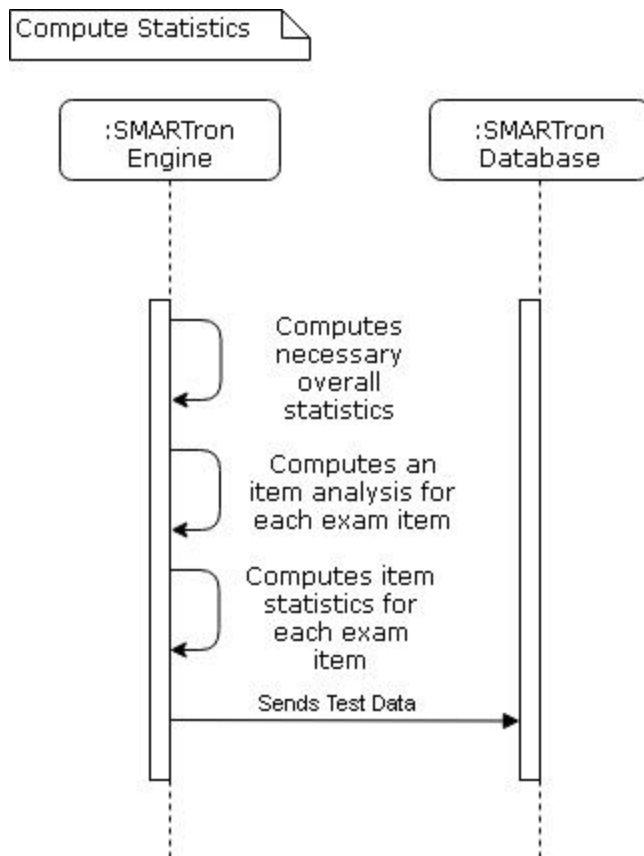
3.4 Sequence Diagrams

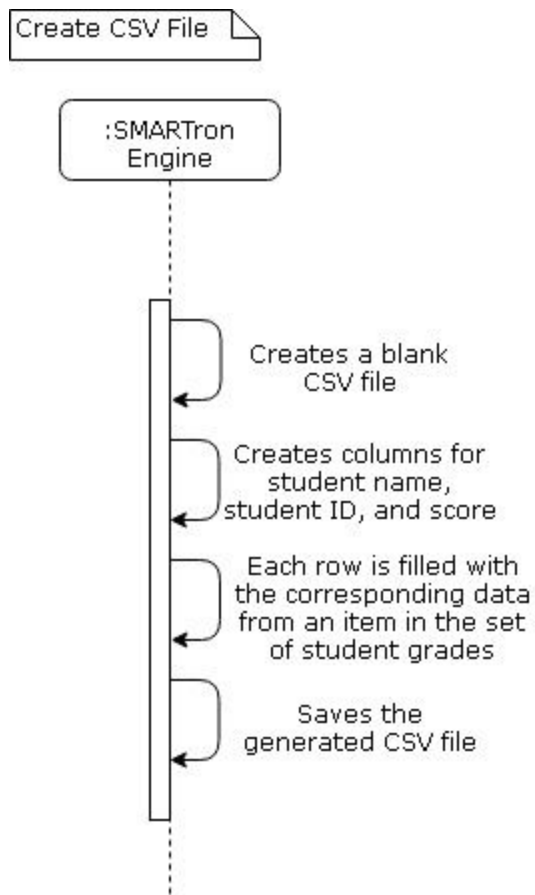


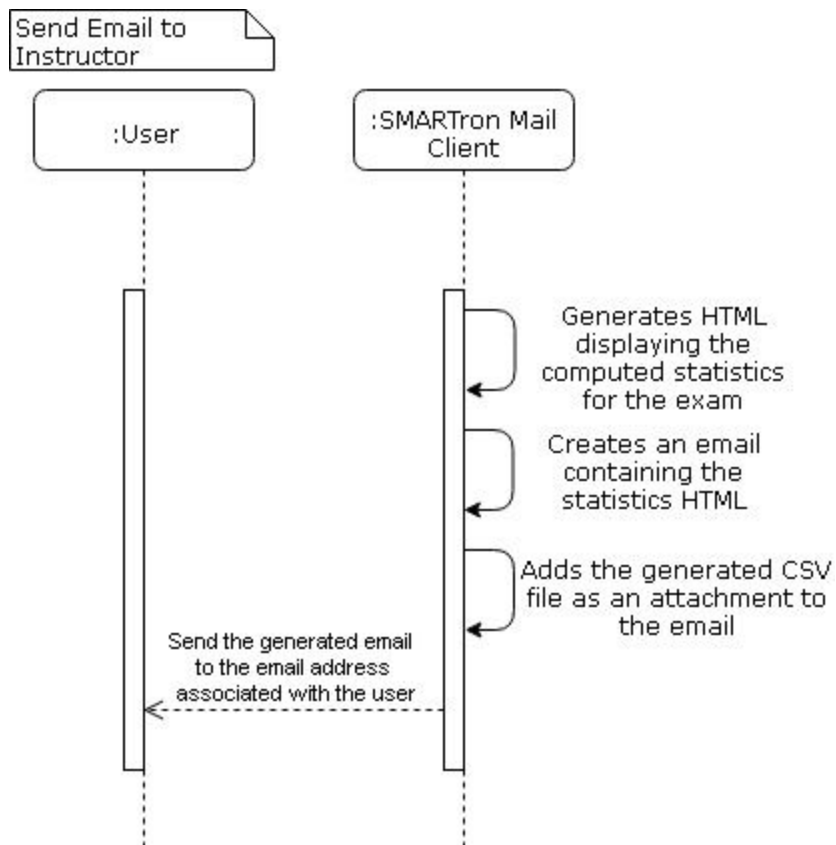


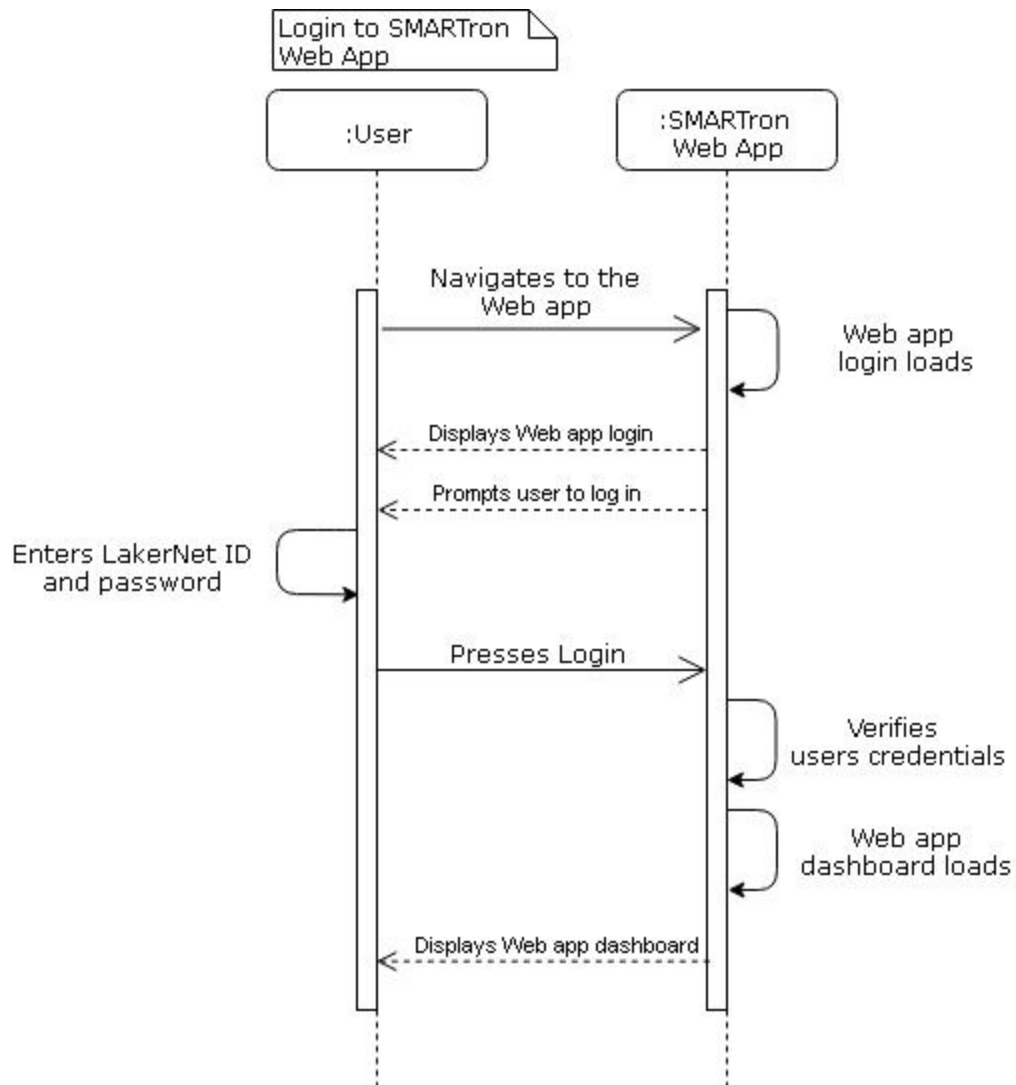




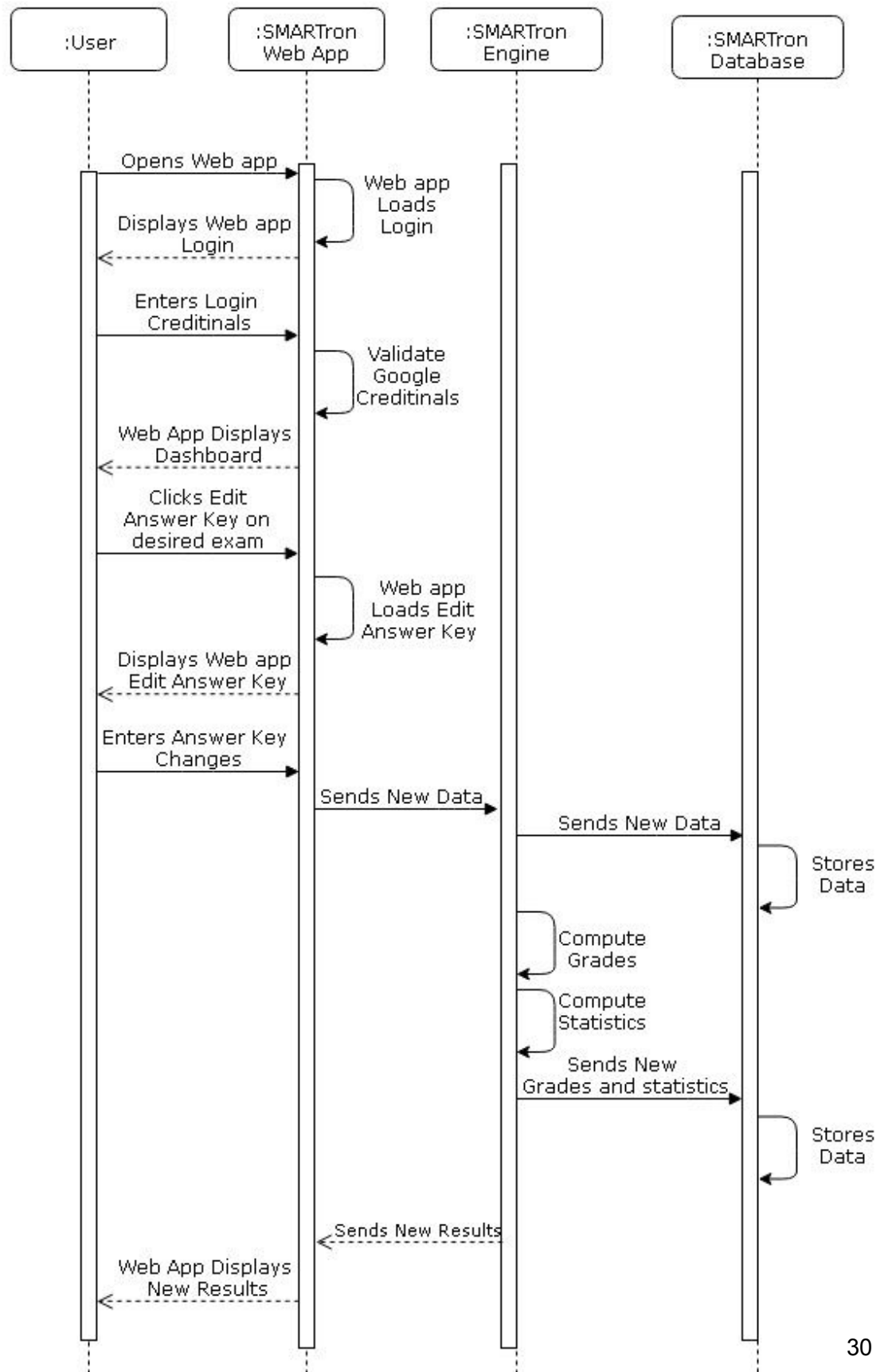


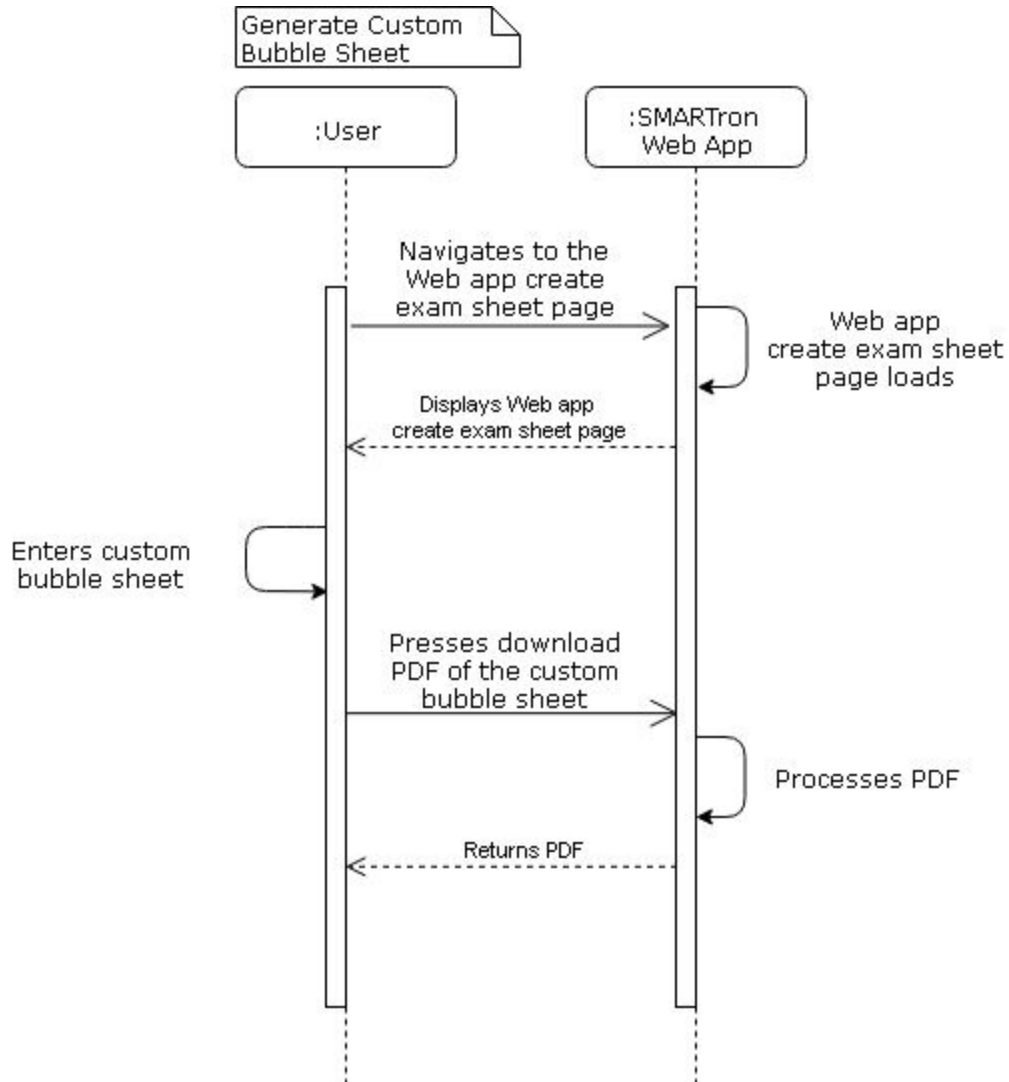




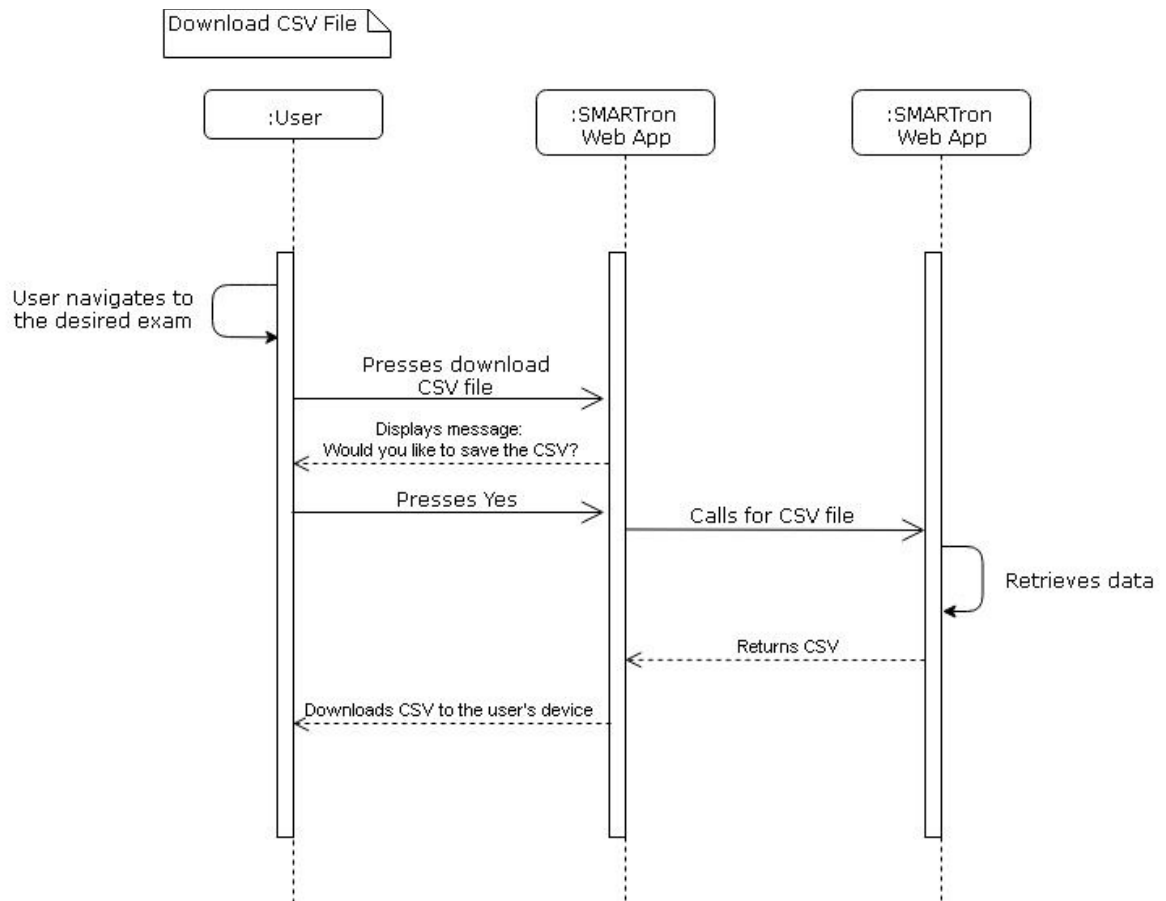


Edit Answer Key

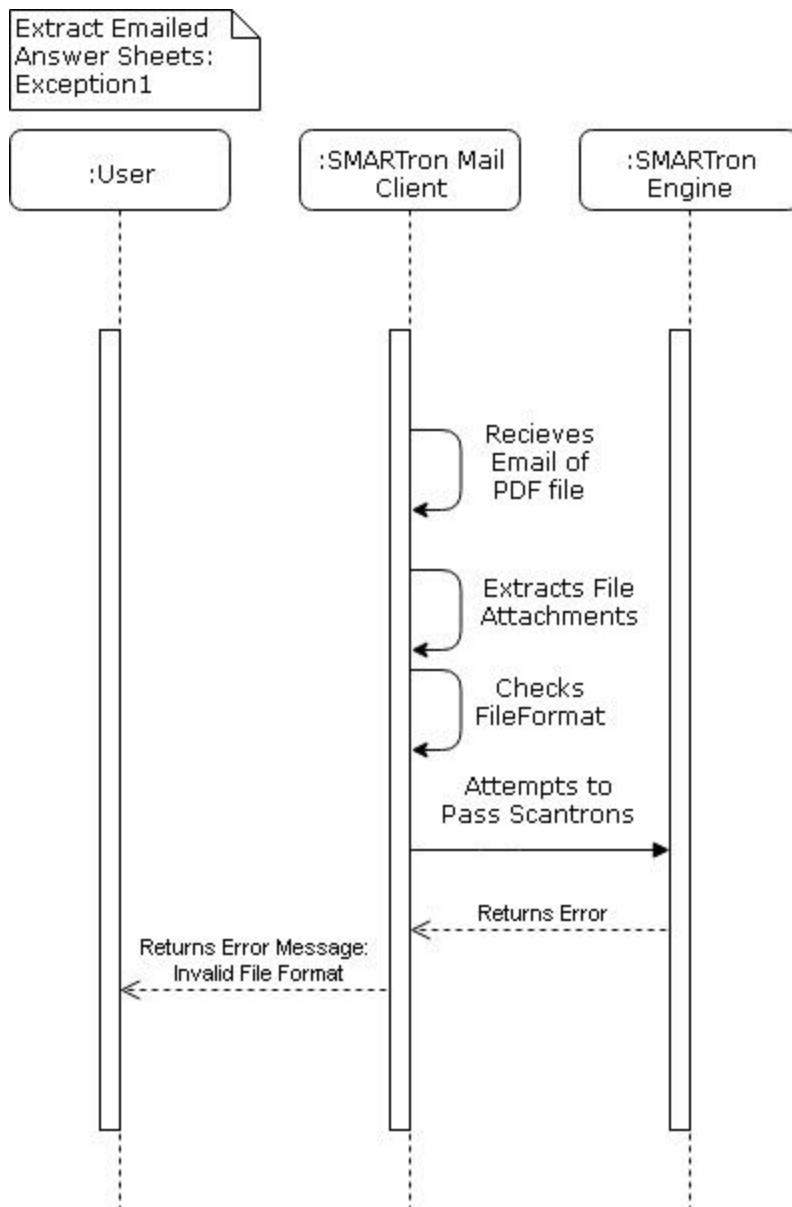


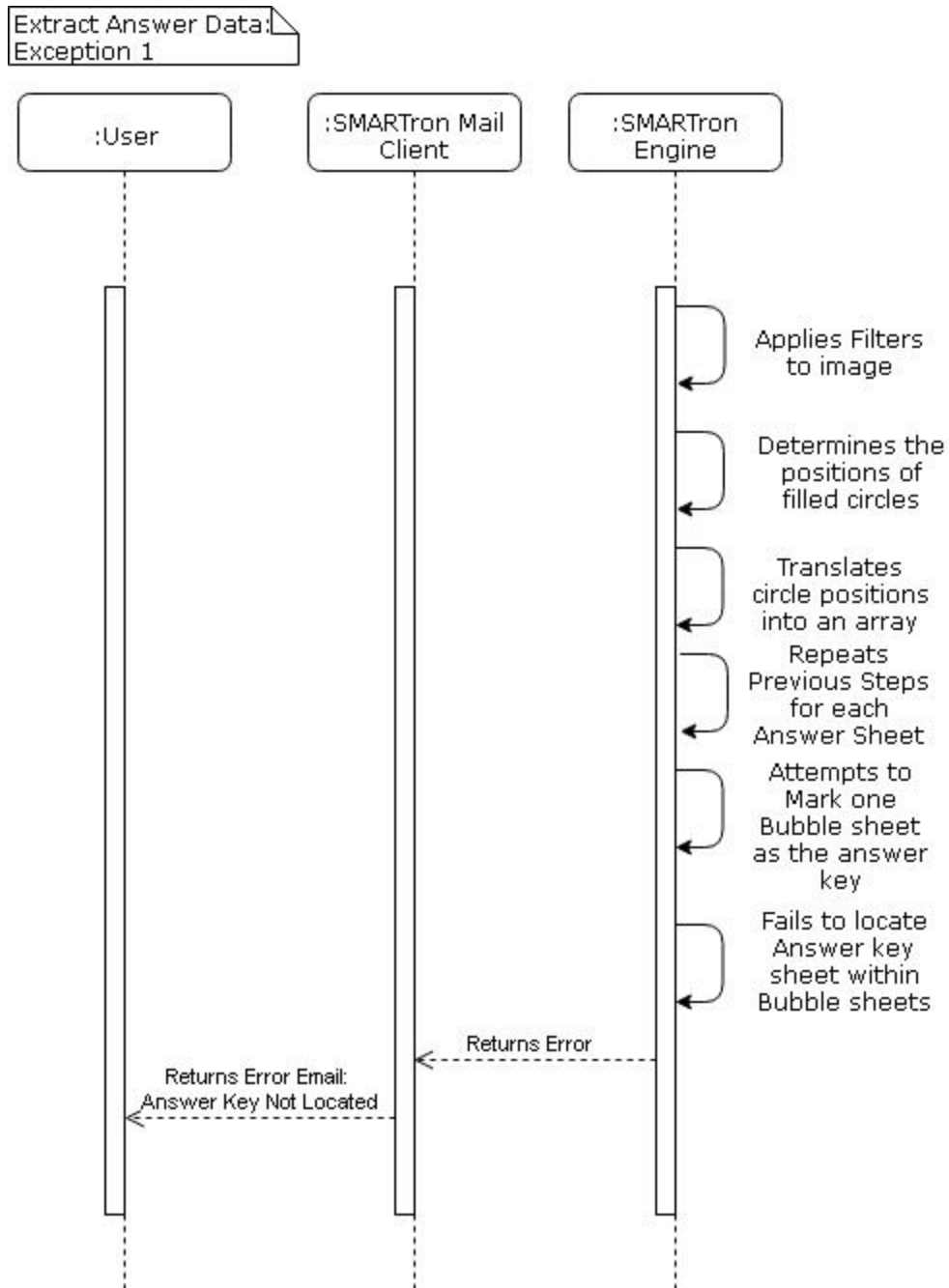


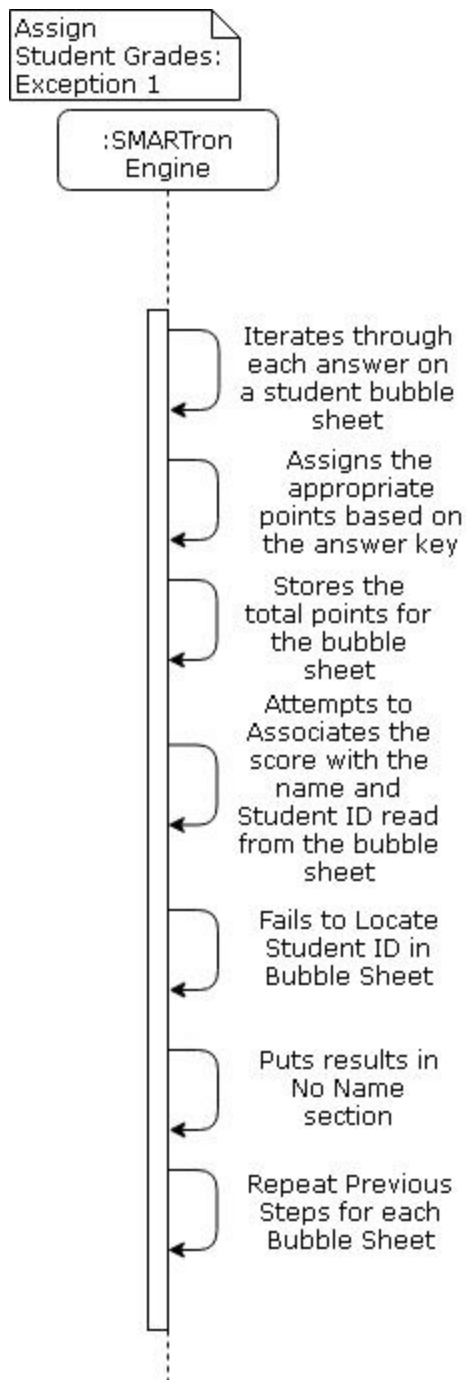
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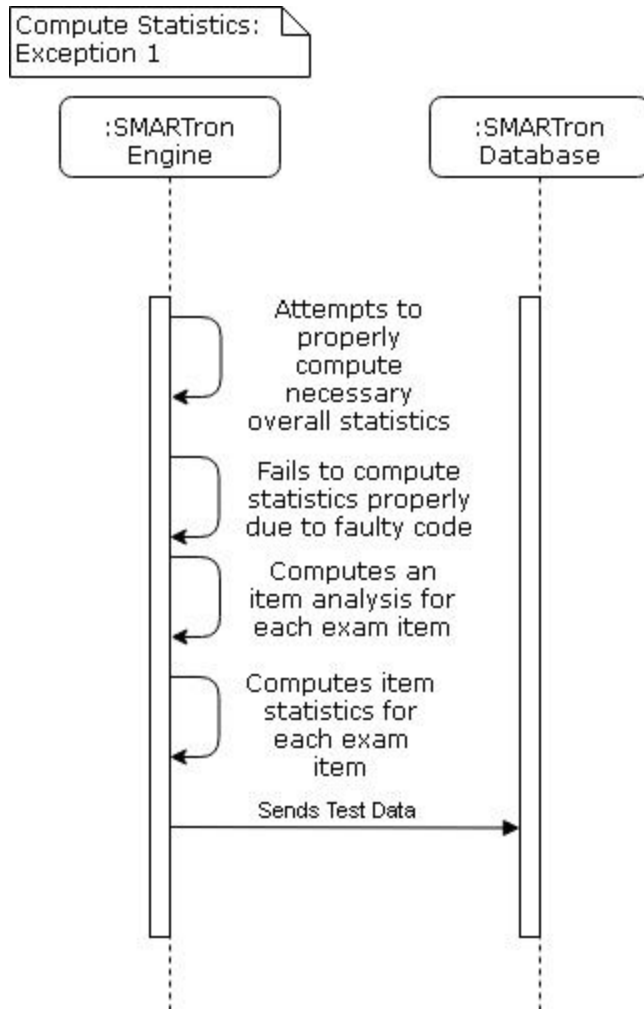


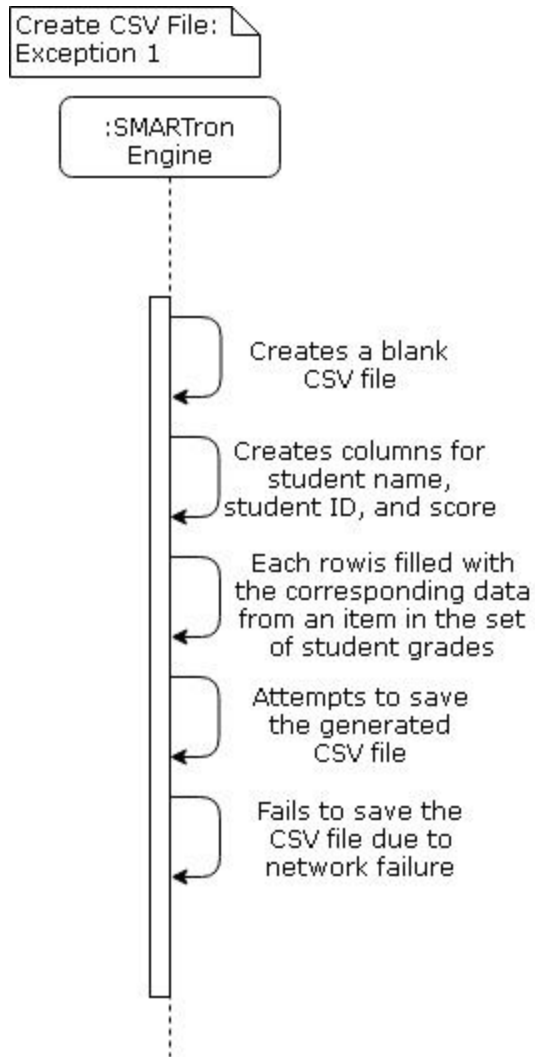
3.5 Exception Sequence Diagrams

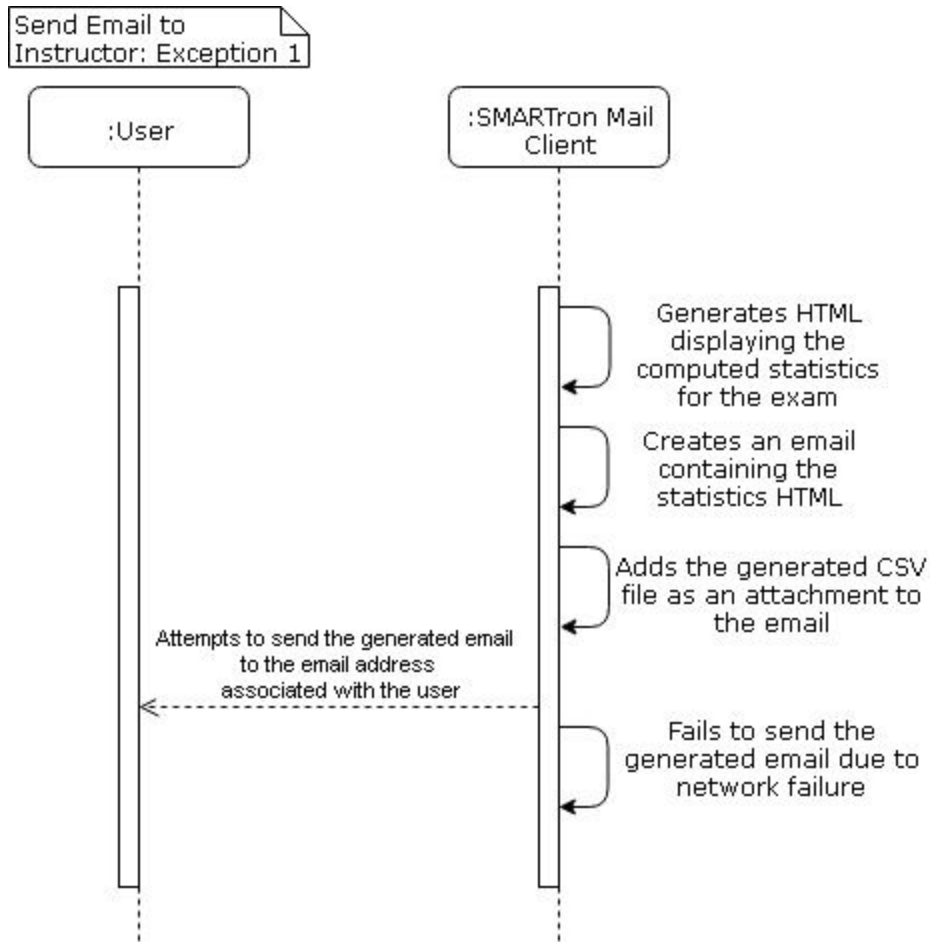


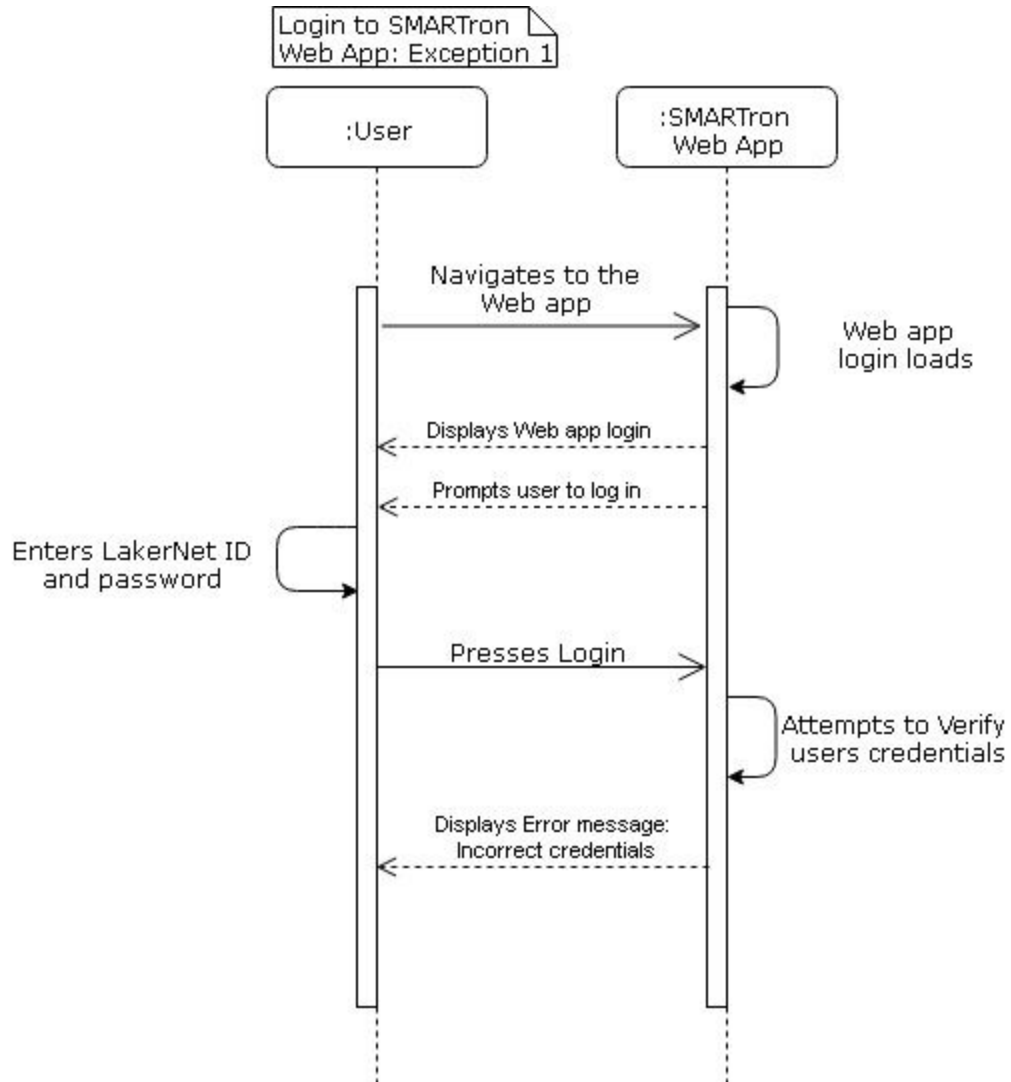




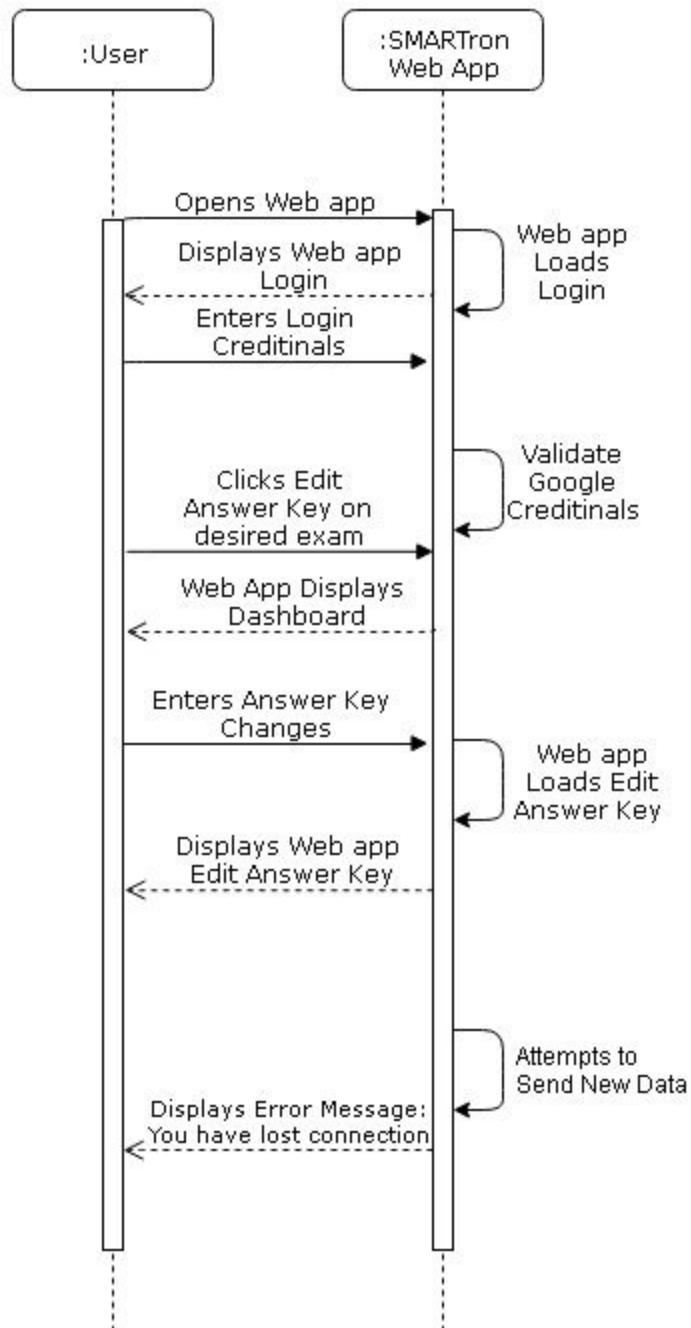


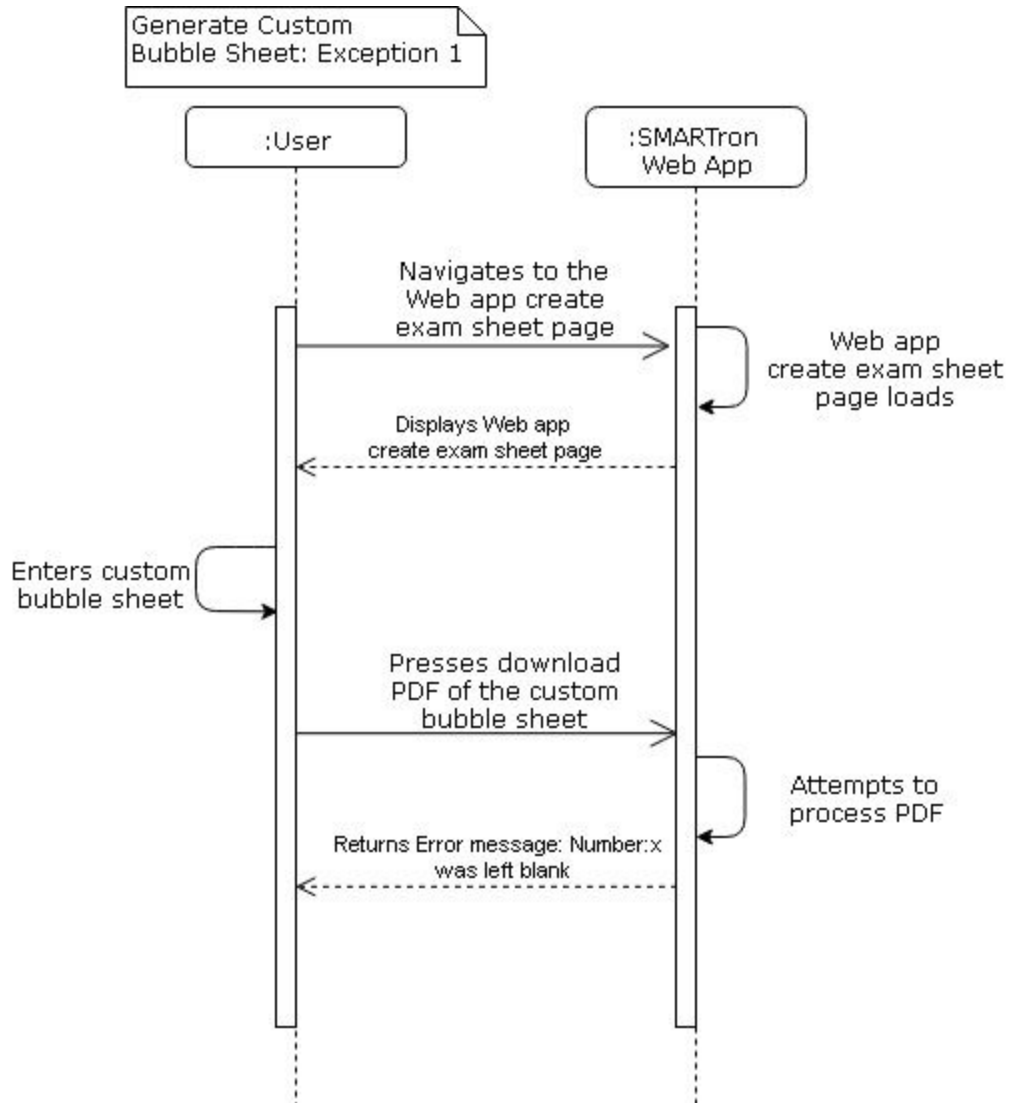


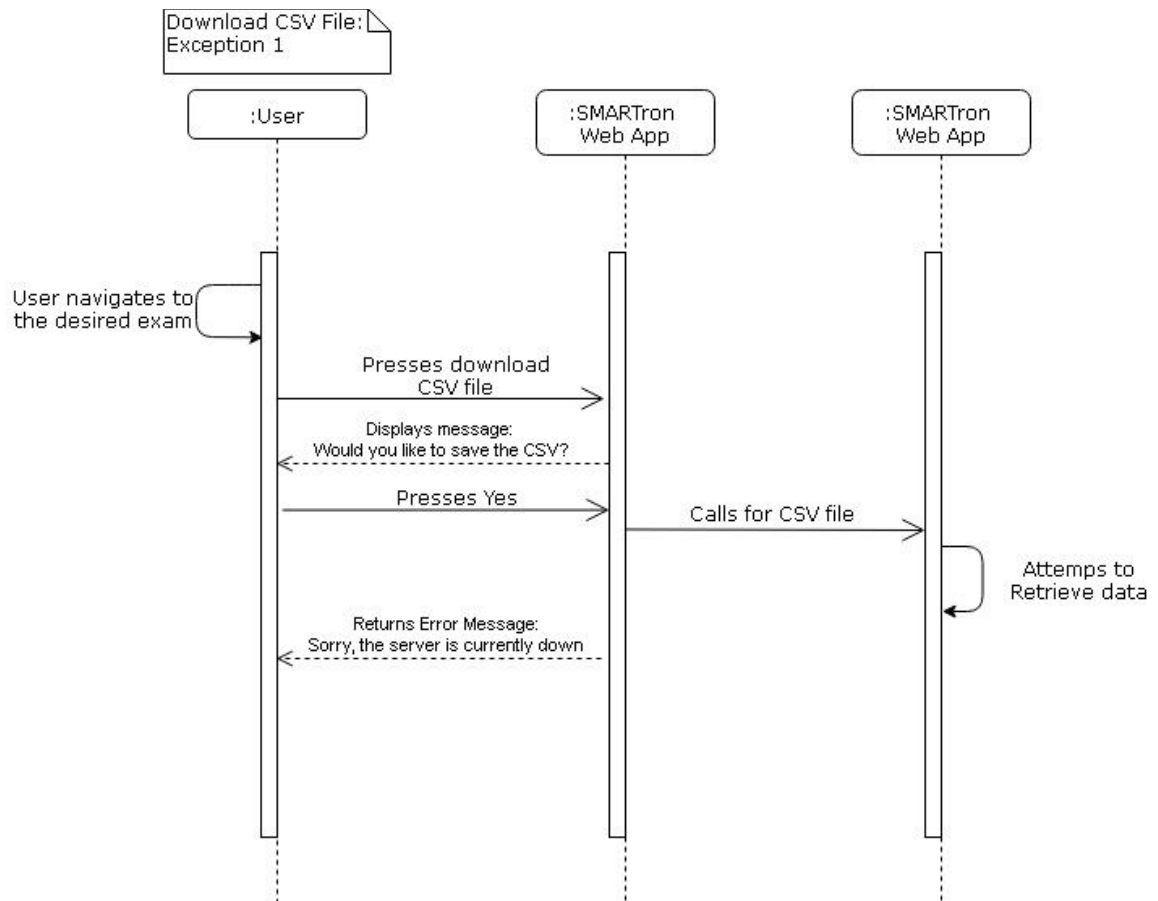




Edit Answer Key:
Exception 1







Appendix A: 200 Question Scantron Sheet

NAME (Last, First, M.I.)

BIRTHDATE

MO.	DAY	YR.
Jan.		
Feb.		
Mar.		
Apr.		
May		
Jun.		
Jul.		
Aug.		
Sep.		
Oct.		
Nov.		
Dec.		

IDENTIFICATION NUMBER

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P

SPECIAL CODES

Q	R	S	T	U	V	W	X	Y	Z

GENERAL PURPOSE - SCANTRON® - ANSWER SHEET

SEE IMPORTANT MARKING INSTRUCTIONS ON SIDE 2

SIDE 1

1	A B C D E	11	A B C D E	21	A B C D E	31	A B C D E	41	A B C D E
2	A B C D E	12	A B C D E	22	A B C D E	32	A B C D E	42	A B C D E
3	A B C D E	13	A B C D E	23	A B C D E	33	A B C D E	43	A B C D E
4	A B C D E	14	A B C D E	24	A B C D E	34	A B C D E	44	A B C D E
5	A B C D E	15	A B C D E	25	A B C D E	35	A B C D E	45	A B C D E
6	A B C D E	16	A B C D E	26	A B C D E	36	A B C D E	46	A B C D E
7	A B C D E	17	A B C D E	27	A B C D E	37	A B C D E	47	A B C D E
8	A B C D E	18	A B C D E	28	A B C D E	38	A B C D E	48	A B C D E
9	A B C D E	19	A B C D E	29	A B C D E	39	A B C D E	49	A B C D E
10	A B C D E	20	A B C D E	30	A B C D E	40	A B C D E	50	A B C D E
11	A B C D E	21	A B C D E	31	A B C D E	41	A B C D E		
12	A B C D E	22	A B C D E	32	A B C D E	42	A B C D E		
13	A B C D E	23	A B C D E	33	A B C D E	43	A B C D E		
14	A B C D E	24	A B C D E	34	A B C D E	44	A B C D E		
15	A B C D E	25	A B C D E	35	A B C D E	45	A B C D E		
16	A B C D E	26	A B C D E	36	A B C D E	46	A B C D E		
17	A B C D E	27	A B C D E	37	A B C D E	47	A B C D E		
18	A B C D E	28	A B C D E	38	A B C D E	48	A B C D E		
19	A B C D E	29	A B C D E	39	A B C D E	49	A B C D E		
20	A B C D E	30	A B C D E	40	A B C D E	50	A B C D E		

SIDE 2

SCANTRON®
GENERAL PURPOSE
ANSWER SHEET
form no. 4521

101	A B C D E	111	A B C D E	121	A B C D E	131	A B C D E	141	A B C D E
102	A B C D E	112	A B C D E	122	A B C D E	132	A B C D E	142	A B C D E
103	A B C D E	113	A B C D E	123	A B C D E	133	A B C D E	143	A B C D E
104	A B C D E	114	A B C D E	124	A B C D E	134	A B C D E	144	A B C D E
105	A B C D E	115	A B C D E	125	A B C D E	135	A B C D E	145	A B C D E
106	A B C D E	116	A B C D E	126	A B C D E	136	A B C D E	146	A B C D E
107	A B C D E	117	A B C D E	127	A B C D E	137	A B C D E	147	A B C D E
108	A B C D E	118	A B C D E	128	A B C D E	138	A B C D E	148	A B C D E
109	A B C D E	119	A B C D E	129	A B C D E	139	A B C D E	149	A B C D E
110	A B C D E	120	A B C D E	130	A B C D E	140	A B C D E	150	A B C D E
151	A B C D E	161	A B C D E	171	A B C D E	181	A B C D E	191	A B C D E
152	A B C D E	162	A B C D E	172	A B C D E	182	A B C D E	192	A B C D E
153	A B C D E	163	A B C D E	173	A B C D E	183	A B C D E	193	A B C D E
154	A B C D E	164	A B C D E	174	A B C D E	184	A B C D E	194	A B C D E
155	A B C D E	165	A B C D E	175	A B C D E	185	A B C D E	195	A B C D E
156	A B C D E	166	A B C D E	176	A B C D E	186	A B C D E	196	A B C D E
157	A B C D E	167	A B C D E	177	A B C D E	187	A B C D E	197	A B C D E
158	A B C D E	168	A B C D E	178	A B C D E	188	A B C D E	198	A B C D E
159	A B C D E	169	A B C D E	179	A B C D E	189	A B C D E	199	A B C D E
160	A B C D E	170	A B C D E	180	A B C D E	190	A B C D E	200	A B C D E

EXAMPLES

WRONG
1 1 1 3 4 5

WRONG
2 1 2 3 4 5

WRONG
3 1 2 3 4 5

RIGHT
4 1 2 3 4 5

IMPORTANT DIRECTIONS
FOR MARKING ANSWERS

- Use #2 pencil only.
- Do NOT use ink or ballpoint pens.
- Make heavy black marks that fill the circle completely.
- Erase cleanly any answer you wish to change.
- Make no stray marks on the answer sheet.

DO NOT WRITE
IN THIS SPACE

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Appendix B: Sample Results

Student Statistics Report			
Overall			
Student	Grade	Total	Percent
	F	0 / 24	0.00
	B	20 / 24	83.33
	D	16 / 24	66.67
	C	18 / 24	75.00
	B	20 / 24	83.33
	B	20 / 24	83.33
	D	16 / 24	66.67
	F	14 / 24	58.33
	B	20 / 24	83.33
	A	22 / 24	91.67
	F	14 / 24	58.33
	F	14 / 24	58.33
	F	14 / 24	58.33
	D	16 / 24	66.67
	D	16 / 24	66.67
	A	22 / 24	91.67
	C	18 / 24	75.00
	C	18 / 24	75.00
	B	20 / 24	83.33
	A	24 / 24	100.00
	C	18 / 24	75.00
	C	18 / 24	75.00
	B	20 / 24	83.33
	C	18 / 24	75.00
	D	16 / 24	66.67
	B	20 / 24	83.33
	F	14 / 24	58.33
	D	16 / 24	66.67
	B	20 / 24	83.33
	D	16 / 24	66.67
	C	18 / 24	75.00

3/8/2017

Student Statistics Report

Page 1

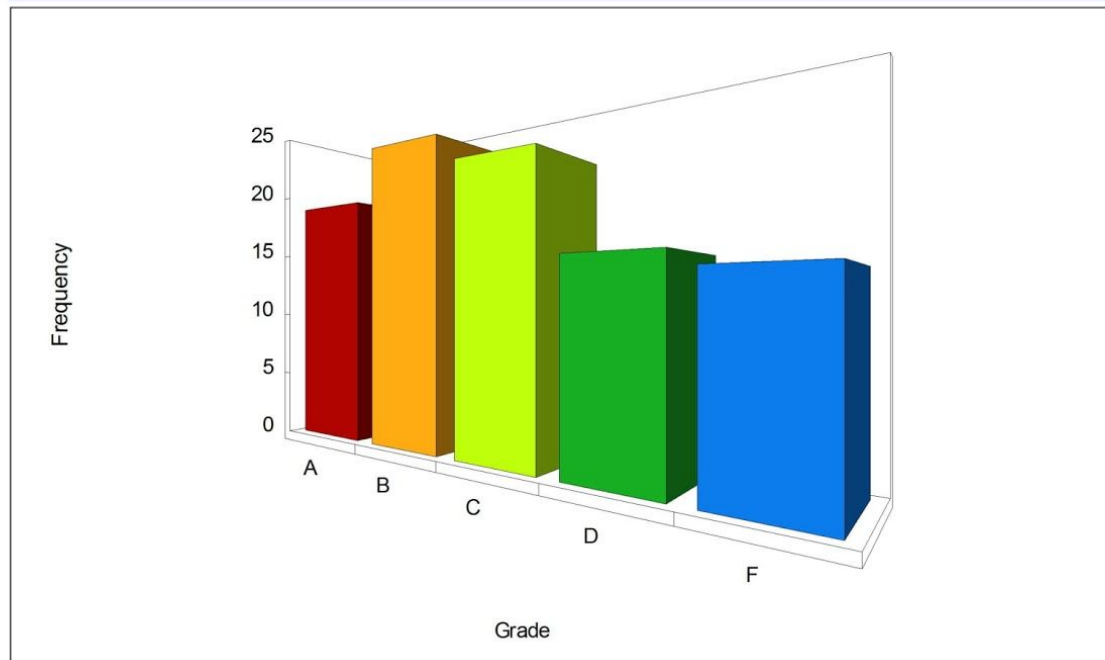
Class Frequency Distribution Report

Overall

Mean Score: 76.02%



Grade	Percent Score	Raw Score	Frequency	Percent
A	90.00 - 100.00	21.60 - 24.00	19	21.11
B	80.00 - 89.99	19.20 - 21.59	23	25.56
C	70.00 - 79.99	16.80 - 19.19	21	23.33
D	60.00 - 69.99	14.40 - 16.79	14	15.56
F	0.00 - 59.99	0.00 - 14.39	13	14.44



Note: No 3D bar graphs!

Test Statistics Report		
Overall		
Score Data		
Number of Graded Items	12	
Total Points Possible	24	
Maximum Score	24	
Minimum Score	0	
Statistics		
Mean Score	18.24	
Mean Percent Score	76.02	
Benchmark Score	-	
Range of Scores	24.00	
Standard Deviation	3.71	
Variance	13.76	
Percentiles		
Percentile (25)	16.00	
Median Score	18.00	
Percentile (75)	20.00	
Inter Quartile Range	4.00	
Confidence Intervals		
1%	17.22	
5%	17.47	
95%	19.02	
99%	19.27	
Test Reliability		
Kuder-Richardson Formula 20	0.57	
Kuder-Richardson Formula 21	1.84	
Coefficient (Cronbach) Alpha	0.57	

Condensed Item Analysis Report

Legend: Correct: ■ Incorrect: ■ Distractors Chosen More than Correct Answer: ■

Question1

Response	Frequency	Percent	
*A	83	92.22	<div><div style="width: 92.22%;"></div></div>
B	4	4.44	<div><div style="width: 4.44%;"></div></div>
C	0	0.00	<div><div style="width: 0.00%;"></div></div>
D	2	2.22	<div><div style="width: 2.22%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question2

Response	Frequency	Percent	
A	1	1.11	<div><div style="width: 1.11%;"></div></div>
B	1	1.11	<div><div style="width: 1.11%;"></div></div>
*C	87	96.67	<div><div style="width: 96.67%;"></div></div>
D	0	0.00	<div><div style="width: 0.00%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question3

Response	Frequency	Percent	
A	4	4.44	<div><div style="width: 4.44%;"></div></div>
*B	82	91.11	<div><div style="width: 91.11%;"></div></div>
C	3	3.33	<div><div style="width: 3.33%;"></div></div>
D	0	0.00	<div><div style="width: 0.00%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question4

Response	Frequency	Percent	
A	6	6.67	<div><div style="width: 6.67%;"></div></div>
B	34	37.78	<div><div style="width: 37.78%;"></div></div>
*C	49	54.44	<div><div style="width: 54.44%;"></div></div>
D	0	0.00	<div><div style="width: 0.00%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question5

Response	Frequency	Percent	
A	5	5.56	<div><div style="width: 5.56%;"></div></div>
B	16	17.78	<div><div style="width: 17.78%;"></div></div>
C	3	3.33	<div><div style="width: 3.33%;"></div></div>
*D	65	72.22	<div><div style="width: 72.22%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question6

Response	Frequency	Percent	
*A	78	86.67	<div><div style="width: 86.67%;"></div></div>
B	6	6.67	<div><div style="width: 6.67%;"></div></div>
C	0	0.00	<div><div style="width: 0.00%;"></div></div>
D	4	4.44	<div><div style="width: 4.44%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	2	2.22	<div><div style="width: 2.22%;"></div></div>

Question7

Response	Frequency	Percent	
A	0	0.00	<div><div style="width: 0.00%;"></div></div>
*B	79	87.78	<div><div style="width: 87.78%;"></div></div>
C	1	1.11	<div><div style="width: 1.11%;"></div></div>
D	8	8.89	<div><div style="width: 8.89%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	2	2.22	<div><div style="width: 2.22%;"></div></div>

Question8

Response	Frequency	Percent	
A	2	2.22	<div><div style="width: 2.22%;"></div></div>
*B	76	84.44	<div><div style="width: 84.44%;"></div></div>
C	11	12.22	<div><div style="width: 12.22%;"></div></div>
D	0	0.00	<div><div style="width: 0.00%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question9

Response	Frequency	Percent	
A	43	47.78	<div><div style="width: 47.78%;"></div></div>
*B	21	23.33	<div><div style="width: 23.33%;"></div></div>
C	20	22.22	<div><div style="width: 22.22%;"></div></div>
D	5	5.56	<div><div style="width: 5.56%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

Question10

Response	Frequency	Percent	
A	21	23.33	<div><div style="width: 23.33%;"></div></div>
*B	43	47.78	<div><div style="width: 47.78%;"></div></div>
C	11	12.22	<div><div style="width: 12.22%;"></div></div>
D	14	15.56	<div><div style="width: 15.56%;"></div></div>
E	0	0.00	<div><div style="width: 0.00%;"></div></div>
Missing	1	1.11	<div><div style="width: 1.11%;"></div></div>

SMARTron Software Requirements Specification v1.0

Question11

Response	Frequency	Percent	
A	1	1.11	
B	6	6.67	
C	1	1.11	
*D	81	90.00	
E	0	0.00	
Missing	1	1.11	

Question12

Response	Frequency	Percent	
A	2	2.22	
B	6	6.67	
C	4	4.44	
*D	77	85.56	
E	0	0.00	
Missing	1	1.11	

SMARTron Software Requirements Specification v1.0

Test Item Statistics Report								
Question		Summary Statistics				Reliability		
Question	Points	Graded	Correct	Incorrect	No Response	Point Biserial	Percent Correct	
Question1	2	90	83	6	1	0.35	92.22	<div><div></div></div>
Question2	2	90	87	2	1	0.55	96.67	<div><div></div></div>
Question3	2	90	82	7	1	0.40	91.11	<div><div></div></div>
Question4	2	90	49	40	1	0.48	54.44	<div><div></div></div>
Question5	2	90	65	24	1	0.58	72.22	<div><div></div></div>
Question6	2	90	78	10	2	0.41	86.67	<div><div></div></div>
Question7	2	90	79	9	2	0.35	87.78	<div><div></div></div>
Question8	2	90	76	13	1	0.49	84.44	<div><div></div></div>
Question9	2	90	21	68	1	0.37	23.33	<div><div></div></div>
Question10	2	90	43	46	1	0.45	47.78	<div><div></div></div>
Question11	2	90	81	8	1	0.36	90.00	<div><div></div></div>
Question12	2	90	77	12	1	0.35	85.56	<div><div></div></div>

Appendix C: Entity-Relationship Diagram

