DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

PROJECT CHARTER
CSE 4316: SENIOR DESIGN I
FALL 2021

VENDING SERVICES
AUTOMATED VENDING & RESERVATION SYSTEM

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	10.08.2021	HL	document creation
0.2	10.12.2021	WA, HL, SS, NW	complete draft

CONTENTS

LIST OF FIGURES

1 PROBLEM STATEMENT

Building the smart vending machine that give the convenience for both sellers and customers. It can help the seller manage and control the vending machine effectively, while the customer can easily to buy or reserve products and make a payment.

2 METHODOLOGY

We are going to build an automated snack vending machine and reservation system where customers may order before hand or use traditional methods of control. The customers will reserve the snacks by using an app for a period time, and they will be given the code to pick up the snacks. The payment is made through the app or at the machine.

3 VALUE PROPOSITION

The University of Texas at Arlington can benefit from the project Vending Services is undertaking. Currently, the network of vending machines on campus is marred by the unreliability of the card payment system and the fact that the system is not smart enough to detect whether if a product is dispensed. Students are also unable to track the current availability of certain items at a specific vending machine location. Additionally, the distribution of snacks currently is preformed by an outside party contracted by the University. A problem with this is that the MavID system, which is supposed to be able to allow for students to pay with their MavID cards does not work. Vending Services, through this project, strives to demonstrate with a proof-of concept product that the University may implement a better system of managing its vending machines.

4 DEVELOPMENT MILESTONES

This list of core project milestones should include all major documents, demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month.

Provide a list of milestones and completion dates in the following format:

- Project Charter first draft - October 2021

- System Requirements Specification - October 2021

- Architectural Design Specification - November 2021

- Demonstration of Vending Machine communicating with the server - February 2022

- Detailed Design Specification - March 2022

- Demonstration of client application communicating with the server - January 2022

- Demonstration of full-featured vending machine without the use of client app - April 2022

- CoE Innovation Day poster presentation - May 2022

- Demonstration of the completed construction of the physical Vending Machine - January 2022

- Demonstration of CAD design of the Vending Machine - November 2021

- Demonstration of full functionality of client app with the Vending Machine - April 2022

- Final Project Demonstration - May 2022

5   BACKGROUND

As many students at The University of Texas at Arlington are aware, the vending machines around campus are quite lack-luster. The machines are an older style design with slightly-more-modern payment terminal operating on the cell phone network. The downtime of these machines are quite bad too. Interestingly enough, the mechanical aspect of the machine hardly fails. The most common failure mode we've observed is the payment terminal refusing to accept a card. Another scenario to consider is walking all the way across campus to a vending machine in UH only to find they are out of Honey Buns. Both of these scenarios result in a loss of potential customers.

These issues could easily be improved in a low-cost manner. Both problems above could be resolved with an Internet of Things (IoT) solution. Status reporting on the machine instead of relying on user-reports for issues would address the downtime. Inventory management and an application can be used to address the out-of-stock problem. We could handle all payments through the application, which would save us some hardware money [NFC/magstrip/chip reader]. However, customer convenience should be prioritized, so we will only cut the physical payment methods for budget issues.

Other less important issues with vending machines include: item not vending but charging the customer for the transaction [hurts brand trust / reputation], having to run a call center for technical support, and lack of automation for statistical analysis.

A solution to this issue would be the use of infrared sensors at the base of the machine to detect if the item has vended or not. This implementation has already been used on garage door openers as a federally-mandated safety feature since 1993. An idea is continuing to drive the vending screw until we detect the beam is broken [for a maximum of 5 seconds, failure results in no charge to customer + log the event with the server for tracking]. Having a touchscreen on the machine means we get less mechanical sturdiness but more flexibility. We can have a "report an issue" menu and even have it chat with a customer service rep or email a ticket. Especially since this newer generation of students does not like calling via phone nearly as much [1]. Finally, each machine can produce data for automated statistic gathering [such as downtime, restocking rates, sales figures, etc.].

6   RELATED WORK

Commercially available there are currently a few other products which are similar. To name a few, Signifi Solutions Inc. - Spark [2], Crane Merchandising Systems - Merchant MEDIA Combo [3], Automated Merchandising Systems Inc. - SensitÂ® Guaranteed Delivery System equipped vending machines [4], Digital Media Vending International, LLC. - Smart Vending Machines [5], and VendNovation, LLC. - VN Cloud [6].

listed two examples of touch screen equipped vending machines, Signifi Solutions Inc. - Spark and Crane Merchandising Systems - Merchant MEDIA Combo. Both are quite successful from what research we have seen with their market share reports. However, a premium is charged for the touchscreen variant. Some of these appear to be normal vending machines with just a touchscreen module replacing the industry standard key-pad setup. We have one of these on campus and I believe the touchscreen solution to be quite robust compared to a standard capacitive touch screen. Likely just a thicker "glass" front. The screen is set back quite a ways from the outside of the "glass". The functionality of these screens (in the videos on the respective websites) is limited for the hardware. Usually a product grid with a popup window for more details / confirm pricing / etc.

For the sensing beam at the bottom of the machine, Automated Merchandising Systems Inc. - SensitÂ® Guaranteed Delivery System equipped vending machines appear to be the industry standard. Not only are they one of the largest manufacturers of vending machines in the US, but they also hold a great deal of patents for their Sensit system.

An interesting example is Digital Media Vending International, LLC. - Smart Vending Machines which

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are custom built (this appears to include the software solution) for the product you want to vend. The vending machine diversity is quite impressive on their website. Their touchscreen software seems to have much more functionality than the main vending machine manufacturers. That is to say, they take full advantage of the larger touch screens with extra features.

For the cloud statistics / reporting, VendNovation, LLC. - VN Cloud appears to be the current leader. They don't have many specifics other than features and services. A few interesting ones they list is the ability to update the front-page graphics on the screen from the cloud, third party integration, and access control. The graphics on screen portion seems like it might be do-able for our project, but the other two are quite involved and we likely wouldn't have time.

7   SYSTEM OVERVIEW

Our solution will be a system very similar to current vending machines but with added functionality of a web/mobile app which can reserve items, check inventory, handle transactions, multiple item vends, etc. We intend to use a touch screen for physical interaction. This would be the primary method for most customers. The app would be focused on customers who worked in that building or would use that vending machine often. The "app" on the touch screen will be very similar in style and UX to the mobile/web app. This will make it feel very familiar for a user no matter which interface they use. For reservations, we will handle it as Amazon Lockers do: users will be given a pin and enter it on the touchscreen to redeem it.

On the backend, the inventory will be manually updated whereas sales will decrement item counts. We will have the ability for the server to see if a machine has error states, failed to vend, offline, etc. Order information will also need to be kept in a database for reservations / reporting.
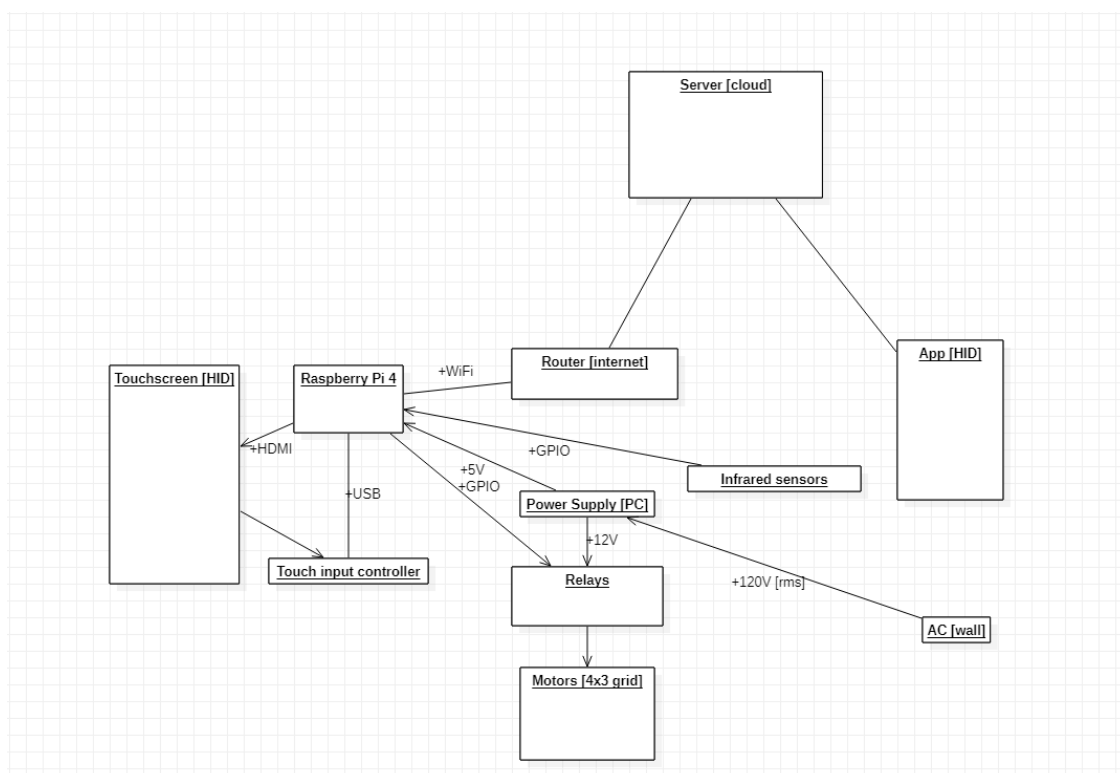

Figure 1: Diagram of major system components

8 ROLES & RESPONSIBILITIES

The stakeholders of this project are Dr. Christopher Conly and the members of the Vending Services team. The point of contact on the customer side will be done in person, generally after class, during office hours, or through email.

The team members of Vending Services are: William Anderson, Han Le, Sean Slater, and Noah Walker. William Anderson, Software Engineering major, naturally will handle administrative tasks, such as the Scrum Master role throughout the course of the project, and lead the formal design specifications of the project. Anderson will also be in charge of scheduling meetings, assigning sprint tasks, and writing the presentations. Han Le and Sean Slater, Computer Engineering major, will handle assisting the design of the physical hardware systems and the design of the physical Vending Machine case. Noah Walker, Computer Science major, will assist in the design of the software systems such as the client app, maintenance app, physical app, communication between devices,etc. The product owner will be the entire team of Vending Services.

9 COST PROPOSAL

The current approximation of the budget currently stands at $\tilde{\$}650$. With our preliminary review of the construction of vending machines, and availability of hardware that meets within our budget of $ 800 we have determined that we will need to construct the machine by hand at a miniature scale compared to most traditional vending machines. The biggest expense of the project is the computer control of the physical machine. We will be using a Raspberry Pi 4 as it allows for General Purpose Input and Output (GPIO) control to relays to control the motors, and has provisions to run a touchscreen for user control using traditional methods. Additionally, as this product is a vending machine, snacks are obviously needed to test to see if the system works properly. These snacks will rest on metal spiral coils located in product bins.

9.1 PRELIMINARY BUDGET

Item	$	amount	subtotal
Product Bins	3.98	12	47.76
Raspberry Pi	109.99	1	109.99
Metal	18.00	6	108.00
Motors	12.99	12	155.88
Touchscreen	98.99	1	98.99
Relays	7.92	3	23.76
Snacks	20.00	1	20.00
Coils	18.22	1	18.22
Acrylic	9.55	1	9.55
Misc. Hardware	50.00	1	50.00
		total	642.15

9.2 CURRENT & PENDING SUPPORT

As of this time, the budget for this project is $ 800 and is derived from the base budget that the Computer Science and Engineering has allotted to each Senior Design team. Vending Services is not currently looking for potential project sponsors.

10   FACILITIES & EQUIPMENT

The Vending Services team will be conducting all operations in ERB 202 or on Microsoft Teams. Vending Services will be preforming some manufacturing tasks off-campus due to space limitations and potential tool availability issues.

11   ASSUMPTIONS

An assumption is a belief of what you assume to be true in the future. You make assumptions based on your knowledge, experience or the information available on hand. These are anticipated events or circumstances that are expected to occur during your project's life cycle.

The following list contains critical assumptions related to the implementation and testing of the project.

- Vending Services will not be directly processing payments and will use cloud services

- All parts will delivered for assembly according to specifications by the 6th sprint cycle

- Access to the customer installation site will be provided by the 8th sprint cycle

- The customer will provide ample power and network connectivity at the installation site

- The off site network infrastructure will allow TCP network traffic on port 80.

12   CONSTRAINTS

Constraints are limitations imposed on the project, such as the limitation of cost, schedule, or resources, and you have to work within the boundaries restricted by these constraints. All projects have constraints, which are defined and identified at the beginning of the project.

Constraints are outside of your control. They are imposed upon you by your client, organization, government regulations, availability of resources, etc. Occasionally, identified constraints turn out to be false. This is often beneficial to the development team, since it removes items that could potentially affect progress.

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by April 30th, 2022

- The customer will provide no more than two maintenance personnel to assist in on-site installation

- Customer installation site will only be accessible by development team during normal business hours

- Total development costs must not exceed $800

- All data obtained from customer site must be reviewed and approved for release by the Information Security Office prior to being copied to any internet connected storage medium

13   RISKS

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Availability of X part due to contractor delay	0.50	20	10
Offsite server access not available at installation site	0.20	14	2.8
Internet access not available at installation site	0.30	9	2.7
Delays in shipping from overseas vendors	0.10	20	2.0
Change in required materials which changes budget	0.15	10	1.5

Table 1: Overview of highest exposure project risks

14 DOCUMENTATION & REPORTING

14.1 MAJOR DOCUMENTATION DELIVERABLES

14.1.1 PROJECT CHARTER

The Project Charter will be maintained by all team members of Vending Services. Changes to the Project Charter will be conducted whenever there is major information that needs to be added, modified or deleted. Changes will be made based on a group consensus. The initial version of the Project charter will be delivered in October 2021. The final version of this project charter will be delivered sometime in May 2022. Updates to this document are to be made on a case-by-case basis.

14.1.2 SYSTEM REQUIREMENTS SPECIFICATION

The System Requirements Specification will be maintained by all team members of Vending Services. Changes to the Project Charter will be conducted whenever there is major information that needs to be added, modified or deleted. Changes will be made based on a group consensus. The initial version of the System Requirements Specification will be delivered in late October 2021. The final version of this System Requirements Specification will be delivered sometime in May 2022. Updates to this document are to be made on a case-by-case basis.

14.1.3 ARCHITECTURAL DESIGN SPECIFICATION

The Architectural Design Specification will be maintained by all team members of Vending Services. Changes to the Architectural Design Specification will be conducted whenever there is major information that needs to be added, modified or deleted. Changes will be made based on a group consensus. The initial version of the Architectural Design Specification will be delivered in mid-November 2021. The final version of this Architectural Design Specification will be delivered sometime in May 2022. Updates to this document are to be made on a case-by-case basis.

14.1.4 DETAILED DESIGN SPECIFICATION

The Detailed Design Specification will be maintained by all team members of Vending Services. Changes to the Architectural Design Specification will be conducted whenever there is major information that needs to be added, modified or deleted. Changes will be made based on a group consensus. The initial version of the Detailed Design Specification will be delivered in March 2022. The final version of this Detailed Design Specification will be delivered sometime in May 2022. Updates to this document are to be made on a case-by-case basis.

14.2 RECURRING SPRINT ITEMS

14.2.1 PRODUCT BACKLOG

Items are to be added based on group consensus and prioritised based on project milestones listed in Section 4 of the Project Charter. Trello will be used starting in Sprint 2 to assist in managing tasks.

14.2.2 SPRINT PLANNING

There will be a total of eight (8) sprints for this project. Sprint 1 begins with the project group assignment on 18 September 2021, and Sprint 8 will conclude in May 2022.

14.2.3 SPRINT GOAL

The Sprint Goal will be determined and decided upon through a group consensus. The goal will be determined based upon the tasks to be completed in each sprint.

14.2.4 SPRINT BACKLOG

The Sprint Backlog will be decided on a group consensus and Trello and Slack will be used to maintain the backlog.

14.2.5 TASK BREAKDOWN

Individual tasks will be determined by William Anderson, who will decide what tasks to assign to each team

14.2.6 SPRINT BURN DOWN CHARTS

William Anderson will be responsible for producing the burn charts, in which the total amount of effort spent on each task will be determined using Trello. The burn charts will be developed using non-manual methods.

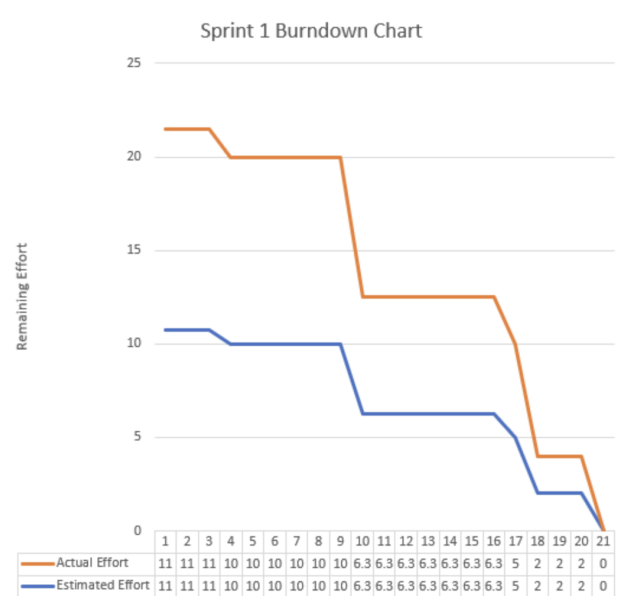|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Actual Effort	11	11	11	10	10	10	10	10	10	6.3	6.3	6.3	6.3	6.3	6.3	6.3	5	2	2	2	0
Estimated Effort	11	11	11	10	10	10	10	10	10	6.3	6.3	6.3	6.3	6.3	6.3	6.3	5	2	2	2	0

Figure 2: Example sprint burn down chart

14.2.7 SPRINT RETROSPECTIVE

The sprint retrospective will be handled such that any mistakes, problems, and other notable events that were observed during the sprint are addressed and resolved in the next sprint. Additionally, there will be a presentation given to the class, and that presentation will be overseen by William Anderson, and will document events that occur during each Sprint.

14.2.8 INDIVIDUAL STATUS REPORTS

Individual Status Reports will be completed at the end of every sprint by every member of Vending Services. These Individual Status reports will include a sprint burn chart, tasks that were assigned to the group and each individual, some actions that are to be taken in the next Sprint, and a review of the performance of each team member in several different categories.

14.2.9 ENGINEERING NOTEBOOKS

The engineering notebooks will be updated, at a minimum, once every team meeting. Two pages of notes would be considered acceptable but may vary per meeting topic. The "witness" who will sign off on each page of an engineering notebook may be a team member, a person who holds an engineering degree from an accredited university, or an engineering major at The University of Texas at Arlington. Random checks will be conducted in order to hold people responsible for maintaining an engineering notebook.

14.3 CLOSEOUT MATERIALS

14.3.1 SYSTEM PROTOTYPE

The final system prototype will be a miniature vending machine, a server for which to communicate to devices, an client application, and a application for preforming maintenance. There will be a Prototype Acceptance Test (PAT) and a Field Acceptance Test (FAT) with the customer. The product will be demonstrated off-site to ensure that it can communicate outside the campus network.

14.3.2 PROJECT POSTER

The project poster will include major topics of the project, plus the use cases and value proposition. It will be of standard size normally used in the CoE innovation day. The poster will be delivered at the end of Sprint 8.

14.3.3 WEB PAGE

Vending Services will maintain a private web page hosted on a campus server (Omega) that will require VPN access to the campus network. When the project is completed in May 2022, the private web page will be open to the public, which will require a new hosting server and a domain name. The website will be updated on an regular basis, around once every two sprints. The website will contain some photos, a description of the product, contact links, and the demo video.

14.3.4 DEMO VIDEO

A 10 minute demo video will be recorded that will show all aspects of the functionality of the entire system. It will cover topics such as using the machine from a client standpoint and maintaining the machine when it is needed.

14.3.5 SOURCE CODE

The source code will be maintained using git, a version control management system. We will use GitHub, a git source control management system, as we can utilize their professional features for free using student licenses. The source code will be turned over to the customer, once completed since this project will be open-source using the MIT license. the license information will be located in all files of the source code, and in a specific, dedicated license file on GitHub.

14.3.6 SOURCE CODE DOCUMENTATION

We will employ the use of Doxygen to document source code and will present this in a browsable HTML format located on the website

14.3.7 HARDWARE SCHEMATICS

We will be using a wiring diagram for the system which will contain the layout for the physical machine itself.

14.3.8 CAD FILES

We will be utilizing CAD software for the physical chassis of our project. We will be using Solidworks or another suitable CAD software. We will be exporting these files using the STL file format.

14.3.9 INSTALLATION SCRIPTS

The customer will be provided with an installation program to install the application to the physical machine through an internal USB port. The client application will be available to the public. The installation program will allow for the installer to connect to a server, and validate the device using a serial number that is authenticated at the server.

14.3.10 USER MANUAL

The customer will receive a digital PDF user manual with this product. We will have links on our website for the customer to view a setup video for assistance in the installation.

References

[1] N. Howe, "Why Millennials Are Texting More And Talking Less," *Forbes*, 2015.

[2] S. S. Inc., "Spark - Signifi Solutions Inc." website, 2021, example of a touch screen vending machine.

[3] C. M. Systems, "Crane Merchandising Systems - Leading Full-Service Vending Solutions Provider," website, 2017, example of a touch screen vending machine.

[4] A. M. S. Inc., "OUR TECHNOLOGY |," website, 2016, iR based sensing technology - list of products equipped.

[5] L. Digital Media Vending International, "Smart Vending Machines - Intelligent Vending Machines for any product," website, 2021, example of custom made touch screen vending machines.

[6] L. VendNovation, "Vending Machine Software | VendNovation," website, 2019, example of cloud based vending system.