A^2 Technologies:

Automating the delivery of anesthesia for the 21st Century

Prepared by
Nivetha Babu
Alexander Moreno
Nguyen Vu
Linda Zhou
in

CS 440 – Software Engineering I
at the
University of Illinois Chicago

with Professor John Bell

Fall 2018

Table of Contents

REMOVE OR REPLACE ALL TEXT IN RED ITALICS BEFORE SUBMITTING REPORT

List of Figures

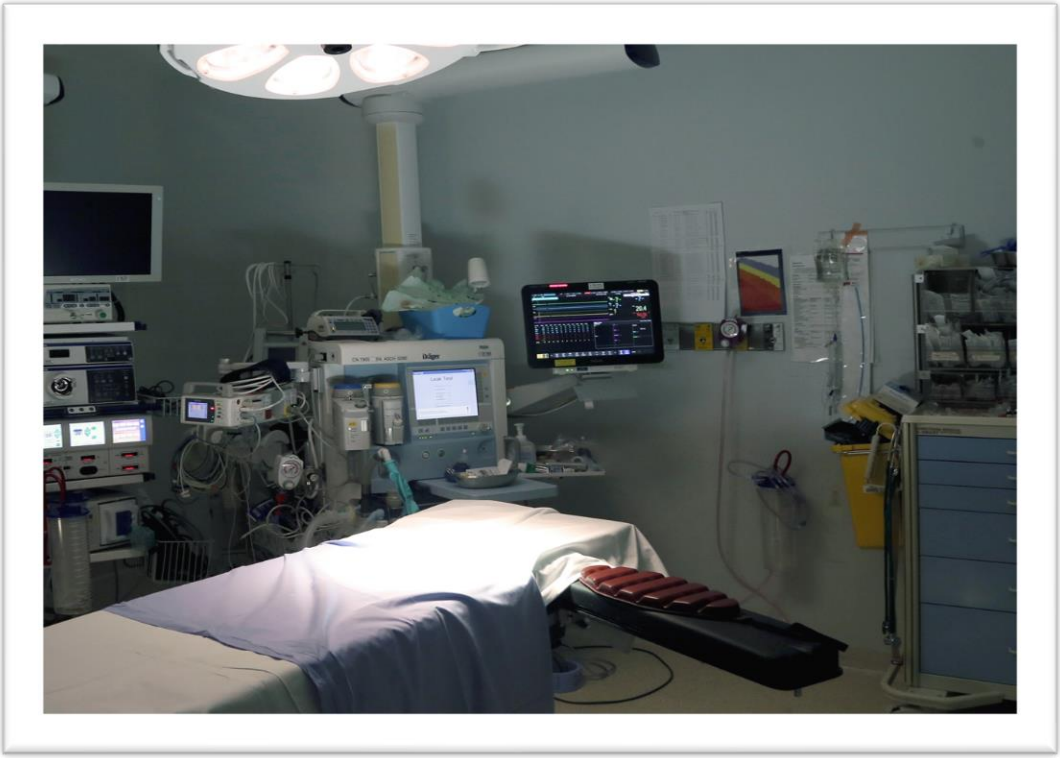


Figure 1 – Sample Image of an machined used by anesthesiology in an operating room[1]. Photo provided by MIT Technology Review.

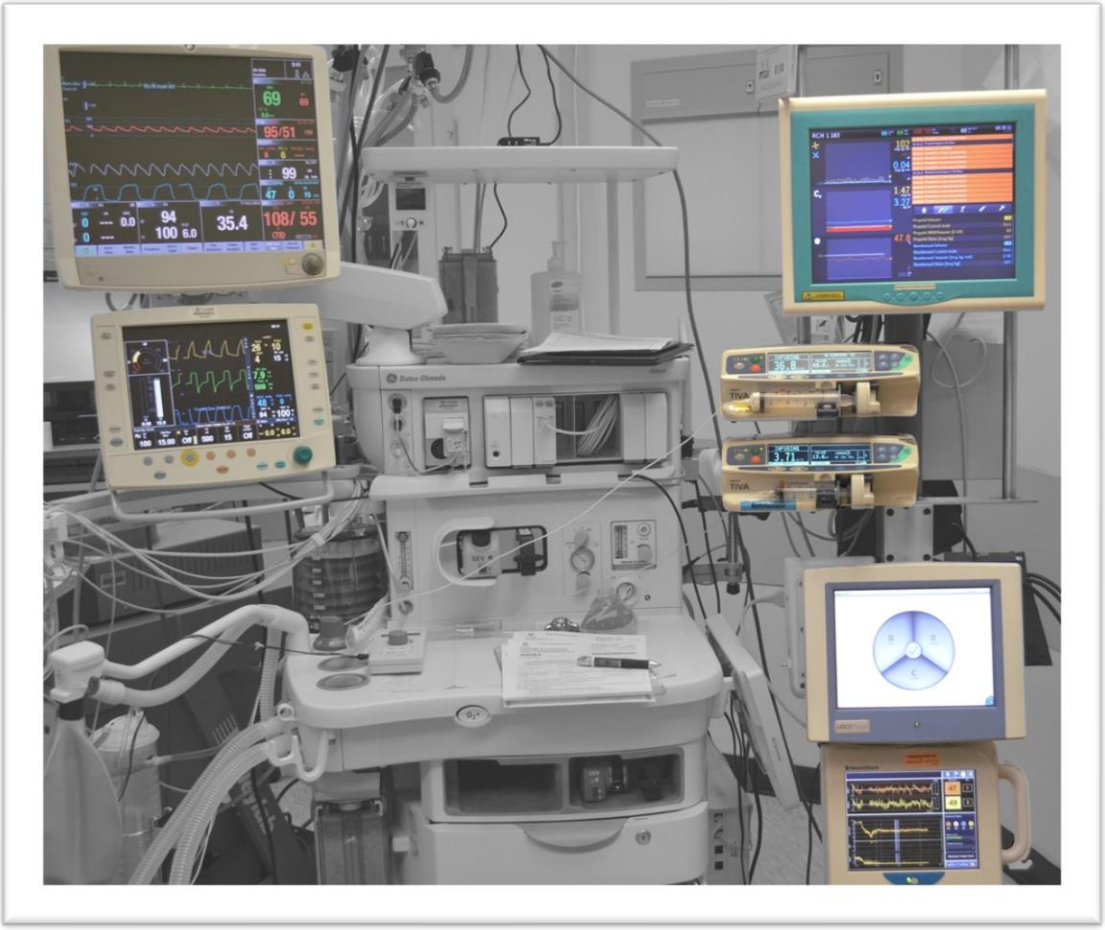


Figure 2 – Sample Image of an Automated Anesthesiologist in an operating room[19]. Photo provided by Washington Post.

List of Tables

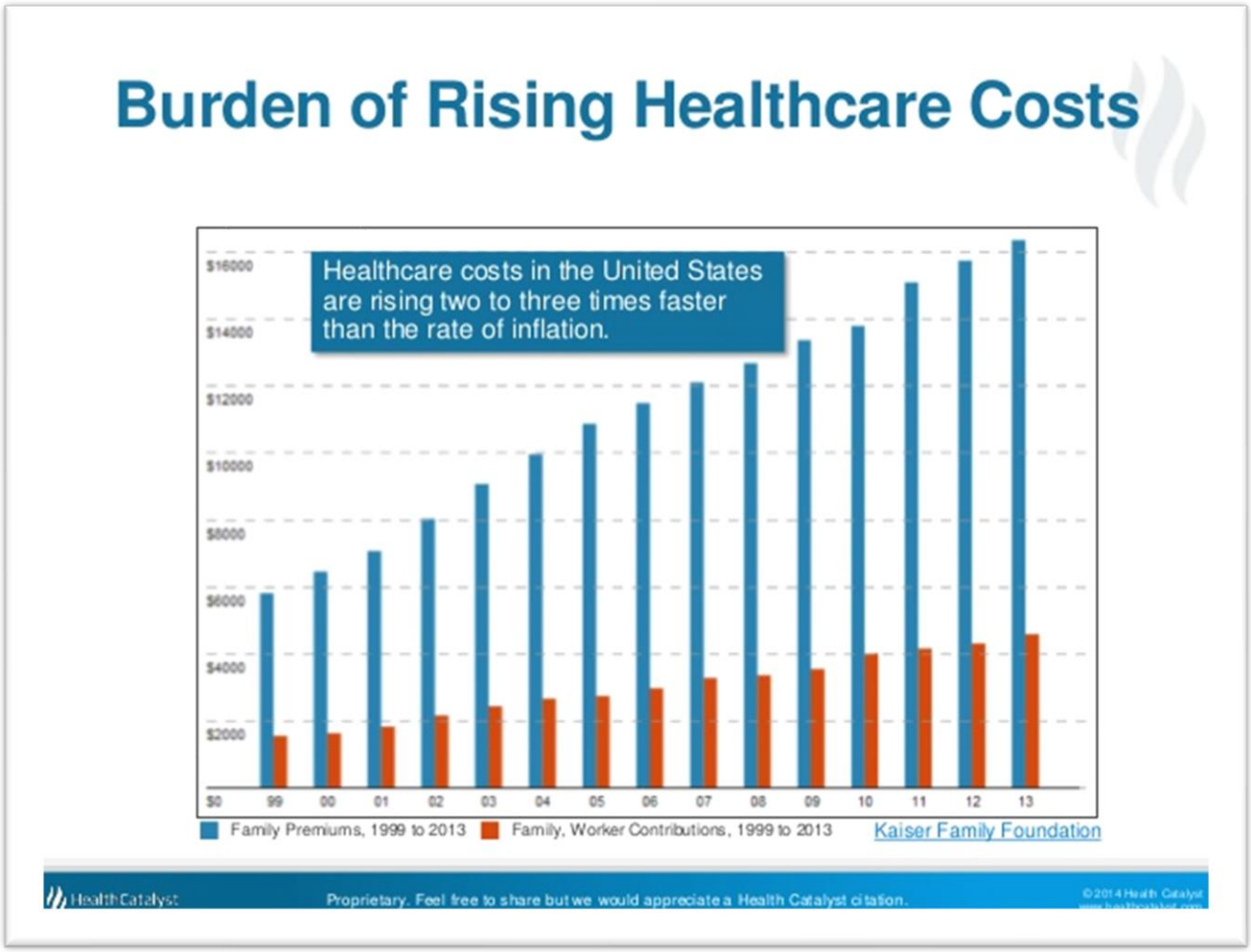


Chart 1 – Rising Healthcare costs are a burden for families across the United States. Photo provided by Kaiser Family Foundation[20].

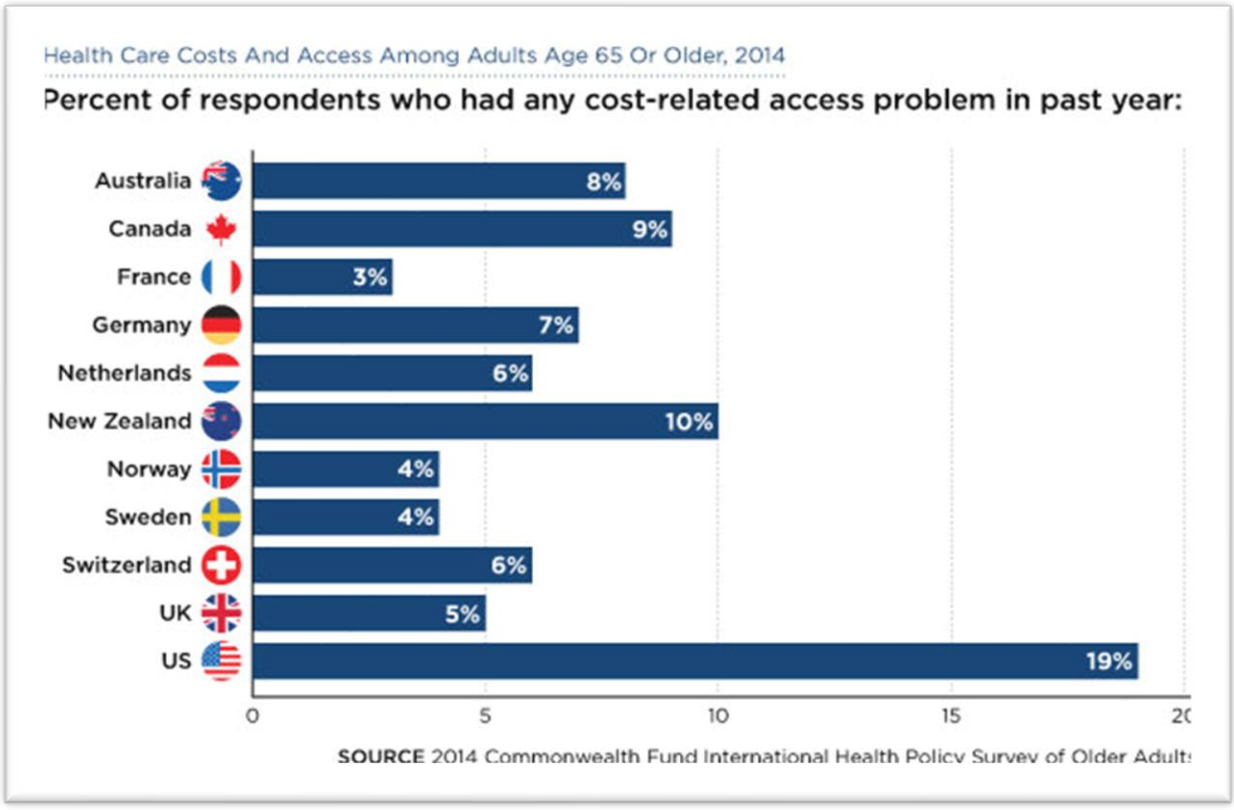


Table 1 – How much a person living in the United States spend on healthcare compared the res the of the developed world[21].

I Project Description

1 Project Overview

The costs of healthcare are expensive, and healthcare spending in the United States is $3 trillion a year, straining the budgets of families, businesses, and taxpayers alike. There is no doubt that a country as developed and industrialized as the United States has built an elaborate and expensive healthcare system. What can we do about this? A huge bulk of the costs lie in anesthetics.

An estimated 40 million anesthetics are administered each year in the United States. Anesthesiologists, professionals who service anesthesia care for patients in a large variety of surgical subspecialties, provide and/or participated in more than 90% of these said anesthetics. Billing of anesthesia services charges increase for specific patient conditions, including but not limited to age ranges, ASA[17] physical statuses, emergency cases, or other special circumstances. Unlike other medical specialties, anesthesia is billed based on units of time. Time, complexity of the surgery, and the overall health of the patient contribute to the calculus of anesthesia charges. For example, less-complicated procedures, such as colonoscopies and upper endoscopies, will typically incur an anesthesia charge of $500 to $700. Procedures for minor joint surgeries and spinal injections may cost $1000 to $1500, while more complex surgeries, such as hip replacements, may cost upwards of $1800.

Staffing of anesthesiologists and other anesthesia providers play a significant role in driving up the costs of the delivery of anesthesia. In a statistic reported by Beckers Hospital Review[18], anesthesia labor costs represent the number one costs to most surgery centers. We pay our doctors, hospitals, and other medical providers in ways that reward doing more, rather than being more efficient. There are inefficiencies involving anesthesia that can accumulated significant expense over time. Most insurers, such as Medicare, pay doctors, hospitals, and other medical professionals under a fee-for-service system that reimburses for each separate test, procedure, and visit. This fee-for-service systems encourages overtreatment and repetitive tests.

2 The Purpose of the Project

2a The User Business or Background of the Project Effort

We can start tackling the high costs of healthcare by outsourcing the work of highly paid anesthesiologists and other anesthesia care providers. Software can be created so that we can cost-effectively outsource the work of anesthesiologists and provide carefully matched anesthetic needs of each patient to that patient's medical condition, responses to anesthesia, and the requirements of the surgery.

Recent innovations in the fields of artificial intelligence, especially machine learning, may usher in a new age of automation across the medical communities. By creating an anesthesiology stimulator that teaches non-anesthesia hospital staff members, we can begin the process of shaving off the high costs of healthcare and developing the future of the practice anesthesia.

2b Goals of the Project

According to the National Academy of Medicine, the healthcare system wastes around $800 billion year. The rising costs of healthcare is an enormous problem, and trying to resolve it all at once springs forth panic and impasse. A^2 Technologies is the starting point to ending the egregious waste that is draining the country's health care system. As stated by the Academy of Medicine, eliminating this waste lets us to insure about 150 million Americans. Healthcare for Americans will open doors to not just those who can afford it, but for those who cannot.

Patients and doctors often demand the newest treatments and the newest medical devices. Putting A^2 Technologies in the market will push the boundaries of how much responsibility is turned over to technology. It's a leap forward to medical innovation and affordable healthcare for all.

2c Measurement

The project has the promise advancing medical technology of controlling patients' bodily systems when anesthetized, and the project may contribute to improved management of anesthesia. A^2 Technologies will meet the criteria of our project goals if the software is able to encompass all the skills of an anesthesiology professional: supervise the administration of medication so that the patient will not experience pain. The type of pain relief includes general anesthesia, sedation, and regional anesthesia. During a medical procedure, A^2 Technologies will continue to be responsible for the monitor physiological variables of the patient. A^2 Technologies monitors the patient's bodily function, assess the best way to tree the vital organs, and provide a balance of medications suited to the patient's needs.

A^2 Technologies' algorithms makes all medical decisions that a typical anesthesiologist does. It produces a second-by-second documentation of the patient's heart rate and rhythm, breathing, blood pressure, body temperature, and fluid balance. The investment of A^2 Technologies will bring quality software that accomplishes an anesthesiologist's functions and duties. How much can we reduce the cost without impacting the quality?

3 The Scope of the Work

The United States is a free market economy, which is understood that when demand for a particular product increases, resources multiply. A^2 Technologies is a subset of a medical automation market. The medical automation market includes diagnostic and monitoring automation, therapeutic automation, laboratory and pharmacy automation, and medical logistics and training. Increasing the application of automated devices are driving the growth of the market.

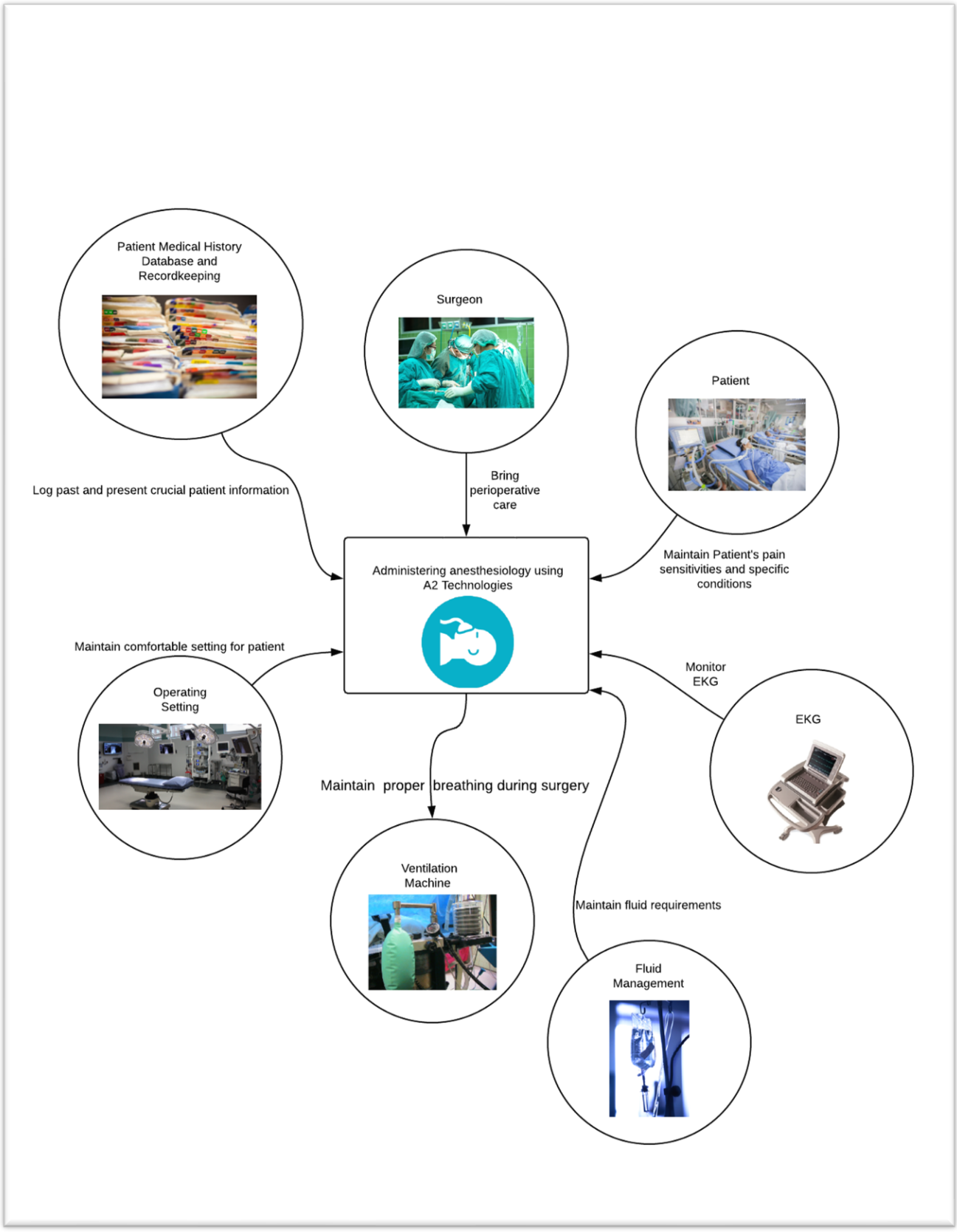
Interestingly, the idea of fully automating anesthesia is not new. Automating anesthesia was first proposed in the 1950s. Anesthesiologists and other medical professionals in Canada, France, India, and China have prototyped similar automating devices. One early roles for their machines was used in war zones or remote areas, where an anesthesiologist does not exist.

3a The Current Situation

Anesthesiologist are required to be physically present and available for induction of anesthesia, emergence, and pre-anesthetic and post-anesthetic care, and monitor the course of anesthesia at frequent intervals. Anesthetic is administered locally, intravenously, spinally, or caudally. One of the main responsibilities is to provide and maintain life support and airway management of a patient. They keep a record of type and amount of anesthesia and patient condition throughout the procedure. Anesthesiologist examines the patient, obtain medical history, and use diagnostic test to determine risk during the procedure. Anesthesiologist are in contact with operating surgeon throughout the surgery or medical procedure. They also supervise other anesthesia professionals, such as anesthesia assistants and CRNA, or Certified Registered Nurse Anesthetists. In addition, they position patient on operating table to maximize patient comfort and surgical accessibility.

The work of anesthesiologists is mostly made up repetitive tasks, therefore, the outsourcing of anesthesiology to lower paid staff members can be implemented to decrease the menial aspects that machines do well. A^2 Technologies help human practitioners improve care by increasing precision and reliability.

3b The Context of the Work



3c Work Partitioning

Business Event List		
Event Name	Input and Output	Summary
1. Patient	Receive anesthesia (in) Submit pertinent medical history (in) Supervise and access the patient (out)	Patient's medical history, current medications, physical examination, past diagnoses is examined before surgery begins.
2. Surgeon	Deliver perioperative care (out) Supervise and access the patient (in)	The surgeon is responsible for preoperative diagnosis of the patient, for performing the operation, and providing the patient with postoperative surgical care and treatment. During the course of the operation, the surgeon must make important decisions about the patient's health and safety and welfare.
3. Patient Medical History Database and Recordkeeping	Maintain electronic patient information	This database is any collection of data organized for storage, accessibility, and retrieval. This database allows for quick, real-time transactional processing. It is built for speed and delivers sub-second response times. The database structure accommodates the creation of a wide range of transactional applications: EHRs, lab systems, financial systems, patient satisfaction systems, patient identification, ADT tracking, administration, billing and payment processing, research, HR, and education. This database holds data that can be used to detect physiologic perturbations and allow intervention before

		the patient suffers harm, and to detect and correct equipment malfunction.
4. Operating setting	Maintain comfortable setting for patient (out)	Operating room is where A^2 Technology is set up. It contains bright lights, instruments, and the entire area/room is extremely sterile.
5. Ventilation Machine	Maintain proper breathing during surgery (out)	The ventilation machine delivers oxygen to a patient. A^2 Technology has improved the modern ventilation machine in accuracy and power to allow ventilation of patients with stiff lungs.
6. Fluid Management	Monitor patient's fluid and blood levels (out)	Management of fluids in the perioperative setting involves trying to forecast the amount of fluids needed based on a duration and severity of a particular operation and empirically replacing fluids based on these estimates. Fluids must be calculated by taking in the data of fluid lost prior to start of anesthesia, maintenance requirements, normal fluid losses that occur during surgery, and response to unanticipated fluid blood loss.
7. EKG	Monitor patient's EKG (out)	EKG applied to the patient include a pulse oximeter, electrocardiography, noninvasive blood pressure device, and a temperature monitor. The monitoring standards include measurement of end tidal carbon dioxide, inspired oxygen concentration, and the use of low oxygen concentration and ventilation disconnect alarms.

3d Competing Products

At the current market, there are a few existing competing products that clients could choose to use instead of A^2 Technologies.

The sharpest competitor is Sedasys, Inc., an experimental anesthesia automation machine that currently on the market. Only four hospitals have used Sedasys, and the machine is restricted to colonoscopies in healthy patients. The medical device includes the following units:

- Beside Monitoring Unit (BMU) that stays with the patient from pre-operation to post-operation recovery.
- Procedure Room Unit (PRU) that the display monitors, contains the propofol infusion pump controller, and disposable devices for single-patient use

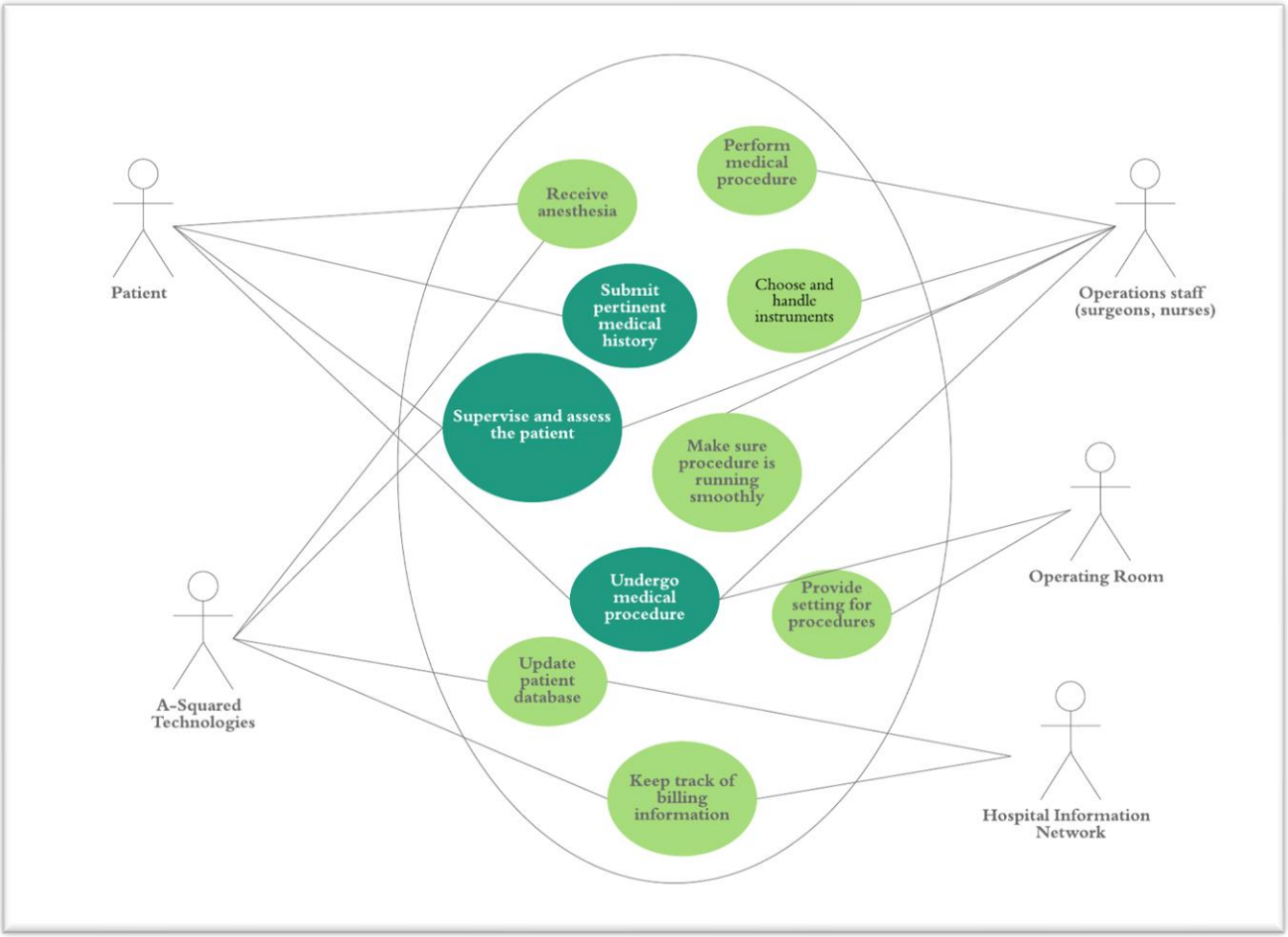
With a simple push of the button, the machine sends a measured dose of sedation drug to a patient via IV infusion. The machine monitors the patient's breathing, heart rate, and blood oxygen levels. Sedasys has a built-in computerized voice that instructs the patient to squeeze a sedation controller. The machine uses an algorithm for propofol dosing that tries to maximize patient comfort and safety. If a problem is detected, the machine slows down or cuts off the drug's infusion into the patient.

The device is innovative, but unlike A^2 Technologies, Sedasys, it doesn't decide alone how much anesthesia to give to patient. Sedasys is only approved to administer anesthesia for healthy patients undergoing esophagogastroduodenoscopy (EGD) procedures and colonoscopy, which means many other patients and procedures requiring anesthesia will not be able to safely utilize Sedasys. A^2 Technologies provides patients with a garden variety of procedures.

4 The Scope of the Product

A^2 Technologies aims to achieve all tasks done by a human anesthesiologist or other anesthesia provider.

4a Scenario Diagram(s)



4b Product Scenario List

A^2 Technologies Scenario Name	External Actors
(1) Review patient physical examination, medical history, lifestyle, and medications	Patient
(2) Physician or medical staff will inform patient of what to expect during the surgery and discuss anesthetic options	Patient, physician or medical staff
(3) Patient shares to physician or medical staff his/her reactions to previous anesthetics, current herbal supplements, food and drug allergies, recent and/or current prescriptions and over-the-counter medications, cigarette smoking and alcohol use, use of street drugs	Patient, physician or medical staff

such as marijuana, cocaine, amphetamines, etc.	
(4) Patient has a clear understanding of their anesthetic needs on day of surgery	Patient, physician or medical staff, A^2 Technologies
(5) During surgery, if patient has a pre-existing medical condition such as diabetes, asthma, heart problems, arthritis, etc., A^2 Technologies is alerted and recorded into database	Patient, physician or medical staff, A^2 Technologies
(6) A^2 Technologies will be adjusted to prepare for patient's surgery according to the medical intake provided	A^2 Technologies
(7) A^2 Technologies directs anesthesia to the patient	A^2 Technologies, patient
(8) A^2 Technologies monitors and observes second-by-second the patient through the entirety of the surgery	Patient, physician or medical staff, A^2 Technologies
(9) A^2 Technologies manages vital functions such as heart rate, blood pressure, heart rhythm, body temperature, and breathing. A^2 Technologies is responsible for fluid and blood replacement, if necessary	A^2 Technologies, patient
(10) Once surgery is over, A^2 Technologies provides the patient with post-operative care and intake	Patient, physician or medical staff, A^2 Technologies
(11) A^2 Technologies updates database	Patient, physician or medical staff, A^2 Technologies

4c Individual Product Scenarios

Product Scenario #1
Before anesthesia and surgery begins, a 31-year-old patient, Danny, begins an intake. This is conducted with the patient and medical professional. During this intake, the health practitioner or medical professional will ask to review patient's physical examination, medical history, lifestyle, and medications. Danny is informed about what to expect during the surgery and anesthetic options. He informs the medical team that he has a history of bad reactions to an anesthetic drug. Discussing any known allergies with medical team is very important, since some anesthetic drugs can cause cross-reactions. He explains in detail the symptoms he experiences, such as feeling nauseating when waking up. Danny also explains that he has

asthma. A^2 Technology takes this information and adjust their anesthetic package according to Danny's medical history, lifestyle, and medications. He has a clear understanding of their anesthetic needs on day of surgery. During surgery, A^2 Technology takes notice that Danny has a history of asthma, so the breathing ventilator is programmed to cater to asthmatic patients. A^2 Technology will be adjusted to prepare for Danny's surgery according to the medical intake provided. A^2 Technology delivers a personalized anesthetic package tailored to Danny. A^2 Technology monitors and observes second-by-second Danny's entire surgery. A^2 Technology manages vital functions such as heart rate, blood pressure, heart rhythm, body temperature, and breathing. A^2 Technology manages Danny's bodily fluid and blood levels. Once surgery is over, A^2 Technology provides Danny with post-operative care and outtake. A^2 Technology updates database.

Product Scenario #2

Before anesthesia and surgery begins, a 55-year-old, Adrienne, begins an intake. This is conducted with the patient and medical professional. During this intake, the health practitioner or medical professional will ask to review Adrienne's physical examination, medical history, lifestyle, and medications. Adrienne is informed about what to expect during the surgery and anesthetic options. She informs the medical team that she is a heavy smoker, with a history of bouts of bronchitis. A^2 Technology takes this information and adjust their anesthetic package according to Adrienne's medical history, lifestyle, and medications. Cigarette smoking can affect your body like many prescription medications you may be taking. Because cigarettes affect the lungs, heart, liver and blood, these substances can change the way anesthetic drugs work during surgery. The medical team informs Adrienne that she will heal and recover faster, if she stops smoking before the operation. She has a clear understanding of their anesthetic needs on day of surgery. During surgery, A^2 Technology takes notice that Adrienne is a smoker, so the breathing ventilator is programmed to cater to smoking patients. A^2 Technology will be adjusted to prepare for Adrienne's surgery according to the medical intake provided. A^2 Technology delivers a personalized anesthetic package tailored to Adrienne. A^2 Technology monitors and observes second-by-second Adrienne's entire surgery. A^2 Technology manages vital functions such as heart rate, blood pressure, heart rhythm, body temperature, and breathing. A^2 Technology manages Adrienne's bodily fluid and blood levels. Once surgery is over, A^2 Technology provides Adrienne with post-operative care and outtake. A^2 Technology updates database.

Product Scenario #3

Before anesthesia and surgery begins, a 43-year-old, Claudia, begins an intake. This is conducted with the patient and medical professional. During this intake, the health practitioner or medical professional will ask to review Claudia's physical examination, medical history, lifestyle, and medications. Claudia is informed about what to expect during the surgery and anesthetic options. She informs the medical team that she is a heavy drinker and smoker, with a history alcohol abuse. A^2 Technology takes this information and adjust their anesthetic package according to Claudia's medical history, lifestyle, and medications. Cigarette smoking and heavy alcohol drinking can affect your body like many prescription medications you may be taking. Because alcohol and cigarettes affect the lungs, heart, liver and blood, these substances can

change the way anesthetic drugs work during surgery. The medical team informs Claudia that she will heal and recover faster, if she stops smoking before the operation. She has a clear understanding of their anesthetic needs on day of surgery. During surgery, A^2 Technology takes notice that Claudia is a smoker, so the breathing ventilator is programmed to cater to smoking patients. A^2 Technology will be adjusted to prepare for Claudia's surgery according to the medical intake provided. A^2 Technology delivers a personalized anesthetic package tailored to Claudia. A^2 Technology monitors and observes second-by-second Claudia's entire surgery. A^2 Technology manages vital functions such as heart rate, blood pressure, heart rhythm, body temperature, and breathing. A^2 Technology manages Claudia's bodily fluid and blood levels. Once surgery is over, A^2 Technology provides Claudia with post-operative care and outtake. A^2 Technology updates database.

Product Scenario #4

Before anesthesia and surgery begins, a 83-year-old, John, begins an intake. This is conducted with the patient and medical professional. During this intake, the health practitioner or medical professional will ask to review John's physical examination, medical history, lifestyle, and medications. John is informed about what to expect during the surgery and anesthetic options. He informs the medical team that he takes many over-the-counter drugs, including coumadin, a blood thinner. Coumadin must be discontinued for some time before the surgery because this drug will increase bleeding during or after surgery. The medical team is aware of his daily coumadin intake. A^2 Technology takes this information and adjust their anesthetic package according to John's medical history, lifestyle, and medications. He has a clear understanding of their anesthetic needs on day of surgery. During surgery, A^2 Technology takes notice that John is a smoker, so the breathing ventilator is programmed to cater to smoking patients. A^2 Technology will be adjusted to prepare for John's surgery according to the medical intake provided. A^2 Technology delivers a personalized anesthetic package tailored to John. A^2 Technology monitors and observes second-by-second John's entire surgery. A^2 Technology manages vital functions such as heart rate, blood pressure, heart rhythm, body temperature, and breathing. A^2 Technology manages John's bodily fluid and blood levels. Once surgery is over, A^2 Technology provides John with post-operative care and outtake. A^2 Technology updates database.

5 Stakeholders

5a The Client

Many mid-size to large hospitals have a technology team that looking to invest in the adoption and use of emerging technologies, designed to improve the quality and efficiency of hospital decisions. A^2 Technologies' clients are mostly mid-size to large hospitals and dental offices across the country.

5b The Customer

The patient of a given medical procedure undergoing anesthesia via A^2 Technologies is the "customer" we will be providing quality medical care.

5c Hands-On Users of the Product

A^2 Technologies is built to serve autonomously. This machine will be used to facilitate anesthesiology during an operation conducted by a team of physicians, nurses, and other medical staff. Physicians and subspecialists can range from general surgeons, neurosurgeons, urologists, ENTs, ophthalmologists, Ob/Gyns, dentists, oral surgeons, dermatologists, or plastic surgeons.

5d Maintenance Users and Service Technicians

A^2 Technologies is continuously improving and developing new, appealing features for our users eager to work with the latest technology. A^2 Technologies is programmed to have the most up-to-date maintenance releases and software available, which ensures that there is a regularly scheduled maintenance on a weekly basis. There is an option to setting up an expectation for maintenance windows ahead of time so users can plan ahead for any critical work that must be delivered. Knowing when maintenance is scheduled to happen can significantly improve the user experience.

Each A^2 Technologies machine is subscribed to receive notifications for newly available maintenance releases for the entire software stack, not just a single application. When monitoring for new maintenance releases, users are alerted to pay attention to any end-of-maintenance dates for versions installed in software stack. Versions that are no longer receiving maintenance updates will trigger an upgrade project to keep users up-to-date.

As users receive notifications about the availability of new maintenance releases, the A^2 Technologies software development team makes it a priority to review the list of fixes thoroughly. The team provides a comprehensive list that helps users understand the urgency for when patches should be applied, especially if multiple system elements contain maintenance patches released approximately the same time. Fixes for malfunctions or issues that users report are the most urgent to solve. There will be immediate feedback and complete user assistance.

5e Other Stakeholders

CEO Emma Walmsley and Chairman Sir Philip Hampton of GlaxoSmithKline and A^2 Technologies look forward to the challenge and opportunity to do our part to make healthcare cheaper and more accessible for Americans. Walmsley and Hampton have a support team that is knowledgeable and has a finger at the pulse of United States healthcare. Their support and research team provides A^2 Technologies with a wealth of information of trends in the practice of anesthesiology. We support initiatives in developing innovative products that improve healthcare worldwide and in conducting operations in a responsible, ethical manner. We continue to meet our mutual commitments to these goals.

Founder John Abele and Peter Nicholas of Boston Scientific Corp. and A^2 Technologies will work together to deliver an effective automated system to administer anesthesiology. We hope this novel milestone will address the issues of the rising costs of healthcare and medical help. We

support each others' efforts to increasing affordable patient access to care. We continue to educated ourselves of the rapidly changing and complex global medical technology markets.

Chariman and CEO John L. Flannery and VP and Controller Jan R. Hauer of General Electric both made a commitment to constant improvement in the social responsibility of shaping lives of Americans for the better. They are committed to contributing significant scientific inventions, leading to many consumer and industrial products such as A^2 Technologies. We have combined our efforts to using technology and software engineering to answer consumer needs. GE believes efficiency matters, therefore, A^2 Technologies pushes to outperform our target net efficiency rates.

CFO Joe Wolk of Johnson & Johnson has a high interest in the next medical device to bring affordable healthcare to insured Americans across the country. The company, a giant in the pharmaceutical and healthcare industry, share an interest in A^2 Technologies' impactful outcome. One of their medical device products is Depuy Synthes, and they see parallels in A^2 Technologies. They see automated anesthesiology and its expansion in their crystal ball.

5f User Participation

A^2 Technologies is intended to be automated, however, there may be healthcare professionals that may need to learn how use the product. The user-interface of A^2 Technologies is created to be intuitive and easy to use. The UI of A^2 Technologies may be one of the most important feature of the product because our product hopes to autonomously administer anesthesiology without the intellect of an anesthesiologist or other healthcare professionals.

A^2 Technologies has installable Ask For Help videos or live chats. Should there be system interrupt, users may easily submit feedback in four formats: live chat, email, phone, or snail mail. Users, especially from physicians and surgeons, may provide insightful advice on improving the machine. They can help us answer the following burning questions: How can automated anesthesia enter the daily practice in a useful and structured way? How can we allow a smooth transition and transformation from present state of anesthesia towards the future of anesthesia?

5g Priorities Assigned to Users

The following table lists a ranking of priorities assigned to Key Users, Secondary Users, and Unimportant Users.

A^2 Technologies Key Users
Physicians, Nurses, other medical staff Physicians, surgeons, nurses, and other medical staff members work as a team to diagnose and treat injuries or illnesses. They work alongside A^2 Technology to examine patients, take medical histories, prescribe medications, and order, perform, and interpret diagnostic tests. They also counsel patients on diet, hygiene, and preventative healthcare.
Software Developer

Software Developer write code that brings applications and systems development of A^2 Technologies alive. They design, construct, test, and maintain applications software that meets the needs of A^2 Technology services. They implement programming languages, depending on the purpose of the program. Software developers on the team determine operational feasibility by evaluating medical analyses, problem definition, requirements, and propose solutions. They document and demonstrate solutions by developing documentation, flowcharts, layouts, diagrams, charts, and code comments.
Software Engineers in Test Software Engineers in Tests are A^2 Technologies' staff members that continuously create test cases, debug, test software, script automatable test cases, and update bug statuses. These engineers should know the in and out of the hardware and software side the product, along with being capable of a fair amount of scripting and coding.
A^2 Technologies Secondary Users
Hospital Administrator The Administrator of hospital is a secondary user in a senior management position at the hospital or other institution. The Administrator keeps the healthcare infrastructure running smoothly. As the head of operations, the Administration oversees clinical units, departments, and medical technologies. They represent the institution at investor meetings, governing board, and within the greater community. Their decisions reverberate throughout the hospital workplace, and their influence extends to the community at large.
Patient The patient is fully informed of the plans for anesthesiology. They must understand the anesthesia options and how they work in the success of their surgery and for their speedy recovery. A^2 Technology aims for the best anesthesia care for the patient.
A^2 Technologies Unimportant Users
Anesthesiologist A^2 Technology works to administer anesthesiology, therefore, A^2 Technology must think like an anesthesiologist, analyze biological information, and constantly adapt its own behavior, even recognizing malfunctions.

6 Mandated Constraints

6a Solution Constraints

A^2 Technology Solution Constraints			
	Description	Rationale	Fit Criterion
1	A^2 Technology will be mounted on wheels, with a one-rear-wheel braking system, touch foam-filled rear tires	We want our product to maintain mobility so that the hospital crew can move the product from one operating room to the next with ease	Unfolded dimensions: 44.5" x 23.5" x 33.5"; folded dimensions: 16" x 23.5" x 36"; weight: no more than 100 pounds
2	Clients request for the software to contain easy-to-use User Interface	We want our product to be easy to use, especially in a high-stakes situation such as operating on a patient.	The software UI look and feel is easy to understand.
3	A^2 Technology utilizes a closed-loop drug delivery system.	We want our product to automate the anesthetic delivery system based on the closing the loop of drug delivery.	Automated drug delivery consist of computer programs designed to maintain a targeted effect by varying and/or adapting the administered amounts of drug based on the feedback of effect of the drugs on specific body functions. A closed-loop system is the ideal means of the automated drug delivery system.

6b Implementation Environment of the Current System

The software behind A^2 Technology is cross-platform, regardless of the operating system. Users using A^2 Technology can run the application on a Windows, MacOS, or Linux operating system.

6c Partner or Collaborative Applications

The client user interface establishes a connection to the database server, where patient's medical information and other recordkeeping is stored and retrieved.

6d Off-the-Shelf Software

A^2 Technology uses both front-end and back-end components. The front-end side includes JavaScript libraries available through open source. HTML5 and CSS is the structure used to create buttons, forms, and other interface elements. The back-end side holds the data hosted on a local server built using Python and MongoDB.

6e Anticipated Workplace Environment

A^2 Technology stands in a given operating room in a hospital, or other healthcare institution. The operating room varies depending on the type of surgery being done. In general, the operating room consists of the operating table in the center of the room. The operating table can be raised, lowered, and tilted in any direction. The operating room lights are over the table to provide bight light, without shadows, during surgery. A^2 Technology is at the head of the operating table. A^2 Technology has tubes that connect to the patient to assist him/her in breathing during surgery, and built-in monitors that help control the mixture of gases in the breathing circuit. The anesthesia cart is adjacent to A^2 Technology machine. It contains medicines, equipment, and other supplies that A^2 Technology may need during operation. Sterile instruments to be used during surgery are arranged on a stainless steel table. An electronic monitor, which records the heart rate and respiratory rate, sits alongside A^2 Technology. The pulse oximeter machine, measuring the amount of oxygen contained in the blood, also sits alongside A^2 Technology.

Traditionally, the operating room is scheduled as block times, adjusted based on surgeons' utilization rates. Depending on the type of operation, staff levels change. Time block releases are one way to instill more flexibility in the operating room schedule. To avoid potential delays and gaps, each day's caseload is reviewed and approved ahead of time. Tardiness can have repercussions for the entire day.

6f Schedule Constraints

The team at A^2 Technology meet for each scheduled release. We may meet to speak about new requested features or bugs that may arise. Each release is critical because A^2 Technology is at the epicenter of monitoring the safety of a patient undergoing a medical operation. A^2 Technology has a responsibility to determine suitable anesthesia plans, and the product strives to provide quality and effective experience for our clients and their patients. The length of a sprint is usually no more than 2 weeks. We will notify our clients of specified releases. We plan to work throughout the year. Releases are continual, and we don't have a specific peak season.

6g Budget Constraints

A^2 Technology targets mid-size to large hospital systems and conglomerates. Our software has a blend of free and for-purchase libraries in the market. We use popularly available free IDEs. The hardware of A^2 Technology may require more funding, however, we are open to refurbishing second-hand hardware such as the ventilator arm of A^2 Technology.

7 Naming Conventions and Definitions

7a Definitions of Key Terms

a: before
@: at
A&P: anterior and posterior
aa: of each
abd: abdomen
ABGs: arterial blood gases
ac: before meals
ADA: American Diabetes Association or American Dietetic Association
ad lib: as desired or as freely as desired
ADH: antidiuretic hormone
ADL: activities of daily living
AF: atrial fibrillation
AFB: acid-fast bacillus
Ag: silver or antigen
AHA: American Hospital Association or American Heart Association
AHCD: advanced health care directive
AIDS: acquired immune deficiency syndrome
AKA: above the knee amputation
ALL: acute lymphocytic leukemia or acute lymphoblastic leukemia

ALOC: altered level of consciousness
ALS: amyotrophic lateral sclerosis
a.m.a.: against medical advice
A.M.A.: American Medical Association
AMB or amb: ambulatory
AMI: acute myocardial infarction or anterior myocardial infarction
amp: ampule
ANA: antinuclear antibody test or American Nurses Association
AP: apical pulse or anterior and posterior
ARDS: acute respiratory distress syndrome or adult respiratory distress syndrome
AS: aortic stenosis
ASA: aspirin or acetyl salicylic acid
ASD: atrial septal defect
ASHD: arteriosclerotic heart disease
AST: aspartate aminotransferase
AV: atrio-ventricular or arterio-venous
ax: axillary
Ba: barium
BE: barium enema
bid: two times a day
BKA: below the knee amputation
BM: bowel movement
BMR: basal metabolic rate
BP: blood pressure

BPH: benign prostatic hypertrophy
BR: bedrest
BRP: bathroom privileges
Updated 5-12-14 NW
BSA: body surface area
BSC: bedside commode
BSE: breast self-examination
BSI: body substance isolation
BSO: bilateral salpingo-oophorectomy
BUN: blood urea nitrogen
bx: biopsy
c: with
C: Centigrade
C&S: culture and sensitivity
Ca++: calcium
CA: cancer or carcinoma
CABG: coronary artery bypass graft
CAD: coronary artery disease
cap: capsule
CAPD: continuous ambulatory peritoneal dialysis
CAT: computed axial tomography
cath: catheter or catheterize
CBC: complete blood count
CBI: continuous bladder irrigation

CBR: complete bedrest
cc: cubic centimeter
CCU: Coronary Care Unit or Critical Care Unit
CC: chief complaint
CDC: Centers for Disease Control
CDE: Certified Diabetes Educator
CEA: carcinoembryonic antigen
cg: centigram
CHF: congestive heart failure
CHO: carbohydrate
CKD chronic kidney disease
Cl - chloride or chlorine
cm: centimeter
CMS: circulation, movement, sensation or color, movement, sensation
CN: cranial nerve
CNS: central nervous system
c/o: complains of or complaint of
CO: cardiac output or carbon monoxide
CO2: carbon dioxide
COPD: chronic obstructive pulmonary disease
CPK: creatinine phosphokinase
CPM: continuous passive motion
CPR: cardiopulmonary resuscitation
CRT: capillary refill time

CSF: cerebrospinal fluid
CT: computed tomography or chest tube
CVA: cerebrovascular accident or costovertebral angle
CVP: central venous pressure
CXR: chest x-ray
dc; D/C: discontinue
D&C: dilation and curettage
DIC: disseminated intravascular coagulation
diff: differential or differential blood count
dil: dilute or diluent
DKA: diabetic ketoacidosis
dl: deciliter
DM: diabetes mellitus or diastolic murmur
DNR: do not resuscitate
DOE: dyspnea on exertion
DSD: dry sterile dressing
DTR: deep tendon reflex or deep tendon reflexes
DVT: deep vein thrombosis
DW: daily weight
D5W: 5% dextrose in water
dx; DX: diagnosis
EC: enteric-coated
ECF: extracellular fluid
ECG; EKG: electrocardiogram

ECT: electroconvulsive therapy
EDB: estimated date of birth
EDD: estimated date of delivery
EEG: electroencephalogram
EGD: esophagogastroduodenoscopy
elix: elixir
EMG: electromyogram
ENT: ear, nose and throat
EOM: extra-ocular movements
ER: extended release or Emergency Room
ESR: erythrocyte sedimentation rate
ESRD: end-stage renal disease
ESRF: end-stage renal failure
ET: enterostomal therapist
ETOH: ethyl alcohol or ethanol
F: Fahrenheit
Fe: iron
FeSO4: iron sulfate
FHR: fetal heart rate
FSBS: fingerstick blood sugar
f/u: follow up
FUO: fever of unknown origin
fx; Fx: fracture or fractional urine test
g; gm; Gm: gram

GERD: gastroesophageal reflux disease
GI: gastrointestinal
gr: grain
grav I, II, III, etc: gravida (pregnancy) 1, 2, 3, etc.
GSW: gunshot wound
gtt: drop or drops
GTT: glucose tolerance test
GU: genitourinary
GYN; Gyn: gynecological
h: hour
H+: hydrogen ion
H/A: headache
H/H: hemoglobin and hematocrit
H&P: history and physical examination
HAV: hepatitis A virus
Hb; Hgb: hemoglobin
HBAg: hepatitis B antigen
HBV: hepatitis B virus
HCO3: bicarbonate
Hct; HCT: hematocrit
HCV: hepatitis C virus
HEENT head, eyes, ears, nose and throat
HD: hemodialysis
Hg: mercury

HHNS: hyperglycemic hyperosmolar nonketotic syndrome
HIPAA: Health Insurance Portability and Accountability Act
HIV: human immunodeficiency virus
h/o: history of
H2O: water
HOB: head of bed
HOH: hard of hearing
HR: heart rate
hs: at bedtime
HTN: hypertension
I&D: incision and drainage
I&O: intake and output
ICD: implantable cardiac defibrillator
ICF: intracellular fluid
ICP: intracranial pressure
ICU: intensive care unit
ID: intradermal
Ig: immunoglobulin
IHI: Institute for healthcare improvement
IM: intramuscular
INR: International Normalized Ratio
IOM: Institute of Medicine
IOP: intraocular pressure
IPPB: intermittent positive pressure breathing

IS: incentive spirometry
IV: intravenous
IVDA: intravenous drug abuse
IVP: intravenous push or intravenous pyelogram
JVD: jugular vein distention or jugular venous distention
K+: potassium
Kg: kilogram
KUB: kidney, ureters, bladder
KVO; kvo: keep vein open
L; l: liter
LA: left atrium or left atrial
LBBB: left bundle branch block
LDH: lactic dehydrogenase
LLL: left lower lobe
LLQ: left lower quadrant
LMP: last menstrual period
LOC: level of consciousness
LP: lumbar puncture
LUL: left upper lobe
LUQ: left upper quadrant
LV: left ventricle or left ventricular
LVH: left ventricular hypertrophy
lytes: electrolytes
m: meter

m; min: minim
MAP: mean arterial pressure
M.A.R.: Medication Administration Record
mcg: microgram
MCV: mean corpuscular volume or mean cell volume
MDI: metered dose inhaler
meq: milliequivalent
met(s): metastasis or metastases
mg: milligram
Mg: magnesium
MI: myocardial infarction
MICU: Mobile Intensive Care Unit or Medical Intensive Care Unit
ml: milliliter
mm: millimeter
MR: mitral regurgitation
MRI: magnetic resonance imaging
Updated 5-12-14 NW
MRSA: methicillin resistant staph aureus
MS: multiple sclerosis or mitral stenosis
MVA: motor vehicle accident
MVC: motor vehicle crash
MW: molecular weight
N: nitrogen
Na: sodium

NaCl: sodium chloride
neg: negative
NG: nasogastric
NICU: Neonatal Intensive Care Unit
NIH: National Institutes of Health
NKA: no known allergies
NKDA: no known drug allergies
NMR: nuclear magnetic resonance
noc: night
NPO: nothing by mouth
NPSG National Patient Safety Goals
NS: normal saline
NSAIDS: nonsteroidal anti-inflammatory drugs
NSR: normal sinus rhythm
NWB: non weight bearing or no weight bearing
O&P: ova and parasites
O2: oxygen
OOB: out of bed
OR: Operating Room
ORIF: open reduction and internal fixation
O.T.: Occupational Therapy or Occupational Therapist
OTC: over the counter
p: after
P: pulse

PA: pulmonary artery
PACU: Postanesthesia Care Unit
pc: after meals
PCA: patient-controlled analgesia
PCN: penicillin
PE: pulmonary embolus or physical examination
PEEP: positive end expiratory pressure
PEG: percutaneous endoscopic gastrostomy
per: through or by way of
PERRLA: pupils equal, round, reactive to light and accommodation
PHI Protected Health Information
Abbreviation Quiz 4: PICC – wt
PICC: peripherally inserted central catheter
PID: pelvic inflammatory disease
PMH: past medical history
PMI: point of maximum impulse or point of maximal impulse
PNA: pneumonia
PND: paroxysmal nocturnal dyspnea
po: by mouth
P.O.D.: post-operative day
pos: positive
postop: postoperative or after surgery
PPD: purified protein derivative
ppd: packs per day

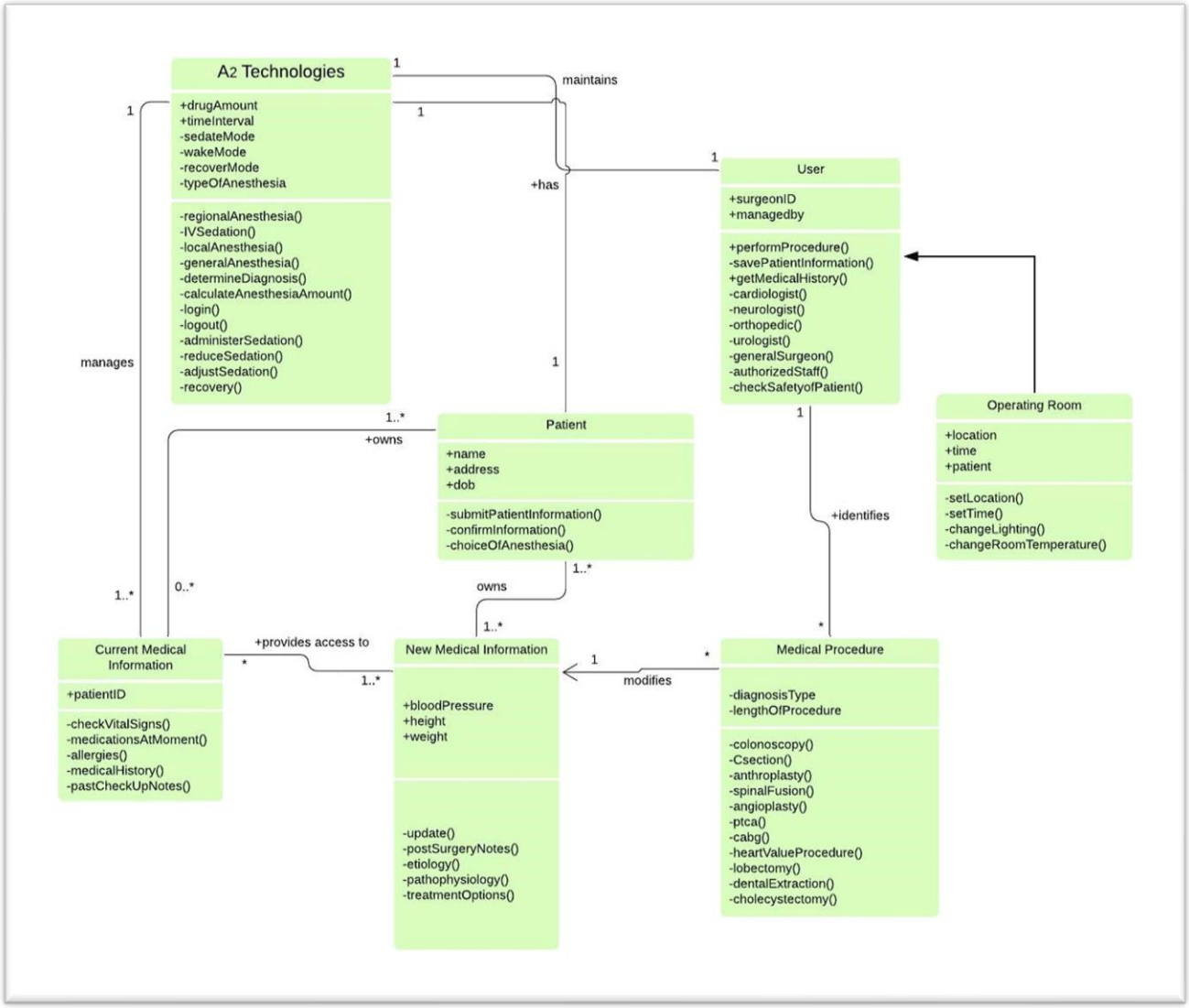
PPN: partial parenteral nutrition
preop: preoperative or before surgery
PRN: as needed
PSA: prostate specific antigen
pt; Pt: patient
PT: Physical Therapy or Physical Therapist or prothrombin time
PTCA: percutaneous transluminal coronary angioplasty
PTT: partial thromboplastin time
PUD: peptic ulcer disease
PVC: premature ventricular contraction
PVD: peripheral vascular disease
q: every or each
qid: four times a day
qs: quantity sufficient
QSEN: Quality and Safety Education for Nurses
R: respirations
RA: rheumatoid arthritis or right atrium
RBC: red blood cell
RLL: right lower lobe
RLQ: right lower quadrant
RML: right middle lobe
R/O: rule out
ROM: range of motion or rupture of membranes
ROS: review of systems

RRR: regular rate and rhythm
r/t: related to
RT: Respiratory Therapist or Respiratory Therapy
RUL: right upper lobe
RUQ: right upper quadrant
RV: right ventricle or right ventricular
Rx: treatment or take
s: without
SBO: small bowel obstruction
SCD: sequential compression device
SGOT: serum glutamic oxaloacetic transaminase
SL; sl: sublingual
SLE: systemic lupus erythematosis
SNF: Skilled Nursing Facility
S.O.A.P.: subjective, objective, assessment, plan
SOB: shortness of breath
sol: solution
s/p: status post
SR: sustained release
s/s: signs and symptoms
STAT: immediately
STD: sexually transmitted disease
Subcut: subcutaneous
supp: suppository

susp: suspension
SVT: supraventricular tachycardia
sx: symptoms or signs
T: temperature
T&C: type and cross
TAH: total abdominal hysterectomy
TB: tuberculosis
TCDB: turn, cough, deep breathe
TEA: thromboendarterectomy
THR: total hip replacement
TIA: transient ischemic attack
TJC: The Joint Commission
tid: three times a day
TKO: to keep open
TKR: total knee replacement
TPN: total parenteral nutrition
TPR: temperature, pulse, respirations
TSH: thyroid stimulating hormone
TURP: transurethral resection of the prostate
UA: urinalysis
up ad lib: up as desired or up as freely as desired
URI: upper respiratory infection
US: ultrasound
UTI: urinary tract infection

V.A.C.: vacuum assisted closure
VS: vital signs
VTBI: volume to be infused
W/A: while awake
WBC: white blood count or white blood cell
WC: wheelchair
WNL: within normal limits
wt: weight

7b UML and Other Notation Used in This Document



7c Data Dictionary for Any Included Models

The software behind A^2 Technology utilizes a hash map data structure to map keys to values. Each patient drug dosage makeup is set up according to a variety of factors, such as age, weight, height, diagnosis, etc. The hash function will assign each key to a unique bucket of patient data. The basic anesthetic drugs package is based on the usual range of doses for fit ASA 0.5 adult patients. Doses are adjusted accordingly.

Induction Agents	Dose
Propofol	2 to 3 mg/kg
Thiopental	3 to 5 mg/kg

Opioids	Dose
Fentanyl	1 mcg/kg
Alfentanil	10 mcg/kg
Morphine	0.1 mg/kg

Muscle Relaxants	Dose (Intubation)
Atracurium	0.5 mg/kg
Vecuronium	0.1 mg/kg
Rocuronium	0.6 mg/kg
Suxamethonium	1 to 1.5 mg/kg

8 Relevant Facts and Assumptions

8a Facts

Some form of anesthesia available on A^2 Technology, such as general anesthesia, is used in more than 100 million surgical procedures performed on Americans on a yearly basis, according to The American Society of Anesthesiologists[4].

In the United States, according to the Anesthesia Quality Institute's National Anesthesia Clinical Outcomes Registry, the overall death rate due to complications with anesthesia during surgery hover over three deaths per 10,000 surgeries or procedures involving anesthesia between 2010 and 2016[4]. A^2 Technology's inaugural test cases resulted in zero deaths.

8b Assumptions

The field of anesthesiology have been slow or even reluctant to adopt such technology. Can automated closed-loop anesthesia improve patient outcomes? Closed-loop delivery of anesthesia is feasible and provides A^2 Technology more anesthetic control as good as better than human delivery. The challenge is now to establish fully the safety, efficacy, reliability, and utility of closed-loop anesthesia for its implementation into the clinical setting.

The idea of A^2 Technologies is a noble one. Our development team are enthusiastic about the problem of high healthcare costs in this country and ready to tackle this problem head-on, however, planning A^2 Technologies was difficult given its novelty and boldness.

II Requirements

9 Product Use Cases

9a Use Case Diagrams

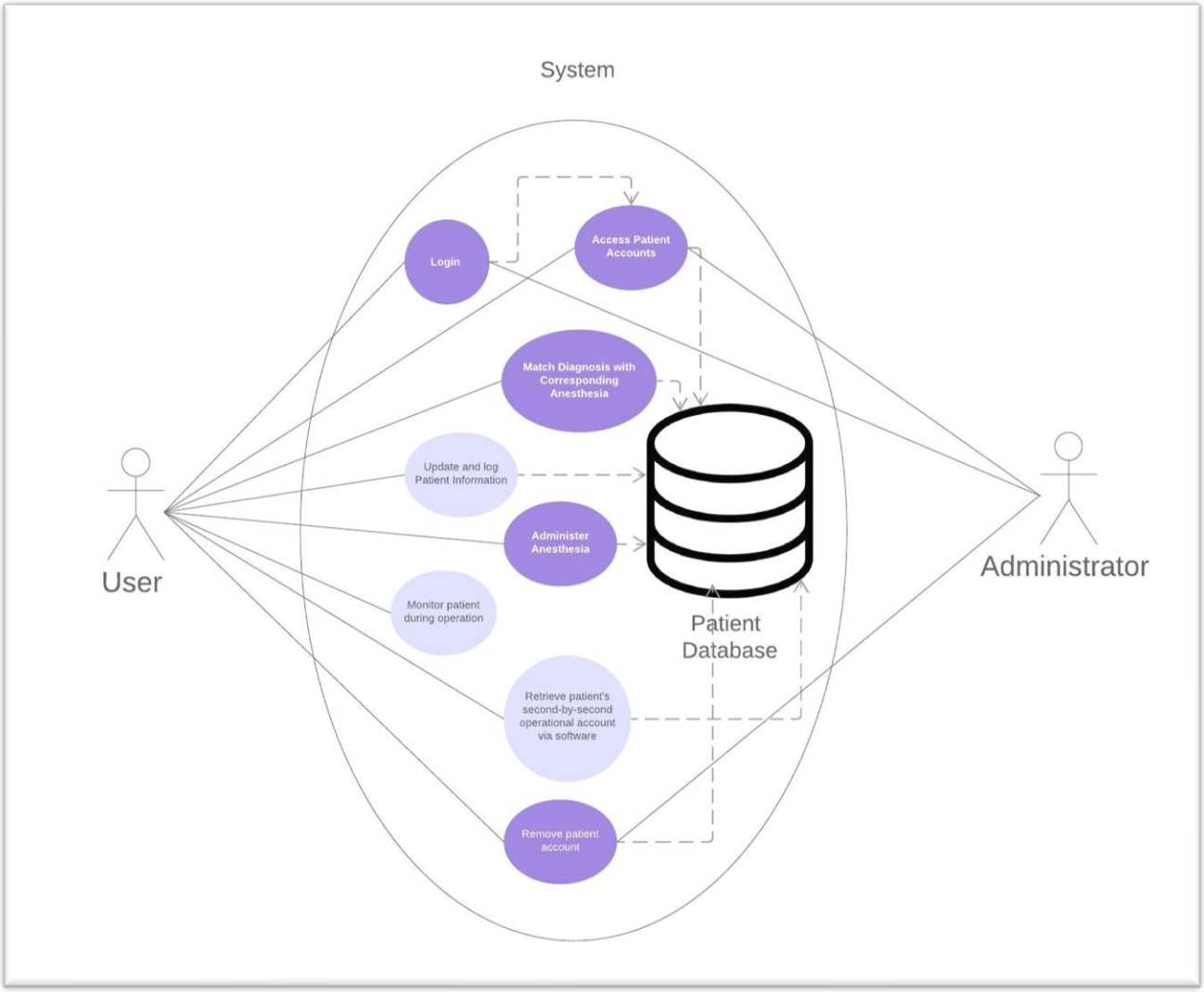


Figure 9. This Product Use Case Diagram shows the boundaries between the product, A^2 Technologies and the actor, the User.

9b Product Use Case List

List of Product Use Cases			
Use Case ID	Use Case Name	Primary Actor	Complexity
1A	1. Login to A^2 portal	Generic User	Medium
2A	2. Administrator fixes login fails	Administrator	Medium
3A	3. Search patient directory	Generic User	Medium
4A	4. Access patient account	Generic User	Medium
5A	5. Review patient account information	Generic User	Medium
6A	6. Add medical updates to patient account	Generic User	Medium
7A	7. Match operation with corresponding anesthesia	Generic User	High
8A	8. Administer anesthesia according to instructions	Generic User	High
9A	9. Monitor patient's vital signs during operation	Generic User	Extremely High
10A	10. Retrieve documentation of patient during operation	Generic User	Extremely High
11A	11. Receive instructions on how to provide post-operation care for patient	Generic User	Extremely High
12A	12. Save record of patient operation to patient account	Generic User	Medium
13A	13. Update patient account post-operation	Generic User	Medium

14A	14. Log out of A^2 portal	Generic User	Medium
15A	15. Remove patient account	Administrator	Medium

9c Individual Product Use Cases

Use case ID	1A
Name	**Login to A^2 Technologies software**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* The software displays a Login Screen. *2.* User logs in with their Staff ID credentials. *3.* User clicks on "Login" button *4.* At successful login, the User enters the software.
Alternatives	N/A The only entry into the software is through logging in with your staff credentials.
Exceptions	If the User is a new employee, there may be a wait time for the software to upload staff credentials. If the User has trouble logging into the software, a Hospital Administrator will have authority to resolve login issues.

Use case ID	2A
Name	**Administrator fixes login fails**
Pre-Conditions	User must have authorized access. Hospital Administrator has access to software.
Post-Conditions	N/A
Initiated By:	Administrator
Triggering Event:	User fails to log into software
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* Administrator logs into the software. *2.* A windows pops up saying "Failed Login Attempt. Please see authorized personnel." *3.* Administrator is alerted. *4.* Administrator resolves the issue by checking if the User has the correct credentials, if the User entered the matching credentials, and if the User may be a new hire. *5.* Issue is resolved. *6.* User is able to login to software.
Alternatives	N/A The only entry into the software is through logging in with your staff credentials.
Exceptions	If the User is a new employee, there may be a wait time for the software to upload staff credentials. If the User has trouble logging into the software, a Hospital Administrator will have authority to resolve login issues.

Use case ID	3A
Name	**Search patient directory**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* If the patient has been entered into the system prior, User may search the patient directory for the patient account. *2.* If the patient has not been entered into the system and is a new patient, then User must create a new patient account. *3.* For old patients, User can look up patient in the search bar on the left hand side of the application. *4.* Enter patient's name. *5.* Patient's name, date of birth, and Patient ID will populate down below the search bar. *6.* Click on the patient account. *7.* User will be entered into the patient account.
Alternatives	N/A
Exceptions	N/A

Use case ID	4A
Name	**Create new patient account**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* If the patient has not been entered into the system and is a new patient, then User must create a new patient account. *2.* There are several tabs on the top right corner of the application. *3.* One of the tabs is called "Create new patient account" *4.* Click on the "Create new patient account" tab. *5.* User will be entered into a new window. *6.* In this new window, User will see a fillable blank form. *7.* Fill in all information about the patient. *8.* Submit the form. *9.* Form will be processed and approved by operating physician and/or nurse. *10.* Once the form is processed, new patient account will be created.
Alternatives	The hospital may have a paper copy of the form that the patient may choose to fill out, instead of filling out the form on the software.
Exceptions	N/A

Use case ID	5A
Name	**Access patient account**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record.
Alternatives	N/A
Exceptions	N/A

Use case ID	6A
Name	**Review patient account information**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record. *10.* Once User are in the patient record, User can see many options on the screen. Some of the options include patient allergies, patient medications, patient past surgeries, doctor's notes, patient insurance, patient diet, patient current surgery, etc.
Alternatives	N/A
Exceptions	N/A

Use case ID	7A
Name	**Add medical updates to patient account**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record. *10.* Inside the patient records window, User can find an option to "Add medical updates to patient account." *11.* Click "Add medical updates to patient account." *12.* User will be entered into a fillable blank form, where it will ask to User to enter a list of updates. *13.* User will submit the e-form. *14.* Updates will be immediately recorded in the database and updated in the patient account.
Alternatives	N/A
Exceptions	N/A

Use case ID	8A
Name	**Match operation with corresponding anesthesia**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record. *10.* Inside the patient records window, User will see a link for "Pending Surgery." *11.* Click on "Pending Surgery." *12.* This will open a new window. *13.* The new window will provide a description of the matching operation with corresponding anesthesia.
Alternatives	N/A
Exceptions	N/A

Use case ID	9A
Name	**Administer anesthesia according to instructions**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	1. User logs into the system. 2. When logged in, they will see a search bar on the left hand side of the application. 3. User can access a patient account by entering patient name and/or patient ID into the search bar. 4. All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. 5. User may choose to click on the first choice on the populated down menu. 6. Or User may choose to click "Go" 7. If User click "Go," the application will take User to a new page with a list of all search results. 8. Once User found the matching patient, User can click on "Access patient account." 9. After clicking on "Access patient account," User will be entered into the patient e-file record. 10. Inside the patient records window, User will see a link for "Pending Surgery." 11. Click on "Pending Surgery." 12. This will open a new window. 13. The new window will provide a description of the matching operation with corresponding anesthesia. 14. The application will now provide an interactive interface, where it will lead the User in administering the anesthesia.
Alternatives	N/A
Exceptions	N/A

Use case ID	10A
Name	**Monitor patient's vital signs during the operation**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	1. User logs into the system. 2. When logged in, they will see a search bar on the left hand side of the application. 3. User can access a patient account by entering patient name and/or patient ID into the search bar. 4. All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. 5. User may choose to click on the first choice on the populated down menu. 6. Or User may choose to click "Go" 7. If User click "Go," the application will take User to a new page with a list of all search results. 8. Once User found the matching patient, User can click on "Access patient account." 9. After clicking on "Access patient account," User will be entered into the patient e-file record. 10. Inside the patient records window, User will see a link for "Pending Surgery." 11. Click on "Pending Surgery." 12. This will open a new window. 13. The new window will provide a description of the matching operation with corresponding anesthesia. 14. The application will now provide an interactive interface, where it will lead the User in administering the anesthesia. 15. After the User administers the anesthesia according to instructions of the software, the User follows more instructions from the screen on how to monitor vital signs. 16. The User will monitor the patient's vital signs until the end of the operation.
Alternatives	N/A

Exceptions	N/A

Use case ID	11A
Name	**Administer anesthesia according to instructions**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse. Post-operation session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	1. User logs into the system. 2. When logged in, they will see a search bar on the left hand side of the application. 3. User can access a patient account by entering patient name and/or patient ID into the search bar. 4. All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. 5. User may choose to click on the first choice on the populated down menu. 6. Or User may choose to click "Go" 7. If User click "Go," the application will take User to a new page with a list of all search results. 8. Once User found the matching patient, User can click on "Access patient account." 9. After clicking on "Access patient account," User will be entered into the patient e-file record. 10. Inside the patient records window, User will see a link for "Post Surgery." The link "Post Surgery" appears after the operation has concluded. 11. A generated report of the second-by-second account is produced and accessible at the "Post Surgery" link.
Alternatives	N/A
Exceptions	N/A

Use case ID	12A
Name	**Receive instructions on how to provide post-operational care**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse. Post-operation session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record. *10.* Inside the patient records window, User will see a link for "Post Surgery." The link "Post Surgery" appears after the operation has concluded. *11.* Click on "Post Surgery" *12.* This will open a new window. *13.* The application will now provide an interactive interface, where it will provide information on post-operation care for patient.
Alternatives	N/A
Exceptions	N/A

Use case ID	13A
Name	**Save record of patient's operation to patient account**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse. Post-operation session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* User can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* User may choose to click on the first choice on the populated down menu. *6.* Or User may choose to click "Go" *7.* If User click "Go," the application will take User to a new page with a list of all search results. *8.* Once User found the matching patient, User can click on "Access patient account." *9.* After clicking on "Access patient account," User will be entered into the patient e-file record. *10.* Inside the patient records window, User will see a link for "Post Surgery." The link "Post Surgery" appears after the operation has concluded. *11.* Click on "Post Surgery" *12.* This will open a new window. *13.* Inside this new window, there is a button called "Save to Record" on the bottom corner of the screen. Click on "Save to Record" *14.* User have saved record of Patient's operation to patient database.
Alternatives	N/A
Exceptions	N/A

Use case ID	14A
Name	**Log out of A^2 portal**
Pre-Conditions	User must have authorized access.
Post-Conditions	N/A
Initiated By:	User
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse. Post-operation session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* User logs into the system. *2.* When logged in, User can see at the bottom right corner containing button named "Log out" *3.* Click on the "Log out" button. *4.* User will be logged out of the A^2 portal *5.* User is returned to the Login screen.
Alternatives	N/A
Exceptions	N/A

Use case ID	15A
Name	**Remove patient account**
Pre-Conditions	Administrator must have authorized access.
Post-Conditions	N/A
Initiated By:	Administrator
Triggering Event:	Operation is approved. Pre-anesthesia session was conducted by nurse. Post-operation session was conducted by nurse.
Additional Actors:	Physicians, Surgeons, Specialists, other medical staff members
Sequence of Events	*1.* Administrator logs into the system. *2.* When logged in, they will see a search bar on the left hand side of the application. *3.* Administrator can access a patient account by entering patient name and/or patient ID into the search bar. *4.* All three of patient's Name, date of birth, and patient ID in one line will be populated down the menu of the search bar. *5.* Administrator may choose to click on the first choice on the populated down menu. *6.* Or Administrator may choose to click "Go" *7.* If Administrator click "Go," the application will take Administrator to a new page with a list of all search results. *8.* Once Administrator found the matching patient, Administrator can click on "Access patient account." *9.* After clicking on "Access patient account," Administrator will be entered into the patient e-file record. *10.* Inside the patient records window, Administrator will see a tab called "Deactivate Account." *11.* Click on "Deactivate Account" *12.* A pop-up window appears on the screen, asking: "Are you sure you want to remove patient? This will be permanent data loss." There are two choices: "Yes" or "No" *13.* If Administrator chooses "Yes," patient will be removed from the roll. *14.* If Administrator chooses "No," the pop-up window will close.
Alternatives	N/A
Exceptions	N/A

10 Functional Requirements

Requirement #A
Description: A^2 Technology has functionality for User to log in to the software with their credentials.
Rationale: The User's ability to log in with their credentials is a way to identify the User and to authorize their access.
Fit Criterion: Administrator oversees and approves whom may gain access to the software. They will be in charge of create a new User account, password recovery options, and removal of patient account. New Hires will require a new User account creation. Administrator shall provide assistance in an event an existing User mistakes their credentials. Once Administrator recovers credentials, User can successful log back into the software.

Requirement #B
Description: A^2 Technology has functionality for User to log in to the software with their credentials.
Rationale: The User's ability to log in with their credentials is a way to identify the User and to authorize their access.
Fit Criterion: Administrator oversees and approves whom may gain access to the software. They will be in charge of create a new User account, password recovery options, and removal of patient account. New Hires will require a new User account creation.

Requirement #C
Description: The User has ability to search patient database in the A^2 Technology software.
Rationale: The User's ability to search patient database allows them to access patient account information, retrieve patient medical data, and many other operational tasks.
Fit Criterion: Administrator oversees and approves whom may gain access to the software. They will be in charge of create a new User account, password recovery options, and removal of patient account. New Hires will require a new User account creation.

Requirement #D
Description: The User has ability to save patient records to respective patient accounts.
Rationale: The User's ability to save patient records provides the A^2 Technology software to have a repository of all patient medical information. This medical information can be accessible for doctors, nurses, medical staff, and other hospital crew members. Access to patient records also gives A^2 Technology software a chance to stand out as a medical device.
Fit Criterion: User should be able to save patient records pre-operation, during the operation, and post-operation.

Requirement #E
Description: Complex systems like A^2 Technology must be designed and built for multiple medical procedures and undertakings. If system shuts down or somehow crashes, the system must have a procedure in place to curtail loss of patient records and data. In order to provide reliable computing systems, software fault tolerance is the ability for software to detect and recover from a fault that is occurring or has happened in the past. This may occur in either software or hardware in the system in which software is running in way of providing medical service.
Rationale: In order to ensure that these systems perform as specified, even under unlikely and extreme conditions, it is important to have fault tolerant computing systems --- both hardware and software. Current methods under the product for software fault tolerances include recovery blocks and self-checking software.
Fit Criterion: Power outages is an example of an event that may cause system shutdown.

Requirement #F
Description: A^2 Technology software must be accessible to all authorized Users 100% of the time.
Rationale: A^2 Technology software strives to function without conflict with regular maintenance. Patient data is available for Users throughout the operation. Availability of data helps Users provide efficient and precise care. Users will also immediately know each patient's medical problems and allergies that may conflict with anesthesia. With such detailed information available to Users, this heightens the care and safety of the treated patient.
Fit Criterion: User should be log out of the A^2 portal.

Requirement #G
Description: The User has ability to log out of the A^2 portal.
Rationale: The User's ability to log out of the A^2 Technology software adds a level of security. Protecting medical records is significant in a hospital or health care setting.
Fit Criterion: User should be log out of the A^2 portal.

ID	A
Name	**Functional Requirements**
Description	To determine whether the system is ready for release, the User will test the system to find out whether the application meets the business' needs. Once this process has been completed and the software has passed, the program will then be delivered to production. Logging into A^2 Technologies software confirms the authentication, authorization, and access of the User. Logging in is a means of tracking events that happens when A^2 Technologies software runs.
Rationale	If the events of authentication, authorization, and access of User is successful, that means the User is able to test the software and experience the software for its full purpose. Failed authentication and authorizations translates to the User being unable to access the system, the data, and the application.
Fit Criterion	These events include changes to systems or applications, changes to data such as creation and destruction, and application installation and changes.
Acceptance Tests	A. Application login successes are useful acceptance tests because these logs provide information from an operational standpoint. Faults and errors affect the application availability. Availability events include startup and shutdown of systems and applications.

11 Data Requirements

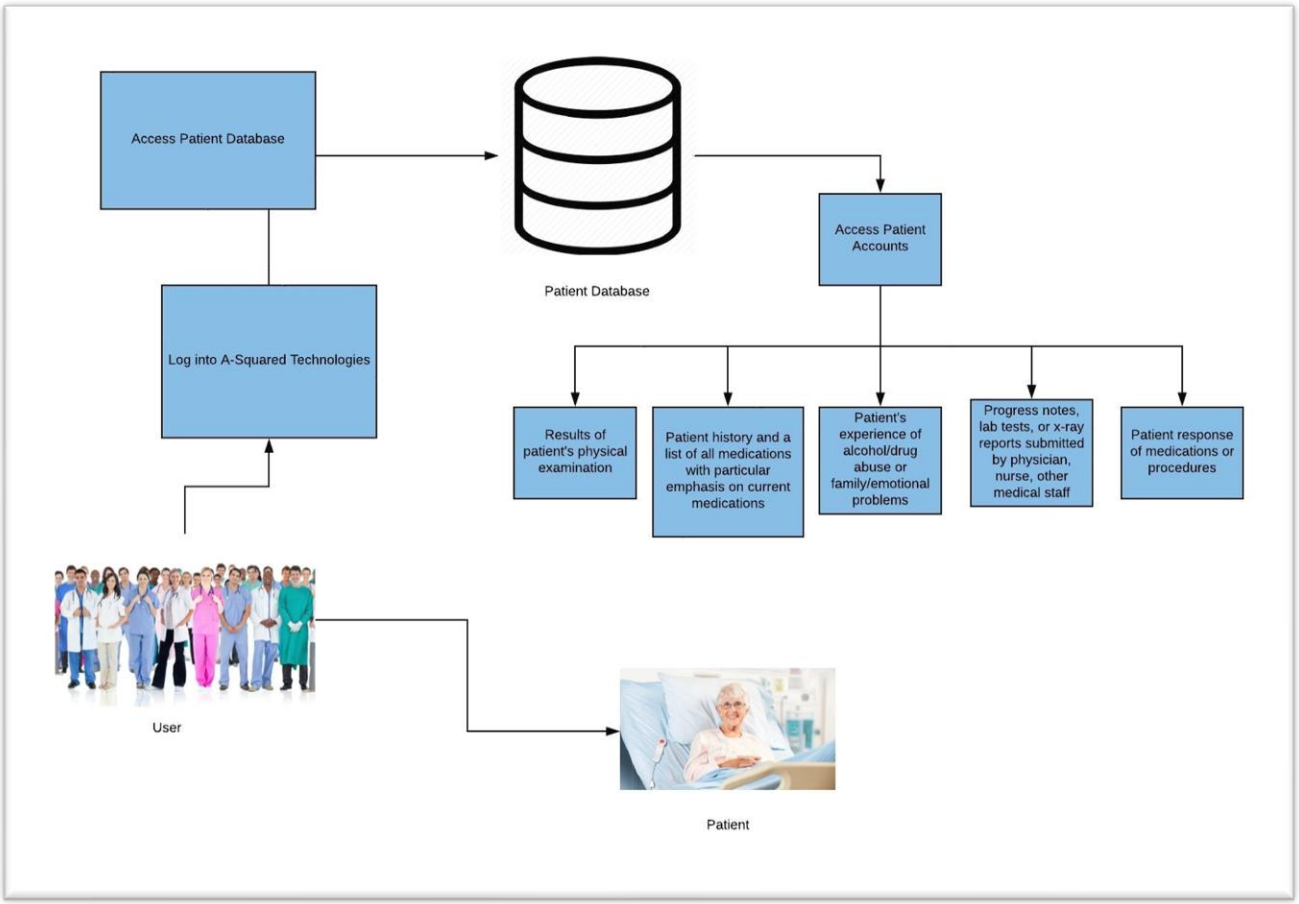


Figure 10. This diagram captures the required data collected through the A^2 Technology software.

ID	B
Name	**Data**
Description	To determine whether the system is ready for release, the User will test the system to find out whether the application meets the business' needs. Once this process has been completed and the software has passed, the program will then be delivered to production. Logging into A^2 Technologies software confirms the authentication, authorization, and access of the User. Logging in is a means of tracking events that happens when A^2 Technologies software runs.

Rationale	If the events of authentication, authorization, and access of User is successful, that means the User is able to test the software and experience the software for its full purpose. Failed authentication and authorizations translates to the User being unable to access the system, the data, and the application.
Fit Criterion	These events include changes to systems or applications, changes to data such as creation and destruction, and application installation and changes.
Acceptance Tests	B. Application login successes are useful acceptance tests because these logs provide information from an operational standpoint. Faults and errors affect the application availability. Availability events include startup and shutdown of systems and applications.

12 Performance Requirements

12a Speed and Latency Requirements

Running A^2 Technology on a computer requires a broadband network connection, commanding a faster speed. With this product being used in a high stakes, life-or-death environment such as a hospital setting, A^2 Technology is very dependent on the continuous flow of data. User is logged into the software immediately. Patient profiles and account information should be loaded within 1 second. Following the directions of the administration of anesthesia should be within 100 milliseconds. Screens must be loaded within seconds after running the software. New screens and pop-up windows must be completed loaded within one second. We cannot have a delay or stall as an operation is being performed on a patient.

ID	C
Name	**Speed and Latency**
Description	To determine whether the system is ready for release, the User will test the system improve application performance and reduce latency.
Rationale	Latency is clearly the biggest factor in speed and network constraints, such page loading or database search running on A^2 Technology. Speed and latency measures the delay between action and a response. Individual delays the application level can aggregate, as each element of the communication domino is linked in the chain.

Fit Criterion	Run measurements of real Users and test synthetic measurements changes especially with upload and download speeds. Unless Users start with an especially slow Internet connection, in the case of tripling speed, there is a difference. With latency upsurges, load times for Running A^2 Technology applications increases linearly.
Acceptance Tests	C. Asynchronous development approaches such as Ajax and the use of any Javascript framework can reduce the delays by separating program logic from the need of constant and inherent network connectivity. The A^2 Technology software makes efforts in reducing application chattiness. An acceptance test such as reducing the number of requests makes the page less chatty.

12b Precision or Accuracy Requirements

Users must provide accurate medical information for matching patient accounts. No medical record submitted to the A^2 Technology patient database is vague, incomplete, or altered without approval. All operational events for the patients are well documented. A^2 Technology software ensure medical record entries and annotations are clear and readable. In case of an error, make a mark next to the error and write the date, the time, and User initials in the margins.

Users should always indicate the date and time of an entry. Ensure each page on the application includes the patient's name, date of birth, and patient ID. Avoid the dangerous habits of copying or cutting and pasting. User must include a detailed and accurate medical history, physical findings, differential diagnoses, treatment plan, care rendered, advice given, and other matters pertinent to the patient's medical operation. User should avoid personal abbreviations; only standard or accepted medical abbreviations are used. User is responsible for documenting patient's verbatim statements.

ID	C
Name	**Precision**
Description	To determine whether the system is ready for release, the User will test the system for improvements in access to complete and accurate patient health information. No data gap is acceptable. Quality data provides a more structured medical operation in a faster, more efficient manner, which will lead to better treatment.
Rationale	Having access to quality data in A^2 Technology is a priority when using the data for decision making. Electronic health records hold up-to-date

	information and quality data with A^2 Technology that can improve the ability to diagnose diseases and reduce medical errors while improving patient anesthetic outcomes.
Fit Criterion	100% of providers report that A^2 Technology makes patient records readily available at point of care. All report that their electronic health records produces clinical and anesthetic benefits for the practice. Providers report that A^2 Technology allows them to deliver better patient care.
Acceptance Tests	C. An acceptance test sets up the criteria for systems to be secure transfer of all patient data from A^2 Technology, access to all patient's available data for authorized use, and configuration of technology so there is not information blocking or erasure. No data gap is acceptable. If clinicians have to search through the media/documents tab in the records, they must have up-to-date information to use for making medical decisions. This could potentially put a patient's safety at risk and greatly stall the treatment process. A^2 Technology works to provide up-to-date results in their data-keeping methods. A^2 Technology pulls important data from anywhere within the patient records and routes that data to discrete field when operating on a patient.

12c Capacity Requirements

The server running A^2 Technology will be able to handle up 100,000 active users logged in simultaneously. The server may handle at least 1,500,000 requests running concurrently.

ID	C
Name	**Capacity**
Description	To determine whether the system is ready for release, the User will test the system for improvements in access to complete and accurate patient health information. No data gap is acceptable. Quality data provides a more structured medical operation in a faster, more efficient manner, which will lead to better treatment. A^2 Technology will hold a lot information such as identifying and maintaining a patient record.
Rationale	Having access to quality data in A^2 Technology is a priority when using the data for decision making. Electronic health records hold up-to-date information and quality data with A^2 Technology that can improve the ability to diagnose diseases and reduce medical errors while improving patient anesthetic outcomes. A^2 Technology will manage a large capacity of data, such as patient demographics, problem lists, medication

	lists, patient history, clinical documents and notes, external clinical documents, present care plans and guidelines and protocols, and generate and record patient-specific instructions. Therefore, A^2 Technology must be able to handle thousands of requests in any given amount of time. A^2 Technology must maintain critical, highly sensitive private information in healthcare, and need to be frequently shared among authorized Users.
Fit Criterion	Storing data between multiple pages, maintaining access control through numerous consents may complicate the process of patient's treatments. A^2 Technology provides a shared, immutable, and transparent history of all transactions access several records at a given amount of time, with trust, accountability, and transparency. A^2 Technology has a unique opportunity to develop a secure and trustable data management and sharing system.
Acceptance Tests	C An acceptance test implements a framework in a prototype that ensures privacy, security, availability, and fine-grained access control over A^2 Technology data. Data stored in A^2 Technology is highly sensitive, private information for diagnosis and treatment in healthcare. The network would be formed by healthcare institutions and primary caregivers. The network will run consensus protocol and maintain a distributed ledger, documenting all actions that have happened to all participants of the network (i.e. patient modifying permissions or consent, a User accessing or uploading data, etc.).

13 Dependability Requirements

13a Reliability Requirements

If there is a A^2 Technology system failure, no patient data, such as currently administered anesthesia or doctors' progress notes, is lost or damaged.

System maintenance is conducted more than periodically. The system will notify Users of the time and duration of the maintenance in advance. An appropriate message notifying User that A^2 Technology is down for maintenance is generated 24 hours in advance.

ID	D
Name	**Reliability**
Description	To determine whether the system is ready for release, the User will test the system for improvements in access to complete and accurate patient health information. No data gap is acceptable. Quality data provides a more structured medical operation in a faster, more efficient manner, which will lead to better treatment. A^2 Technology will hold a lot information such as identifying and maintaining a patient record.
Rationale	Having access to quality data in A^2 Technology is a priority when using the data for decision making. Electronic health records hold up-to-date information and quality data with A^2 Technology that can improve the ability to diagnose diseases and reduce medical errors while improving patient anesthetic outcomes. A^2 Technology will manage a large capacity of data, such as patient demographics, problem lists, medication lists, patient history, clinical documents and notes, external clinical documents, present care plans and guidelines and protocols, and generate and record patient-specific instructions. Therefore, A^2 Technology must be able to handle thousands of requests in any given amount of time. A^2 Technology must maintain critical, highly sensitive private information in healthcare, and need to be frequently shared among authorized Users.
Fit Criterion	Storing data between multiple pages, maintaining access control through numerous consents may complicate the process of patient's treatments. A^2 Technology provides a shared, immutable, and transparent history of all transactions access several records at a given amount of time, with trust, accountability, and transparency. A^2 Technology has a unique opportunity to develop a secure and trustable data management and sharing system.
Acceptance Tests	D. An acceptance test implements a framework in a prototype that ensures privacy, security, availability, and fine-grained access control over A^2 Technology data. Data stored in A^2 Technology is highly sensitive, private information for diagnosis and treatment in healthcare. The network would be formed by healthcare institutions and primary caregivers. The network will run consensus protocol and maintain a distributed ledger, documenting all actions that have happened to all participants of the network (i.e. patient modifying permissions or consent, a User accessing or uploading data, etc.).

13b Availability Requirements

Other than undergoing maintenance, the A^2 Technology applications must be available to the User 24 hours per day, 365 days per year (or 366 days per leap year). The software must allow Users to access patient portfolios at all times. Updates for A^2 Technology applications is available every two weeks. New versions of the A^2 Technology applications is available once every 6 months.

ID	D
Name	**Availability**
Description	To determine whether the system is ready for release, the User will test the system for improvements in access to complete and accurate patient health information. No data gap is acceptable. Quality data provides a more structured medical operation in a faster, more efficient manner, which will lead to better treatment. A^2 Technology will hold a lot information such as identifying and maintaining a patient record.
Rationale	A^2 Technology software strives to function without conflict with regular maintenance. Patient data is available for Users throughout the operation. Availability of data helps Users provide efficient and precise care. Users will also immediately know each patient's medical problems and allergies that may conflict with anesthesia. With such detailed information available to Users, this heightens the care and safety of the treated patient.
Fit Criterion	Storing data between multiple pages, maintaining access control through numerous consents may complicate the process of patient's treatments. A^2 Technology provides a shared, immutable, and transparent history of all transactions access several records at a given amount of time, with trust, accountability, and transparency. A^2 Technology has a unique opportunity to develop a secure and trustable data management and sharing system.
Acceptance Tests	D. An acceptance test would implement a test to enhance the ability for Users to complete information-intensive tasks.

13c Robustness or Fault-Tolerance Requirements

When there is a disconnection with the database, the system will notify all Users operating on the A^2 Technology software. In the event of lost of connection to the server, A^2 Technology will

automatically save current progress and return the most recent application as soon as the connection is recovered.

ID	D
Name	**Fault-Tolerance**
Description	To determine whether the system is ready for release, the User will test the system for improvements in access to complete and accurate patient health information. No data gap is acceptable. Quality data provides a more structured medical operation in a faster, more efficient manner, which will lead to better treatment. A^2 Technology will hold a lot information such as identifying and maintaining a patient record.
Rationale	Complex systems like A^2 Technology must be designed and built for multiple medical procedures and undertakings. If system shuts down or somehow crashes, the system must have a procedure in place to curtail loss of patient records and data. In order to provide reliable computing systems, software fault tolerance is the ability for software to detect and recover from a fault that is occurring or has happened in the past. This may occur in either software or hardware in the system in which software is running in way of providing medical service.
Fit Criterion	Fit Criterion: Power outages is an example of an event that may cause system shutdown.
Acceptance Tests	D. A^2 Technology software tests its ability to semi-automate the adding of fault tolerance into software. This would be a significant medical device enhancement to the market today. Recovery block system include hardware support for rollback operations. Self-checking software are extra checks, which walks to the heap finding and correcting data defects.

13d Safety-Critical Requirements

ID	D
Name	**Safety Critical Requirements**
Description	Since many software hazards are caused by incompleteness or omissions of safety requirements, the safety analysis of software requirements becomes more crucial.

Rationale	In spite of best efforts, accidents can, and sometimes do, happen. A^2 Technology's biggest challenge is the process of ensuring that the system is sufficiently secure to operate. We must ensure that the system is free from external threats that can cause malicious harm. It is a matter of degree and risk management. A^2 Technology values the importance of addressing not just the prevention of accidental harm, hazards, accidents, and risks. We also stress the importance of detecting their existence and occurrence and reacting properly. Users of the A^2 Technology software may also face safety requirements. User using the A^2 Technology software must perform the same physical motions thousands of times an hour. This may lead to repetitive strain injuries such as carpal tunnel syndrome and forearm tendinitis. If left untreated, the User may endure permanent nerve damage. Tendonitis can harm tendons, ligaments, and muscles that are engaged in repetitive motions. A^2 Technology applications requires Users to holder their hands in a fixed and unnatural position to click through the tabs and windows and other user interface elements. The forearm is further strained by these motions. If the desk is too high, some Users may need to flex their wrists, which puts a lot of pressure on the median nerve.
Fit Criterion	Repetitive strain injury may not be the only job hazard that Users may face. Intense sessions at the computer screen can cause computer-caused eye problems such as eye strain or headaches. User of the A^2 Technology software may use an anti-glare filter on their screens.
Acceptance Tests	D. An acceptance test implements a framework in a prototype that ensures privacy, security, availability, and fine-grained access control over A^2 Technology data. Data stored in A^2 Technology is highly sensitive, private information for diagnosis and treatment in healthcare. The network would be formed by healthcare institutions and primary caregivers. The network will run consensus protocol and maintain a distributed ledger, documenting all actions that have happened to all participants of the network (i.e. patient modifying permissions or consent, a User accessing or uploading data, etc.).

14 Maintainability and Supportability Requirements

14a Maintenance Requirements

In the A^2 Technology software lifetime, we will follow four types of maintenance: corrective maintenance, adaptive maintenance, perfective maintenance, and preventive maintenance. Corrective maintenance includes modifications and updates that are completed in order to correct, resolve, or fix problems, which are either discovered by User/Administrator or concluded by User/Administrator error reports. Adaptive maintenance involves modifications and

updates applied to the A^2 Technology to maintain the product software up-to-date in the ever-changing, fast-paced world of the healthcare field. Bugs in the software shall be fixed promptly. To continually improve reliability and performance, a perfective maintenance is performed on the A^2 Technology software. Perfective maintenance involves modification and updates done in order to keep the A^2 Technology software usable over a duration of time. New features and User/Administrator requirements are introduced as modifications and updates. To prevent future software issues, preventative maintenance is also performed on the A^2 Technology software. Modifications and updates on problems that may not seem like an issue at the moment are looked over during preventative maintenance. Any patches of bugs in the software will be released immediately within the bug error report has been filed.

ID	E
Name	**Maintenance**
Description	Since many software hazards are caused by incompleteness or omissions of safety requirements, the safety analysis of software requirements becomes more crucial.
Rationale	In spite of best efforts, accidents can, and sometimes do, happen. A^2 Technology's biggest challenge is the process of ensuring that the system is sufficiently secure to operate. We must ensure that the system is free from external threats that can cause malicious harm. It is a matter of degree and risk management. A^2 Technology values the importance of addressing not just the prevention of accidental harm, hazards, accidents, and risks. We also stress the importance of detecting their existence and occurrence and reacting properly. Users of the A^2 Technology software may also face safety requirements. User using the A^2 Technology software must perform the same physical motions thousands of times an hour. This may lead to repetitive strain injuries such as carpal tunnel syndrome and forearm tendinitis. If left untreated, the User may endure permanent nerve damage. Tendonitis can harm tendons, ligaments, and muscles that are engaged in repetitive motions. A^2 Technology applications requires Users to holder their hands in a fixed and unnatural position to click through the tabs and windows and other user interface elements. The forearm is further strained by these motions. If the desk is too high, some Users may need to flex their wrists, which puts a lot of pressure on the median nerve.
Fit Criterion	Repetitive strain injury may not be the only job hazard that Users may face. Intense sessions at the computer screen can cause computer-caused eye problems such as eye strain or headaches. User of the A^2 Technology software may use an anti-glare filter on their screens.

Acceptance Tests	E. An acceptance test implements a framework in a prototype that ensures privacy, security, availability, and fine-grained access control over A^2 Technology data. Data stored in A^2 Technology is highly sensitive, private information for diagnosis and treatment in healthcare. The network would be formed by healthcare institutions and primary caregivers. The network will run consensus protocol and maintain a distributed ledger, documenting all actions that have happened to all participants of the network (i.e. patient modifying permissions or consent, a User accessing or uploading data, etc.).

14b Supportability Requirements

ID	E
Name	**Supportability**
Description	At an affordable cost, supportability is A^2 Technology's capability keeping the software functioning, of a total system design to support operations and readiness needs throughout the lifecycle of the A^2 Technology software.
Rationale	The set of activities, including all processes, resources, and infrastructure, necessary to ensure that A^2 Technology operationally fulfills its original requirements and any subsequent modifications to those requirements. It provides resources of assessing the suitability of a total system design for a set of operational needs within the intended operations and support environment, such as cost, A^2 Technology equipment readiness, and medical staff manpower constraints. When total system of A^2 Technology demonstrates operational affordability and suitability, the elements of the total system designs are considered complete. Characteristics of a total system are subject to change as time progresses.
Fit Criterion	Client expects hospital and administration servers are secured. The hardware is designed to run 24/7, and any interruptions, malware attacks, shutdown, etc. must be planned days or weeks in advance. In many cases, the client is not allowed to reboot the machine or to debugged. What ultimately matters is how the support process is implemented, the duration of the process, and what are the costs for the Client.
Acceptance Tests	E

14c Adaptability Requirements

ID	E
Name	**Adaptability**
Description	The adaptability of A^2 Technology is far-reaching due to nature of training humans treating vulnerable humans. An increasingly important quality attribute of a complex software systems is adaptability.
Rationale	Software architecture for A^2 Technology software should be flexible enough to accommodate all components and feature that A^2 Technology offers. Costs of new enhancements in software processes will be lesser in the future.
Fit Criterion	Systems that run in most recent versions of Windows, Mac OS, and Linux OS is fitting software architecture for the A^2 Technology software. The adaptability of A^2 Technology should have the ability to manage complex and interconnected systems of multiple stakeholders, which will increase business flows.
Acceptance Tests	E

14d Scalability or Extensibility Requirements

The A^2 Technology software is proposed to support a hospital staff of 1,500 during the first quarter of the initial release. After 6 months, the product will support multiple hospitals with small to large staff populations.

ID	*E*
Name	*Scalability or Extensibility Requirements*
Description	The scalability of A^2 Technology is far-reaching due to nature of training humans treating vulnerable humans. An increasingly important quality attribute of a complex software systems is adaptability.
Rationale	Software architecture for A^2 Technology software should be flexible enough to accommodate all components and feature that A^2 Technology offers. Costs of new enhancements in software processes will be lesser in the future.

Fit Criterion	Systems that run in most recent versions of Windows, Mac OS, and Linux OS is fitting software architecture for the A^2 Technology software. The scalability of A^2 Technology should have the ability to manage complex and interconnected systems of multiple stakeholders, which will increase business flows.
Acceptance Tests	H

14e Longevity Requirements

ID	E
Name	**Longevity**
Description	Users may face examples of aging software systems involving data loss, software cost overruns, and violations of compliance regulations that require data and traceability of processes. A^2 Technology will make advancements in the keeping the software authentic, medically understandable, and usable through time and across evolving socio-technological environments.
Rationale	The A^2 Technology applications are available to authorized Users during the timespan of their employment at hospital or healthcare setting.
Fit Criterion	Longevity testing uses baseline work efficiency specification to evaluate a large enterprise application such as A^2 Technology.
Acceptance Tests	E

15 Security Requirements

15a Access Requirements

ID	F
Name	**Access**
Description	The Users do not have access to the source code behind A^2 Technology software. The developers and testers will have access to the course code. Users' login credentials are made know to the User and Administrator.
Rationale	Only the A^2 Technology development team and quality assurance team have access to source code due to security reasons.

Fit Criterion	Users have access to patient record database.
Acceptance Tests	F

15b Integrity Requirements

ID	F
Name	**Integrity**
Description	The Users do not have access to the source code behind A^2 Technology software. The developers and testers will have access to the course code. Users' login credentials are made know to the User and Administrator.
Rationale	Only the A^2 Technology development team and quality assurance team have access to source code due to security reasons. The data in the product database is not made public at any point in time. All patient data is stored in a secured patient database.
Fit Criterion	Users have access to patient record database.
Acceptance Tests	F

15c Privacy Requirements

ID	F
Name	**Privacy**
Description	The Users do not have access to the source code behind A^2 Technology software. The developers and testers will have access to the course code. Users' login credentials are made know to the User and Administrator.
Rationale	Only the A^2 Technology development team and quality assurance team have access to source code due to security reasons. The data in the product database is not made public at any point in time. All patient data is stored in a secured patient database. Users of A^2 Technology will be trained to understand and following strict non-disclosure, privacy policies before being able to access the software.
Fit Criterion	Users have access to patient record database.

Acceptance Tests	F

15d Audit Requirements

ID	F
Name	**Audit**
Description	The Users do not have access to the source code behind A^2 Technology software. The developers and testers will have access to the course code. Users' login credentials are made know to the User and Administrator. Users of the A^2 Technology software are not allowed to use the A^2 Technology outside of hospital or healthcare setting grounds. Any attempt to download or upload documents or materials from A^2 Technology will be tracked by cyber security software engineers on the A^2 Technology teams.
Rationale	Only the A^2 Technology development team and quality assurance team have access to source code due to security reasons. The data in the product database is not made public at any point in time. All patient data is stored in a secured patient database. Users of A^2 Technology will be trained to understand and following strict non-disclosure, privacy policies before being able to access the software.
Fit Criterion	Users have access to patient record database.
Acceptance Tests	F

15e Immunity Requirements

ID	F
Name	**Immunity**
Description	The bombardment of software viruses is constant. Viruses can be programmed to cause damage to the medical device, prevent Users from access patient data, or take control of hospital infrastructure. A^2 Technology is up-to-date with antivirus software protection. The A^2 Technology development team is constantly updating their detection tools regularly to deal with the more than 10,000 new pieces of malware created daily. Today's malware changes appearance rapidly to avoid detection by older antivirus software.

	A^2 Technology software will partner with highly rated antivirus software on the market to protect software's patient database. We will have ability to scan specific files or directories for any malware or known malicious patterns. A^2 Technology software will allow for scheduled scans to automatically run for you. The antivirus software built in to A^2 Technology software will remove any malicious code detected. There is health progress report produced by the antivirus software every week.
Rationale	Only the A^2 Technology development team and quality assurance team have access to source code due to security reasons. The data in the product database is not made public at any point in time. All patient data is stored in a secured patient database. Users of A^2 Technology will be trained to understand and following strict non-disclosure, privacy policies before being able to access the software.
Fit Criterion	Users have access to patient record database.
Acceptance Tests	F

16 Usability and Humanity Requirements

16a Ease of Use Requirements

ID	G
Name	**Ease of Use**
Description	A^2 Technology software strives to be efficient, effective, error-tolerant, engaging, and easy-to-learn. An error-tolerant software is designed to prevent unforced errors by the User's interactions, and help guide the User in recovering from any errors that may occur. Error messages are part of the interface, including a clear description of the error and direct links to the choices or pathways in correcting the problem. A^2 Technology has designed links and buttons that distinctive and clear in correcting unexpected errors. The User interface is user-centered design. The effectiveness of the A^2 Technology interface relies on appropriate medical language and presentation of medical alternatives that is understandable to the User. Efficiency can be described as the speed and accuracy in which Users complete tasks on A^2 Technology. With high speed internet connection at any given hospital or healthcare setting, the A^2 Technology applications will not take more than three

	seconds to start. Other efficiency metrics include the number of clicks or keystrokes required. Navigation design elements such as keyboard shortcuts, menus, links, and other buttons on A² Technology impacts efficiency. When they are well-designed, with clearly expressed actions, Users will spend less time and effort needed for them to make navigation and action choices. Making the right choices for efficient use of the A² Technology software depends on how Users prefer to work. For example, do proficient Users use the keyboard shortcuts who work with A² Technology interface intensely?
Rationale	The A² Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A² Technology interface. What is important for the A² Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	A² Technology is the primary interaction tool, so the software can slow down Users whom may be unfamiliar with the software.
Acceptance Tests	G

16b Personalization and Internationalization Requirements

ID	G
Name	**Personalization and Internationalization**
Description	The A² Technology software is initially available in the English language. If popularity for A² Technology grows, other languages may be implemented. In the future, the User may choose different setting options for choice languages.
Rationale	The A² Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the

	User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	A^2 Technology is the primary interaction tool, so the software can slow down Users whom may be unfamiliar with the software.
Acceptance Tests	G

16c Learning Requirements

ID	G
Name	**Learning**
Description	Most Users of the A^2 Technology software are medically trained in some form or fashion. At a minimum, they hold undergraduate degrees in the biological sciences.
Rationale	A^2 Technology caters to all those in the medical field. Having a background in the biological sciences is beneficial.
Fit Criterion	A^2 Technology is the primary interaction tool, so the software can slow down Users whom may be unfamiliar with the software.
Acceptance Tests	G

16d Understandability and Politeness Requirements

ID	G
Name	**Understandability and Politeness**
Description	The A^2 Technology software will not at any point in time showcase violent graphical images. The application will not use offensive, derogatory language that targets any member of the community.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the

	User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	A^2 Technology is the primary interaction tool, so the software can slow down Users whom may be unfamiliar with the software.
Acceptance Tests	G

16e Accessibility Requirements

ID	G
Name	**Accessibility**
Description	The A^2 Technology software will conform to the American with Disabilities Act in order to qualify as a learning tool used in hospitals and other healthcare settings. The A^2 Technology software also will follow guidelines introduced by the American Society of Anesthesiologists as a way to maintain the standards of the medical practice of anesthesiology and improve anesthesia care team mode of practice and education.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	A^2 Technology is the primary interaction tool, so the software can slow down Users whom may be unfamiliar with the software.
Acceptance Tests	G

16f User Documentation Requirements

ID	G
Name	**User Documentation**
Description	Anesthesia documentation represents a detailed account of the patient's anesthesia care during various phases of anesthesia, including pre-operation consent forms, pre-anesthesia assessment and evaluation, informed consent forms, operational anesthesia services, and post-anesthesia care. As seen in Table 5, The pre-anesthesia assessment and evaluation of the patient is an overview of patient's general health, allergies, medical history, preexisting conditions, and anesthesia history. The pre-anesthesia assessment and evaluation record documents patient demographics, height and weight, vital signs, allergies and medication history, health history and review systems, anesthesia plan of care, physical examination, and relevant diagnostic test results. The patient may provide their health and anesthesia history during their doctors' visits or pre-operational interviews.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	Via automated, electronic medical record, documentation captures accurate and comprehensive information that communicates patient's anesthesia experience. All documents will be produced electronically, provided the User is authorized to access documents. The patient's chart is a legal document. If patients have a desire to view a print version of the documentation, User must have approval before releasing forms.
Acceptance Tests	G

16g Training Requirements

Patient Demographics	
Name Unique patient identification number Date of Birth Gender Admission date Height Weight Date, time, and name of surgery/procedure	
Allergies and Medications history	
Allergies (medication, food, environment) Name of medication Dosage Frequency Last dose of current medications prior to anesthesia	
Health history	
Surgical/anesthesia history Personal/family issues related to anesthesia Drug use	
Physical Examination	
Current diagnosis Current vital signs (temperature, pulse, respirations, blood pressure) Airway assessment	

Skin Head Ears Eyes Nose Throat Cardiac examination Pulmonary	
Plan of Anesthesia Care	
Plan of recovery Physical state	

Table 5. Sample pre-anesthesia assessment and evaluation documentation

ID	G
Name	**Training Documentation**
Description	New Users of the A^2 Technology will need to undergo New Users tutorial generated by A^2 Technology software team. The step-by-step guide introduces New Users how to get started with A^2 Technology.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	Via automated, electronic medical record, documentation captures accurate and comprehensive information that communicates patient's anesthesia experience. All documents will be produced electronically,

	provided the User is authorized to access documents. The patient's chart is a legal document. If patients have a desire to view a print version of the documentation, User must have approval before releasing forms.
Acceptance Tests	G

17 Look and Feel Requirements

17a Appearance Requirements

ID	H
Name	**Appearance**
Description	A^2 Technology shall have a very simple User Interface that shall make it easy for a healthcare professional to learn to use the product within a few days of hands-on training. The User Interface shall require very little interaction with a healthcare professional as the product aims to autonomously administer anesthesia to the patient being operated. The user interface shall adopt a flat design thus making it easier to convey all the information quickly while still looking visually appealing.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	The product shall have a quicker-loading and more responsive UI due to the minimal design elements in the user interface.
Acceptance Tests	H

17b Style Requirements

ID	H
Name	**Style**
Description	A^2 Technology shall have a very simple User Interface that shall make it easy for a healthcare professional to learn to use the product within a few days of hands-on training. The User Interface shall require very little interaction with a healthcare professional as the product aims to autonomously administer anesthesia to the patient being operated. The user interface shall adopt a flat design thus making it easier to convey all the information quickly while still looking visually appealing.
Rationale	The A^2 Technology interface is made to be engaging, pleasant, and satisfying to use. The visual design is the most obvious element of how the interface engages Users throughout the operation. The style of the visual presentation, the functions, the symbols, the types of graphic images or colors, and the use of any multimedia elements are part of the User's immediate actions. The design and readability of the text can change the User's ease-of-use with the A^2 Technology interface. What is important for the A^2 Technology team is that the design meets the expectations and needs of the Users who must use the interface.
Fit Criterion	The product shall adopt a flat design style emphasizing minimum use of stylistic elements that give the illusion of three dimensions. The product's style shall focus on a minimalist use of simple elements, typography, and flat colors.
Acceptance Tests	H

18 Operational and Environmental Requirements

18a Expected Physical Environment

ID	I
Name	**Expected Physical Environment**
Description	A^2 Technology offers cross-platform compatibility.
Rationale	A cross-platform compatibility is essential since hospitals and healthcare settings have various operating systems in use.

Fit Criterion	The application shall be cross-platform software. The product shall support users of different operating systems like Windows, MacOS, Linux, etc. The product shall have auto-adjust feature for the display to support clear display of patient's report in the operation theatre.
Acceptance Tests	I

18b Requirements for Interfacing with Adjacent Systems

ID	I
Name	**Interfacing with adjacent systems.**
Description	A^2 Technology offers cross-platform compatibility, as well as interfacing with adjacent systems.
Rationale	Hospitals and healthcare settings have a wide range of equipment and other systems. A^2 Technology is built to work alongside other technologies to deliver quality medicine to patients. A cross-platform compatibility is essential since hospitals and healthcare settings have various operating systems in use.
Fit Criterion	The product shall be placed at the head of the operating table in an operating room. The product shall have tubes that connect to a patient to assist in breathing during the surgery. The product shall have built-in monitors that help control the mixture of gases in the breathing circuit.
Acceptance Tests	I

18c Productization Requirements

ID	I
Name	**Interfacing with adjacent systems.**
Description	A^2 Technology offers cross-platform compatibility, as well as interfacing with adjacent systems.
Rationale	Hospitals and healthcare settings have a wide range of equipment and other systems. A^2 Technology is built to work alongside other technologies to deliver quality medicine to patients. A cross-platform

	compatibility is essential since hospitals and healthcare settings have various operating systems in use.
Fit Criterion	The client software shall be a licensed software that is available for purchase by authorized medical professionals with an authenticated and compatible anesthesiology simulator. The A^2 Technology product will have the client software preinstalled in the device at the time of purchase. The software shall be upgradable for free as and when there are new releases.
Acceptance Tests	I

18d Release Requirements

ID	I
Name	**Release**
Description	A^2 Technology offers cross-platform compatibility, as well as interfacing with adjacent systems.
Rationale	Hospitals and healthcare settings have a wide range of equipment and other systems. A^2 Technology is built to work alongside other technologies to deliver quality medicine to patients. A cross-platform compatibility is essential since hospitals and healthcare settings have various operating systems in use.
Fit Criterion	The software shall notify clients of planned releases well ahead in time, so they have the necessary time to upgrade. The software shall have releases throughout the year to ensure every new customer requirement is met. The product shall have the option to subscribe to receive notifications for newly available maintenance releases for the entire software stack, not just a single application. The product shall receive notifications to alert users to pay attention to any end-of-maintenance dates for older versions installed in software stack.
Acceptance Tests	I

19 Cultural and Political Requirements

19a Cultural Requirements

ID	J
Name	**Cultural**
Description	A^2 Technology celebrates cultural diversity. We strive to accommodate all walks of life in the use of this technology.
Rationale	A^2 Technology hopes to provide training to all walks of life. Some of the most urgent topics in the healthcare field is its goal in eliminating inequities in the quality and availability of health care for ethnic, racial, and economic minorities. This is closely connected to the need to increase both the diversity and the cultural competence of our health care workforce.
Fit Criterion	The product shall be used by medical professional worldwide. The software shall support measurements of anesthetics in different metric systems.
Acceptance Tests	J

19b Political Requirements

ID	J
Name	**Political**
Description	A^2 Technology celebrates cultural diversity. We strive to accommodate all walks of life in the use of this technology.
Rationale	A^2 Technology hopes to provide training to all walks of life. Some of the most urgent topics in the healthcare field is its goal in eliminating inequities in the quality and availability of health care for ethnic, racial, and economic minorities. This is closely connected to the need to increase both the diversity and the cultural competence of our health care workforce.
Fit Criterion	The application shall adhere by all laws laid out by the constitution of the United States. The application shall follow all standards and policies of medical organizations which would be using it.
Acceptance Tests	J

20 Legal Requirements

20a Compliance Requirements

ID	K
Name	**Compliance**
Description	Compliance relates the "how" of the A^2 Technology product.
Rationale	How long do we need to retain this data? How do I manage performance and standards?
Fit Criterion	The software shall be a licensed software available for purchase by authenticated medical organizations. Since the product deals with medical data of patients it shall follow all standards to ensure information privacy. The product shall abide by all international legal laws if expanded for distribution worldwide.
Acceptance Tests	K

20b Standards Requirements

ID	K
Name	**Standards**
Description	While there are a certain number of standards addressing A^2 Technology's software reliability, we abide by a running list of standards provided by the American Society of Anesthesiology.
Rationale	The standards of care provided by A^2 Technology is a clinical requirement. The software participates in a planned program for evaluation of quality and appropriateness of the anesthetic care of patients.
Fit Criterion	The product shall comply with HIPAA (Health Insurance Portability and Accountability Act of 1996) for information privacy of patient data. The product shall comply with IRB (Institutional Review Board) as it involves handling of patient data. The product shall comply with the International standards if distributed for use worldwide in the future.
Acceptance Tests	K

21 Requirements Acceptance Tests

21a Requirements – Test Correspondence Summary

Tests	Requirements										
	10	11	12	13	14	15	16	17	18	19	20
A	X										
B		X									
C			X								
D				X							
E					X						
F						X					
G							X				
H								X			
I									X		
J										X	
K											X

Table 14. Requirements – Acceptance Tests Correspondence

21b Acceptance Test Descriptions

ID# - Name	Descriptions
A - Functional	Functional requirements describe the functionality the A^2 Technology must have. The functionalities are generally derived directly from the steps the A^2 Technology takes during use cases.
B – Data	Data requirements describe data. In the case of A^2 Technology, data is described as patient records.

C – Performance	Performance requirements include speed and latency, precision, and capacity.
D – Dependability	Dependability requirements include reliability, availability, robustness, and safety-critical.
E – Maintainability and Supportability	Maintainability and Supportability requirements include maintenance, supportability, adaptability, scalability, and longevity.
F – Security	Security requirements include access, integrity, privacy, audit, and immunity.
G – Usability and Humanity	Usability and Humanity requirements include ease-of-use, personalization and internationalization, learning, and understandability, politeness, accessibility, user documentation, and training.
H – Look and Feel	Look and Feel requirements include appearance and style.
I – Operational and Environmental	Operational and Environmental requirements include expected physical environment and interfacing with adjacent systems, productization, and release.
J – Cultural and Political	Cultural and political requirements include cultural requirements and political requirements. Cultural requirements describe the sociological factors that affect the acceptability of A^2 Technology. Political requirements describe the political factors that may affect the acceptability of A^2 Technology.
K – Legal	Legal requirements include compliance and standards.

III Design

22 Design Goals

The design goals of A^2 Technology are optimized in the proposed design. A^2 Technology is designed to simulate the training of non-anesthesiologists the knowledge, skills, and professionalism required for clinical excellence, promote compassionate patient care, and develop leaders in anesthesiology, pain medicine, and critical care for the 21st century. The size general competences are patient care, medical knowledge, practice-based learning and improvement, and systems-based practice.

Our team identified the following design goals to deliver an A^2 Technology optimal design:

A) Adaptability

A^2 Technology will be developed in Java. The programming language Java can be utilized in terms of providing cross-platform portability. Java enables A^2 Technology to work in all Java Runtime Environment installed platform, therefore, users such as hospitals or places that deliver anesthesia, do not have to worry about operating system requirements.

B) Efficiency
A^2 Technology must be responsive, and run with high performance at all times.

C) Reliability
A^2 Technology software will be continually released with updates and bug fixes consistent in boundary conditions. Reported bugs or malfunctions will be maintained and corrected accordingly and timely.

D) Usability
The A^2 Technology software is easy to use. The UX/UI interface is created to serve and guide the user throughout all possible procedures. The system is designed that user can easily move through the technology without prior practice or knowledge.

E) Extensibility
A^2 Technology software is created using object-oriented architecture. The object-oriented nature of the product enables system customization and refactoring.

23 Current System Design

There are no pre-existing system.

24 Proposed System Design

24a Initial System Analysis and Class Identification

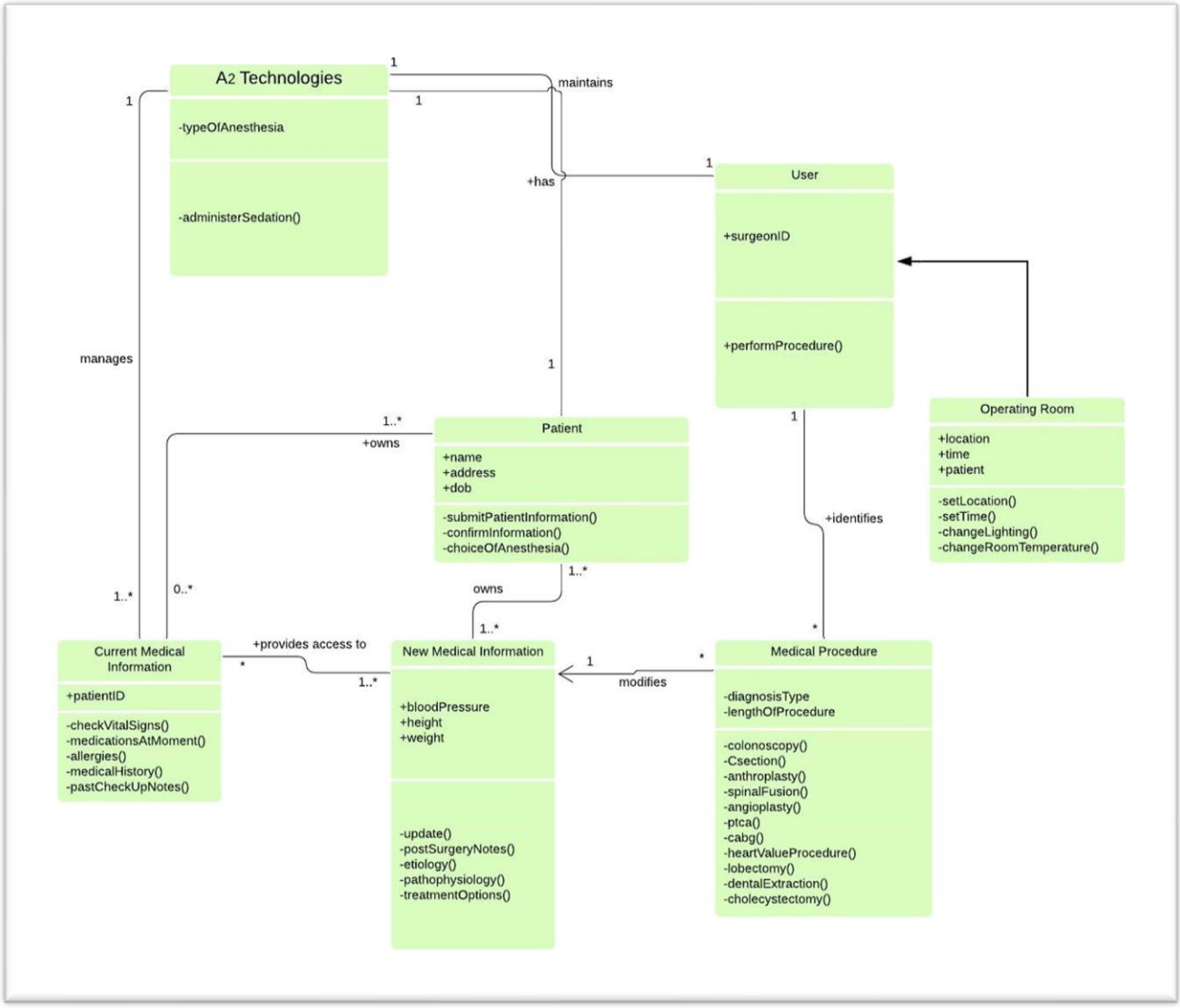


Figure 11. A^2 Technology Simplified UML Diagram identifying important classes.

24b Dynamic Modelling of Use-Cases

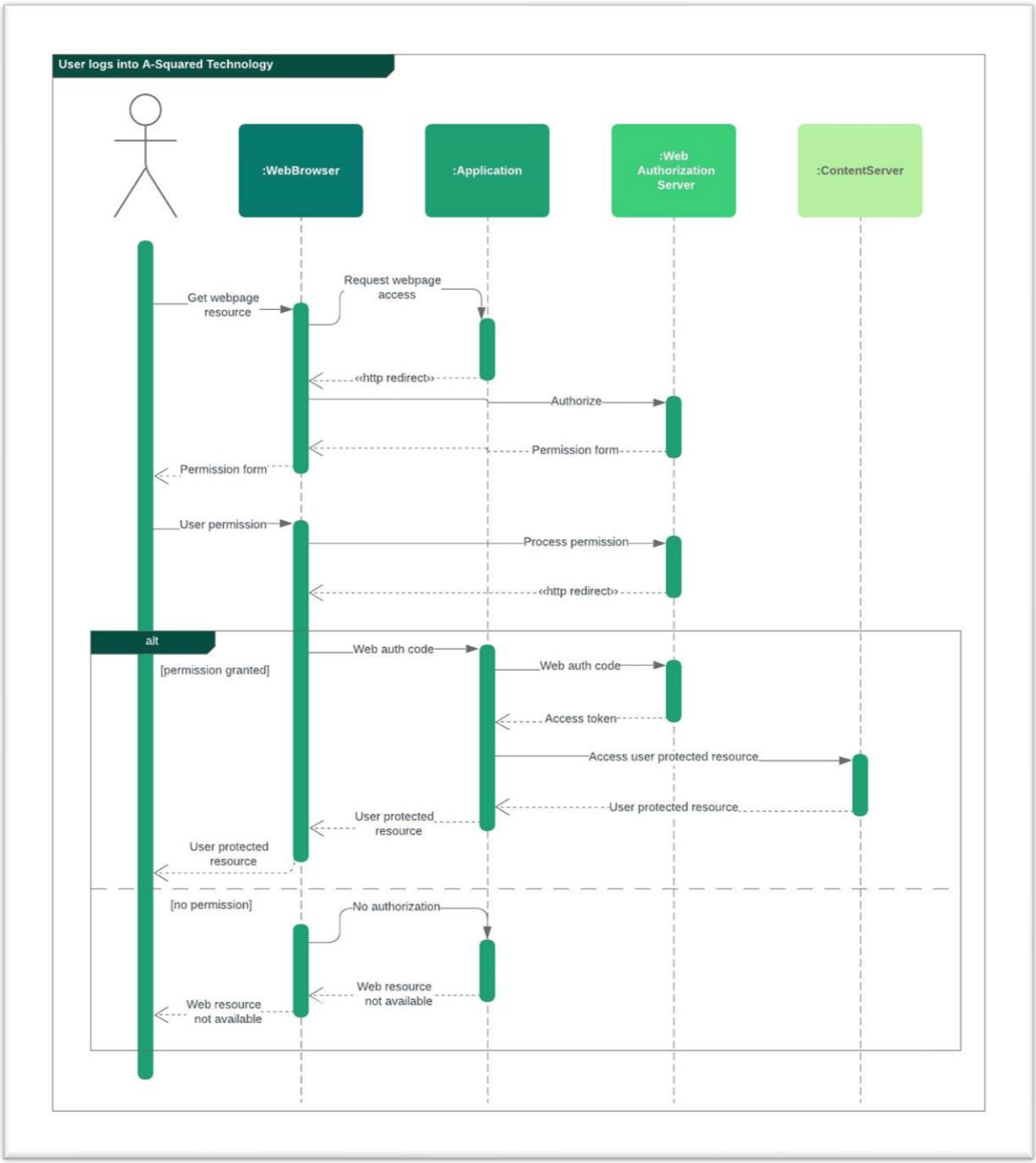


Figure 12. The dynamic modeling of User logging into A^2 Technology.

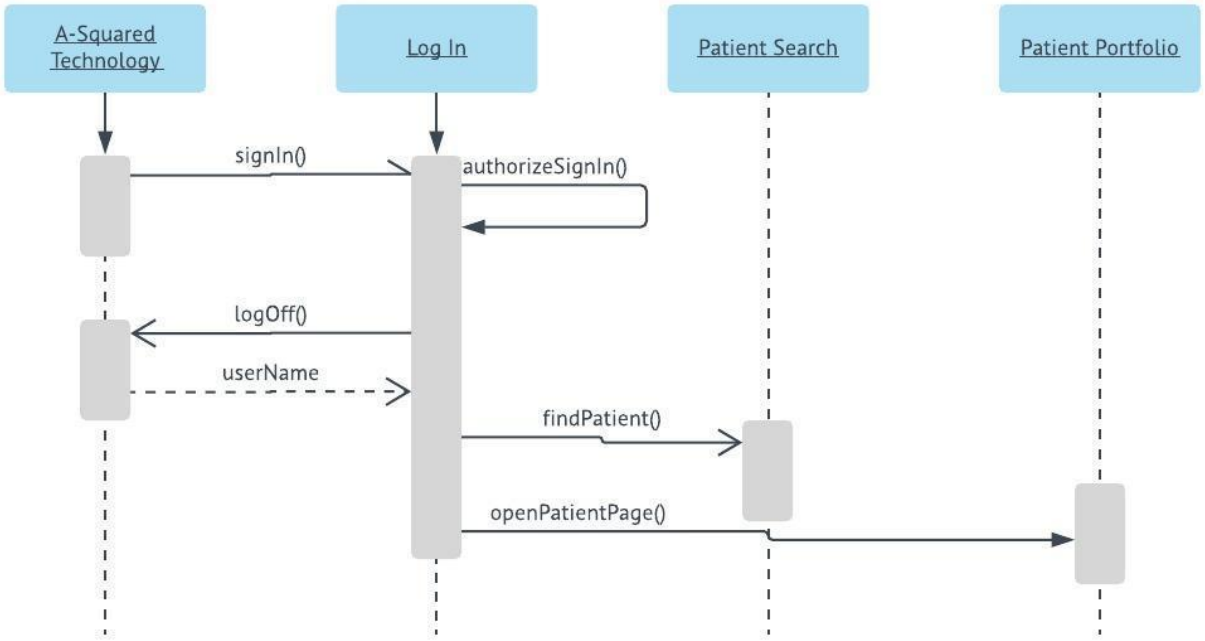


Figure. 13. The dynamic modeling of locating a patient page during a patient search on A^2 Technology.

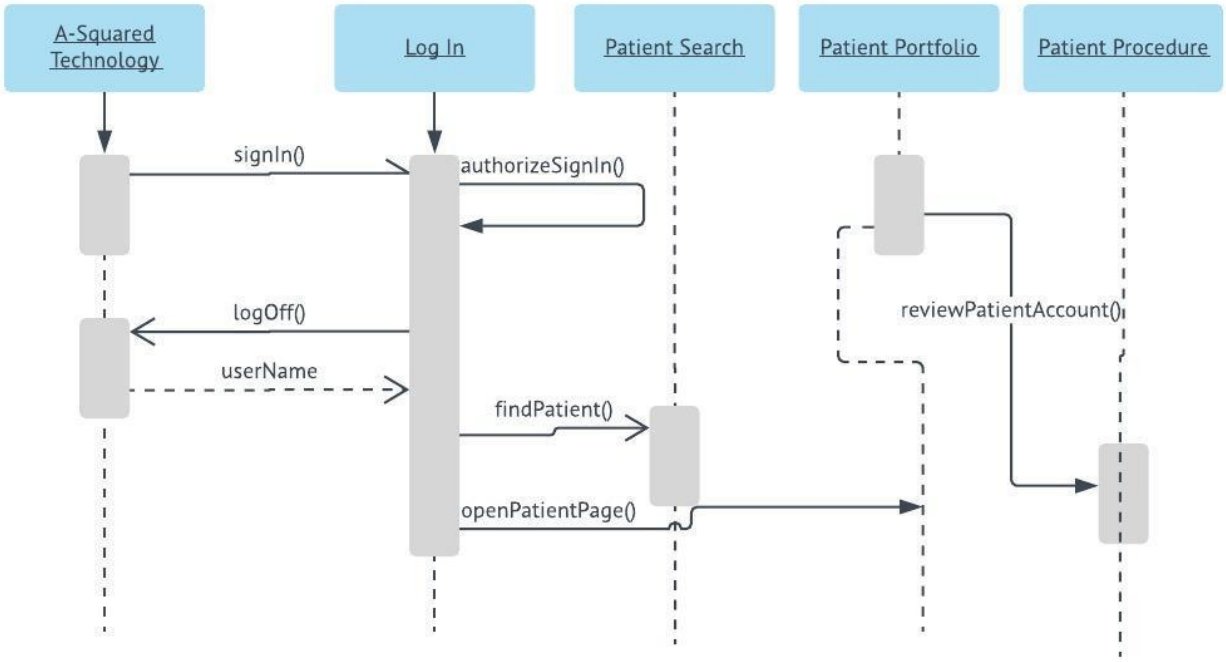


Figure 14. The dynamic modeling of reviewing patient account once patient is found on database is reviewed A^2 Technology software.

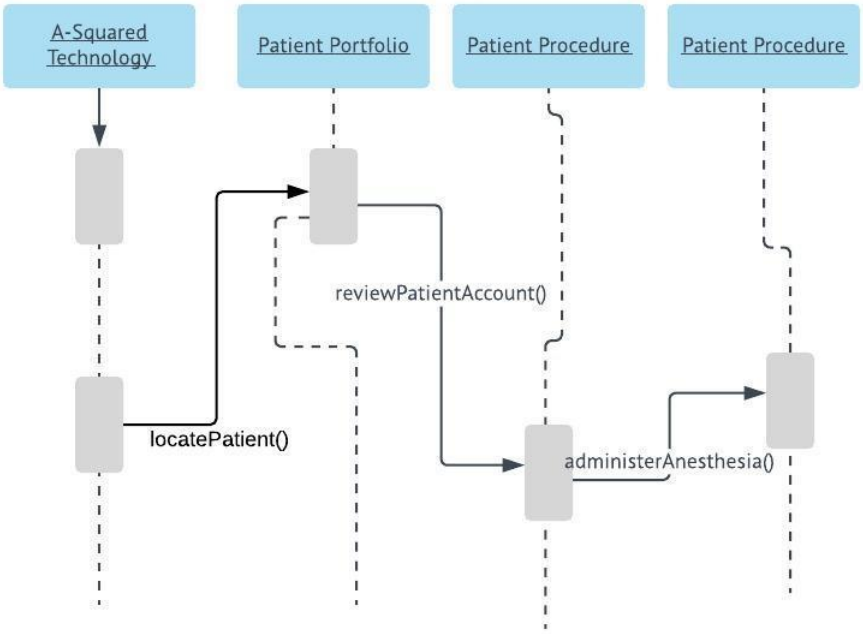


Figure 15. The dynamic modeling of administering anesthesia according to procedures once patient account is reviewed A^2 Technology software.

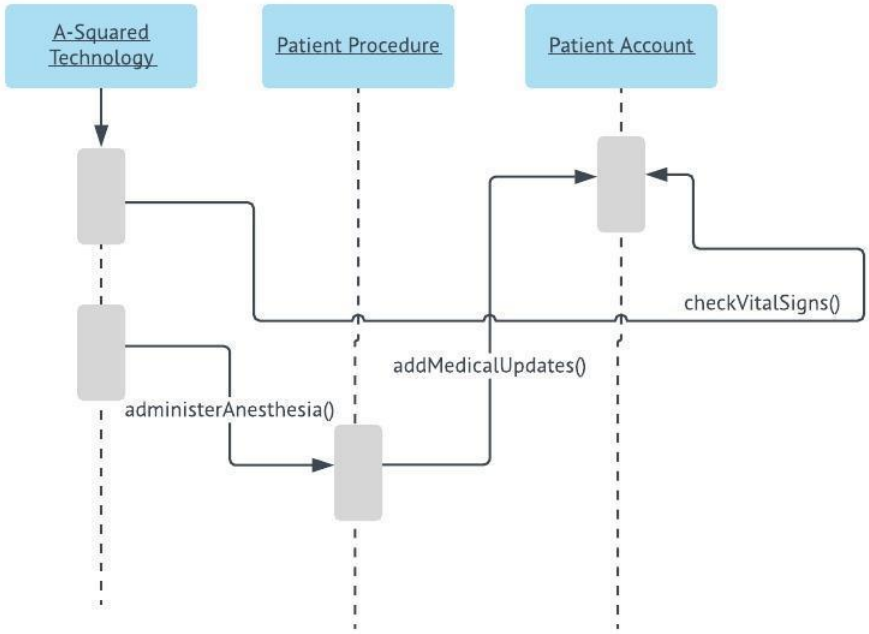


Figure 16. The dynamic modeling of administering anesthesia, adding medical notes and updates to patient account, and checking vital signs according to procedures once patient account is reviewed A^2 Technology software.

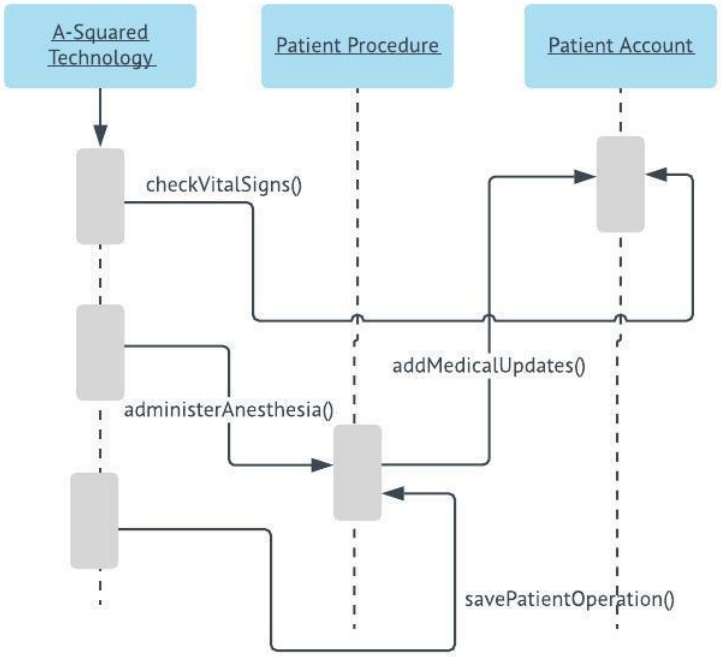


Figure 17. The dynamic modeling of administering anesthesia, adding medical notes and updates to patient account, checking vital signs, and receive instructions on how to provide post-operational care according to procedures received from the A^2 Technology software.

24c Proposed System Architecture

The A^2 Technology software proposes a system architecture that will compose of a three-tier design. The architecture contains a user/admin interface layer, the patient accounts access layer, and the medical procedures storage layer. The user/admin interface layer is an important component of the architecture since A^2 Technology strive to put the user at the forefront of the anesthesia process. The UX/UI guides the user and A^2 Technology displays appropriate procedural and operational information for the user to make progress. The patient accounts access layer contains all information pertaining patients' past and current medical records. The patient accounts access allows A^2 Technology to match to a correct operation and thus, the correct anesthesia administration package. The medical procedures storage layer contains all medical information about patients' operation. information. This data access layer provides information for user and the A^2 Technology application to interact with data base management systems. This storage layer contains up to date DBMS server address path along with require credentials to connect to the remote server to fetch and update with data bases.

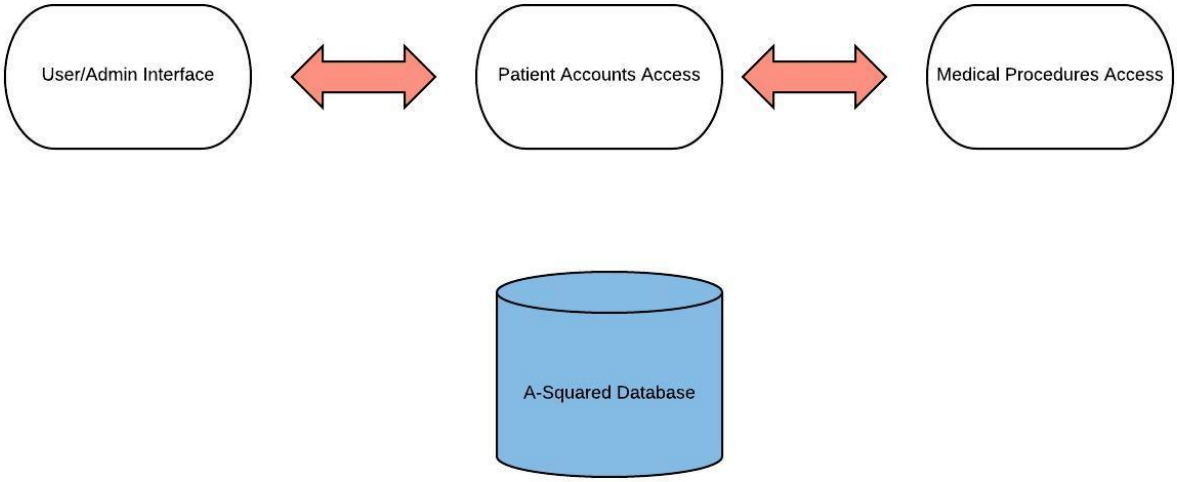


Figure 19. A^2 Technology software is represented in a three-tier architecture diagram.

24d Initial Subsystem Decomposition

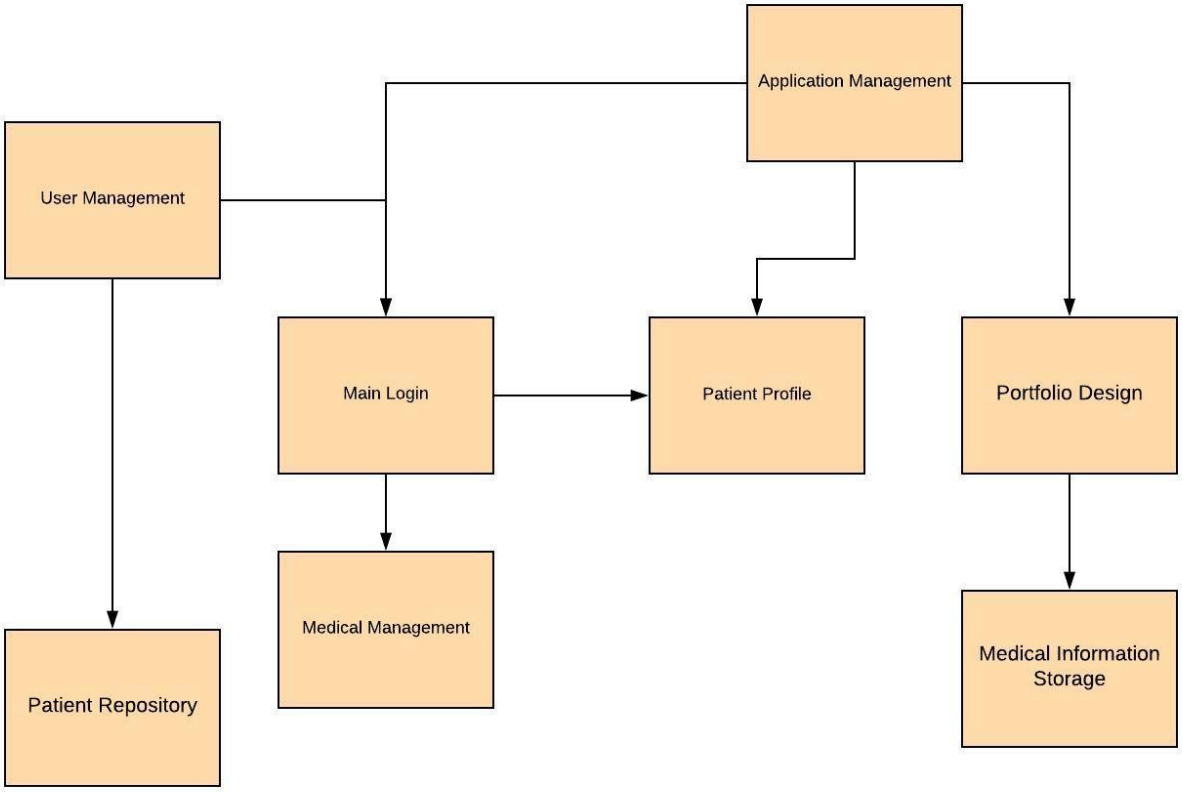


Figure 20. A^2 Technology organization system.

A^2 Technology is subdivided into two systems: the user management and the application management. The user management has access to patient accounts and patient information. The application management has management over the databases that stores patient accounts.

25 Additional Design Considerations

25a Hardware / Software Mapping

A^2 Technology software can run on one or more desktops, given the number of operations occurring. Network communication is managed by Global Frag Networks. This can be achieved using TCP/IP based protocol. The programming language Java was chosen as main programming language in hopes of meeting the goals of compatibility with future usage of programming framework. As shown in Figure 21, a summary of the mapping between hardware components and the software environment can be seen.

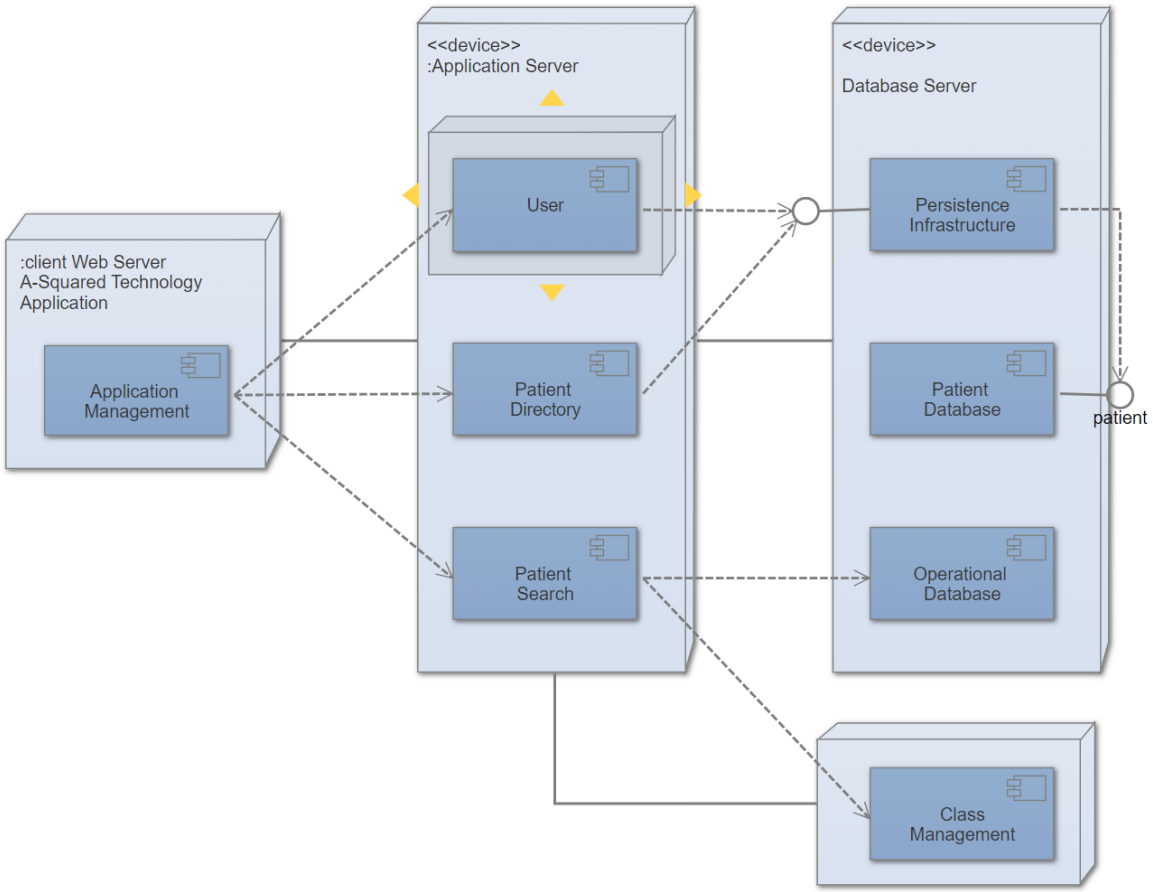


Figure 21. Deployment Diagram of A^2 Technology hardware/software mapping.

25b Persistent Data Management

Persistent data management of the A^2 Technology organization system includes saving and preserving the user/admin database and patient records database. The user/admin database and patient records database will be maintained a relational database. The relational database

management system serves as a collection of programs and capabilities that enables medical teams and others to create, update, administer, and otherwise interact with a relational database. The A^2 Technology relational database connected data elements and includes functions that maintain the security, accuracy, integrity, and consistency of the data.

25c Access Control and Security

In the medical world, access management environments are fragmented and risk-prone. Hospitals and medical record systems are vulnerable to security breaches. Healthcare facilities often have a number of high priority security concerns such as workplace violence, pharmacy control, theft prevention, infant and pediatric security, parking lot security, and many more. A^2 Technology access control and security management simplifies users' access while more securely adopting web, mobile, and cloud technologies. A^2 Technology is capable of restricting access to sensitive areas, protecting both staff and patients. We strive to strike a balance between usability and security through use of risk-based access, single sign-on, integrated access management control, and identify verification and multi-factor authentication capability.

25d Global Software Control

A^2 Technology undergoes the security lifecycle of all in-house developed and acquired software in order to prevent, detect, and correct security weaknesses. Attacks often take advantage of vulnerabilities found in A^2 Technology application software. Vulnerabilities can exist in many forms, such as coding mistakes, logic errors, incomplete requirements, and failure to test for unusual or unexpected conditions. Specific errors include the failure to check the size of user input, failure to filter out unnecessary or potentially malicious character sequences from input streams, failure to initialize and clear variables, and poor memory or database management which thus allows flaws in one part of the software to affect unrelated, critical portions of the software.

As a medical device, A^2 Technology is vulnerable to a flood of attackers and hackers targeting patient public and private information. A^2 Technology have guardrails set in place to protect against attackers injected specific exploits, including buffer overflows, structured query language (SQL) injection attacks, cross-site scripting, cross-site request forgery, and gaining control over the A^2 Technology machine. A^2 Technology software team has established secure coding practices appropriate to the programming language and development environment being used.

When selecting components for the Medical Staff and Patient subsystems of A^2 Technology, we effectively restricted the alternatives for control flow paradigms, such as procedure-driven, event-driven, and thread-driven. A^2 Technology uses an event-driven flow control. When event, such as a new operation for a patient, becomes available, it is dispatched to the appropriate object, based on the information associated with the event. The User class creates three event dispatches classes: a remote dispatches that relays events to the A^2 Technology hardware and a local dispatches that relays events to the patient database.

25e Boundary Conditions

It is widely known that input values at the extreme ends of the input domain cause more errors in the system, and there is no difference with the A^2 Technology software. More or less, application errors occur at the boundaries of input domain. When checking a range of values or inputs, the procedure begins with selecting the set of data that lie in the valid partitions, or boundaries. The next step is to check how the A^2 Technology software behaves at the boundary values of the valid partitions.

For users of the A^2 Technology software to successfully run and participate in the stimulation, there must be a physical network connection such as a wireless LAN. The hospital administration have pre-entered any network parameters such as IP Address and port number.

Turn on and login When a User is logged into the A^2 Technology software, the User begins by searching for patient in the patient database. Further instructions are give to proceed as the operation begins.

Configure operation options All medical operation options, such as increasing the size of the window, or clicking on the next instructions, etc, are configured by the User.

Log off and shut down A^2 Technology alerts the User that operation is over. Final instructions are given as patient begins to wake up. User can log off. A^2 Technology turns off or proceed to sleep mode.

25f User Interface

The user interface of A^2 Technology software is a simple, intuitive conduit between human and computer interaction. The graphical user interface utilizes generated UI elements such as text, links, buttons, and images to construct a medical design system that form the medical staff user experience. Users of A^2 Technology software are familiar with interface elements acting in a certain way, so text and colors and backgrounds layouts are consistent and predictable. Maintaining a universal, consistent layout will help with distraction-free task completion, efficiency, and satisfaction. Once users learn how to do something, users are able to transfer that skill to other parts of the A^2 Technology software.

A^2 Technology UI utilizes typography to create hierarchy and clarity. A^2 Technology software is careful about how typeface, color, and texture is strategically placed. Different sizes, fonts, and arrangements of the text increases legibility, readability, and scalability.

Interface elements of the A^2 Technology software include:

Input controls	Buttons Text fields Checkboxes Radio buttons Dropdown lists List boxes

	Data fields Patient avatars Medical staff avatars Signature boxes
Navigational Components	Breadcrumb Slider Patient Search Field Patient Birthday Search Field Tags Icons
Informational Components	Tooltips Icons Progress bar Help Line Notifications Message Boxes Modal Windows

25g Application of Design Patterns

A^2 Technology software utilizes a creational pattern, such as Singleton and Factory Method, and a structural pattern such as, Composite and Decorator. Composite and Decorator may exhibit similar structure diagrams, given that they depend on recursive composition to shape open-ended number of objects. The Decorator pattern can be used to extend the functionally of objects such as the patient medical operations statically. The Decorator class wraps around the original class. The core object's identity can be hidden inside a decorator object.

26 Final System Design

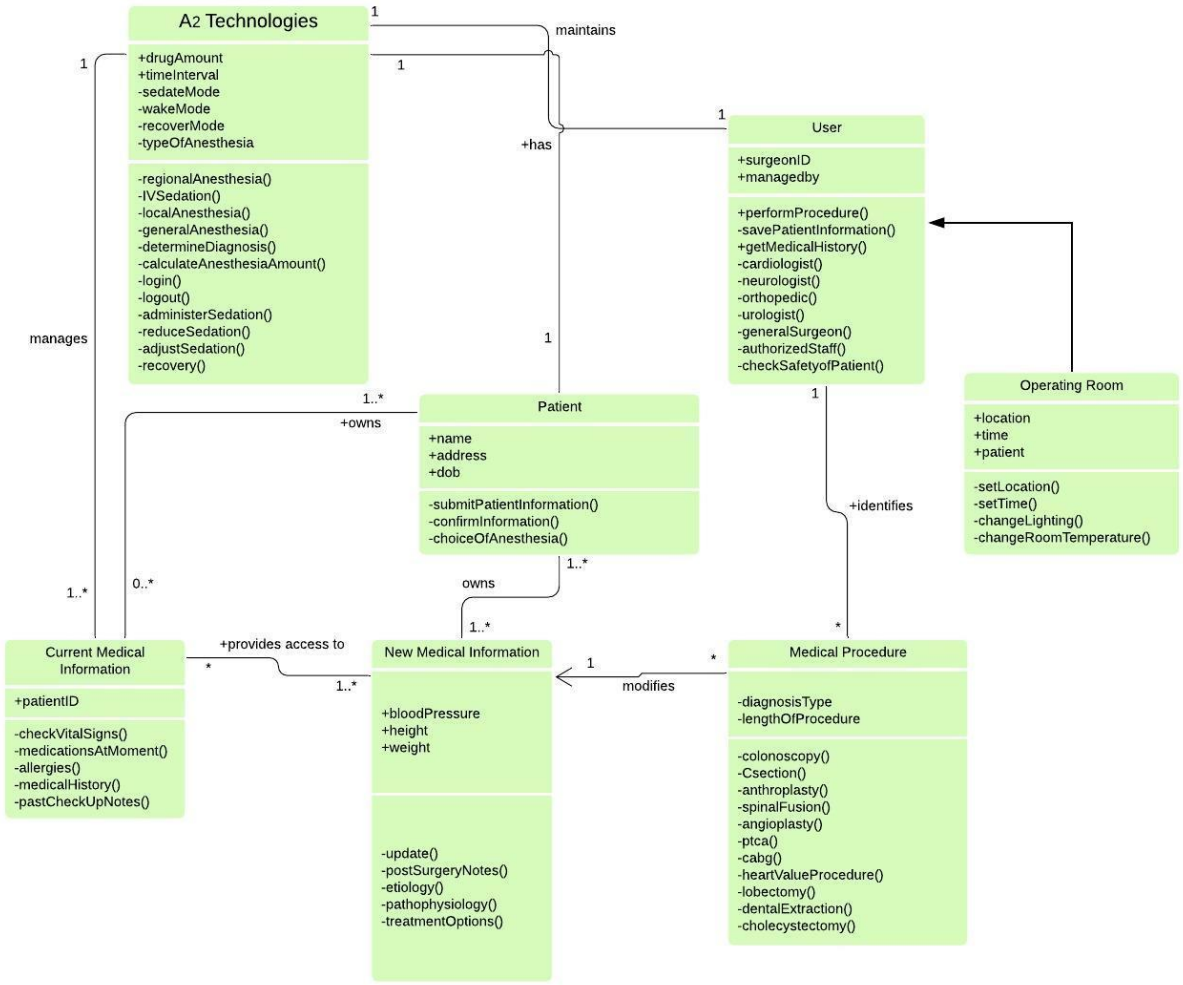


Figure 22. The final system design is represented by this UML diagram.

27 Object Design

27a Packages

The design of A^2 Technology software involves assigning classes to one package known as ASquaredTechnology.

27b Subsystem I

Currently, the design of A^2 Technology software does not contain a Subsystem I, since the addition of a Subsystem I is infeasible. Should the project expand, talks of a new design is welcomed.

27c Subsystem II

Currently, the design of A^2 Technology software does not contain a Subsystem II, since the addition of a Subsystem I is infeasible. Should the project expand, talks of a new design is welcomed.

27d etc.

Currently, the design of A^2 Technology software does not contain a Subsystem etc., since the addition of a Subsystem I is infeasible. Should the project expand, talks of a new design is welcomed.

IV Project Issues

28 Open Issues

When surveying the requirements of the A^2 Technology software, an important open issue did arise. There is too much going on that A^2 Technology may or may not manage at once. Each medical procedure must be correctly matched with the patient and their respective operation. As shown in Figure 23, an algorithm is developed to deliver the correct anesthesia to patient. Devising an algorithm to a population of people with varying conditions and health concerns may be a task onto itself. The A^2 Technology software must take into account the concentration of the drug, patients' past and current medical history, patient's rate of consciousness, dosing scheme, other pharmacokinetic parameters and modeling.

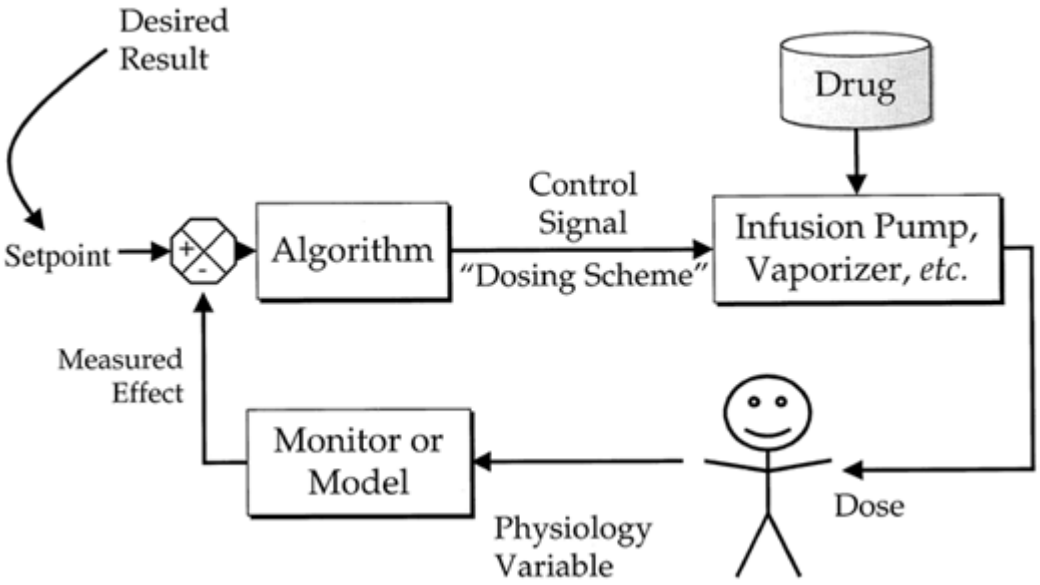


Figure 23. The components of a scientifically tested typical automated drug delivery system. Image is provided by Publications of Anesthesiology[23].

29 Off-the-Shelf Solutions

MIT and the company Johnson & Johnson currently are working on a product called the Sedasys machine, in which it can administer the sedative propofol while monitoring patients' vital signs to ensure that a patient is properly anesthetized to the correct degree without any supervision of an anesthesiologist. The A^2 Technology team can learn and find ways to create an increasingly reliable measurement medical device, robust and adaptive algorithms, and better fault tolerance algorithms in the automation of anesthesiology.

29a Ready-Made Products

Sedasys is joining forces with the medical automation and robotics company called Verb Surgical to improve Sedasys capabilities.

29b Reusable Components

Sedasys is designed to automate mild to moderate sedation during endoscopy procedures. Their limited rollout landed in the hands of only a few medical providers. The machine is a four-piece system that includes a bedside monitoring unit (BMU) that helps keeps the patient from before the procedure through the post-procedure recovery, a procedure room unit (PRU) that contains the propofol infusion controller, the disposable devices for single-patient use, and the display monitors. Sedasys begins administering the measured dose of the sedation drug with a push of the button. The machine's computerized voice instructors the patient to squeeze a sedation dose

controller. Sedasys uses an algorithm for propofol dosing that strives to maximize patient comfort and safety.

What A^2 Technology can learn from Sedasys is their programmable algorithm for routine endoscopies. We can learn from their past mistakes in complying with FDA guidelines in patient selection and fulfillment and maintenance requirements.

29c Products That Can Be Copied

Sedasys is a automated anesthesiology product that A^2 Technology would definitely work hand in hand. Sedasys have delivered anesthesiology during endoscopy procedures successfully in the past. A^2 Technology hopes to perfect their endoscopy algorithm, setting a precedent for many more medical procedures to come.

30 New Problems

30a Effects on the Current Environment

Not everyone is sold on automated anesthesiology. As AI matures, A^2 Technology will disrupt the workforce of anesthesiology. A^2 Technology will target anesthesiologists, one of the best paid medical specialties. Anesthesiology requires 4 years of medical training after 4 years of medical school, which translates to doctors gaining full employment not until their 30s. Their hefty salaries north of $300,000 per year are on the line if replaced by A^2 Technology. The machine has the potential to replicates their skills or handle a medical emergency.

The medical personnel and patient roles will evolve. If anesthesiologists are replaced by a machine, then the dynamic of a medical procedure will likely change. Surgeons and other medical staff who are accustomed to exchanging with a live anesthesiologist, will probably interact with a non-anesthesiologist operating on A^2 Technology. The relationship between the patient and anesthesiologist will no longer exist. Non-anesthesiologist staff members operating on A^2 Technology will take on the role of being the consoler or caregiver for the patient.

30b Effects on the Installed Systems

A^2 Technology will not have adverse effects on other hardware or software systems. Just like software programs such as Microsoft Office, or Visual Studios, A^2 Technology is used to do good, not harm.

30c Potential User Problems

A^2 Technology is created to do as much good for people as possible. No intentional physical or mental harm is inflicted on users of A^2 Technology. The product seeks to provide a pain-free training simulation.

30d Limitations in the Anticipated Implementation Environment That May Inhibit the New Product

There are physical limitations in the operating room of a healthcare setting where A^2 Technology is used. To use to its fullest potential, A^2 Technology must be plugged in to a reliable power source. Electrical interference, or lack of reliable electricity, may cause the computers running the A^2 Technology software to shut down or staff off. Another physical limitations would involve an unforeseen weather conditions that may cause a power outage.

30e Follow-Up Problems

A^2 Technology is anticipating to serve an immeasurably large population of people. A potential problem would be traffic overload: multiple users may conduct a patient search in a short period time, causing a A^2 Technology server jam. We can potentially solve this issue of concurrent connections using cloud hosting. Cloud hosting is flexible because A^2 Technology users can access multiple resources at multiple periods of time.

31 Migration to the New Product

31a Requirements for Migration to the New Product

A^2 Technology is open to new product migration procedures. Before we jump into migration, we have a few steps to check off in the planning on a successful migration:

Step 1. Get to know the user base of the current product before anything new is implemented. Loyal users may have a stronger connection to the current version of A^2 Technology. We will work to understand the levels of product usage, use cases, and other integrated products. Our team will calculate the costs invested in the current product.

Step 2. Make a detailed list of user concerns, wants, likes, needs, opinions, etc. of current product.

Step 3. Create a plan to tackle each users' concerns. Take into account their concerns, the costs, and the timeline.

Step 4. Focus on the current product's biggest users first and foremost. There is a chance that a small portion of the user base provides a majority of the company's revenue. Contact these users individually, either in person or by phone, to communicate the possible migration plan. Ask these users for feedback.

Step 5. Explain the advantages the new product offers over the current product. Does it meet users' concerns?

Step 6. Set an end-of-life date for the current product and the moving date for the new product.

Version #	Implemented By	Start of Revision Date to End of Revision	Approved By	Approval Date	Reason
1.0	<Author name>	<mm/dd/yyyy> to <mm/dd/yyyy>	<name>	<mm/dd/yyyy>	<explanation>

Figure 25. Example of a timetable for migration implementation.

31b Data That Has to Be Modified or Translated for the New System

During any product migration, we must protect patient accounts and patients' medical information. We must following the guidelines of HIPAA Privacy Rule very carefully, as the HIPAA Privacy Rule sets boundaries on the use and release of health records. HIPAA is a US law designed to provide privacy standards to safeguard patients' medical records and other health information provided to health plans, doctors, hospitals and other health care providers[14]. The privacy and security of patient health information is a top priority for A^2 Technology. A^2 Technology will handle patient medical information by protecting it with passwords, encryption, and other technical safeguards.

32 Risks

According to Baker's *Cost accounting for healthcare*[4], the wrong medication was the most common type of drug error at 48% occurring perioperatively, followed by overdose at 38%, incorrect administration route at eight percent. Forty-two percent of wrong medication administration occurred following the wrong choice of drug was made.

Like with real-life anesthesia for surgery, A^2 Technology will encounter many potential risks, namely the risks of inaccurate metrics and inadequate measurements. Because anesthesia drugs change how a patients' body works, there is, of course, a body of risks. Numerous human and system errors can be blamed for occurrence of medication errors.

Inaccurate metrics and inaccurate measurements are unacceptable and sometimes, unavoidable. Wrong medication, patient unexpected reaction, under-dosing and omission, overdose (due to misunderstanding or preconception of the dose, pump misuse and dilution error), and incorrect administration route are common causes of medication error. Medication errors can occur perioperatively either during preparation, administration or record keeping. A^2 Technology must continually improve engineering itself to reduce the likelihood of medication misidentification through tactics such as development of innovative electronic/digital mechanisms that allow double-checking or drug verification in the operating room.

33 Costs

A^2 Technology is estimated to cost up to $5 million, an estimate that takes into account 3 constrains: people, schedule, and scope. People may involve the software development team, product management, and the marketing team. Software development of A^2 Technology is complex. Initial requirements for a medical device are never concrete enough nor complete. The A^2 Technology development team "don't know what they don't know", as the saying goes, meaning that unknowns with the project can only be identified and made known when they arise. More often than not, what appears to be a simple problem is much harder to implement in reality. The teams will become more knowledgeable within the business of the medical field and with the technology of the product they develop.

34 Waiting Room

Not all requirements made it to the upcoming release of A^2 Technology. One in particular is for A^2 Technology to train multiple Users at once. Administering anesthesiology is a team effort, therefore, training users in a group would be an important feature to be implemented on a future release of A^2 Technology.

35 Ideas for Solutions

A^2 Technology contains a help link at the corner of the screen. To report bugs or malfunctions, users would click on the link to submit a report. An idea to fast-track the error submission process is to implement a live chat between the user and the maintenance team. Therefore, errors or malfunctions are taken care of immediately. The engineering team at A^2 Technology will use the live chat to promptly solve the needs of trainees/users/admin with precision, and in real time. This further ensures our customers receive rapid, personalized experiences, and has also brought in operational efficiencies that make assisted anesthesiology extremely scalable.

36 Project Retrospective

Creating A^2 Technology was an eye-opening experience. What really worked well for our team is the Agile process. This software engineering methodology provided us a way think in a team-driven way. Each of us got to decide together how meetings will be run and how decisions will be made about continuous improvements. The Agile process from the start of the idea to drafting the details of how to execute the idea was a long and arduous process, yet very educational. Our team learned not just the about giving birth to an idea, but detailing its requirements, design, and testing components.

Retrospectively, our team can improve on many points. One being communication. Coming into this semester-long project, everyone had many different ideas and methods of solving

a problem. We have spent a lot of time collaborating over email, sprints, coding demo preparations, exchanging design ideas, and attending our weekly meetings. We could improve on communicating who is doing what, when, how, and why. In the future, we hope to create a better environment where communication is part of the normal process. In other words, we practice communication all the time or incrementally, so we can't help but improve at it. Receiving feedback from peers is a good example of communication in practice. Feedback can be part of coding reviews or testing code suites.

V Glossary

Anesthesiology the practice of medicine dedicated to the relief of pain and total care of the surgical patient before, during and after surgery [13].

ASA physical status classification system American Society of Anesthesiologists (ASA) system for assessing the fitness of patients before surgery. There are six categories: 1. Healthy person 2. Mild systemic disease 3. Severe systemic disease 4. Severe systemic disease that is a constant threat to life 5. Moribund person not expected to survive without operation 6. Declared brain dead person whose organs are being removed for donor purposes

BMU Acronym Bedside Monitoring Unit

General anesthesia The patient is anesthetized while the operation lasts.

HIPAA Acronym that stands for the Health Insurance Portability and Accountability

PRU Acronym Procedure Room Unit

Regional anesthesia Local anesthetic is injected near the nerves to numb the area that will be operated; may be nerve blocks or spinal or epidural injections.

Sedation Intravenous drugs clam the patient or make the unaware of the procedure

VI References / Bibliography

The following section describes the documents and other sources from which information was gathered.

[1] Image provided by https://www.technologyreview.com/s/601141/automated-anesthesiologist-suffers-a-painful-defeat/

[2] Reinhardt, Elena K., Sivarajan, Murali, Costs and wastes in anesthesia care. 2012.

[3] Fleisher, L. Value-based care, an issue of anesthesiology clinics. 2013.

[4] Baker, J. J. (2011). Cost accounting for healthcare: A guide to utilizing information and technology for effective decision making. New York: McGraw-Hill.

[5] Nganele, D. (2003). The best healthcare for less: Save money on chronic medical conditions and prescription drugs. Hoboken, NJ: Wiley.

[6] Cogan, J., Hubbard, R. and Kessler, D. (2011). Healthy, wealthy, and wise. Stanford, Calif: Hoover Inst. Press.

[7] Rooney, J. and Perrin, D. (2008). America's health care crisis solved. Hoboken, NJ: Wiley.

[8] Baumol, W. and Ferranti, D. (2012). The cost disease. New Haven: Yale University Press.

[9] Kotlikoff, L. (2007). The healthcare fix. Cambridge, Mass: MIT Press.

[10] Bradley, E. and Taylor, L. 2013. The American health care paradox.

[11] Kronenfeld, J. and Kronenfeld, M. (2004). Healthcare reform in America. Santa Barbara, Calif.: ABC-CLIO.

[12] http://www.asahq.org/lifeline/types%20of%20anesthesia/what%20is%20anesthesiology

[14] Metzner J, Domino KB. Risks of anesthesia or sedation outside the operating room: the role of the anesthesia care provider. Curr Opin Anaesthesiol 2010; 23: 523-31.

[15] Edwards G, Morton HJ, Pask EA, Wylie WD. Deaths associated with anaesthesia; a report on 1,000 cases. Anaesthesia 1956; 11: 194-220.

[16] Abenstein JP, Warner MA. Anesthesia providers, patient outcomes, and costs. Anesth Analg 1996; 82: 1273-83.

[17] https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system

[18] https://www.beckershospitalreview.com/anesthesia/

[19] https://www.washingtonpost.com/news/the-switch/wp/2015/05/15/one-anesthesiology-robot-dips-its-toes-into-whats-possible-this-one-jumps-all-in/?utm_term=.363679538498

[20] https://www.kff.org/

[21] https://www.pbs.org/newshour/health/seven-factors-driving-your-health-care-costs

[22] Merchant R, Chartrand D, Dain S, et al. Guidelines to the Practice of Anesthesia - Revised Edition 2016. Can J Anaesth 2016; 63:86.

[23] Image provided by http://anesthesiology.pubs.asahq.org/article.aspx?articleid=1944688

[24] Lehman LW, Saeed M, Talmor D, et al. Methods of blood pressure measurement in the ICU. Crit Care Med 2013; 41:34.

VII Index