PitFail Report 2

An Online Financial Engineering Game

November 4, 2011

Software Engineering I, Group 3
https://github.com/pitfail/pitfail-reports/wiki

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1 Individual Contributions

Responsibility	Michal Koval	Cody Schafer	Owen Healy	Brian Goodacre	Roma Mehta	Sonu Iqbal	Avanti Kulkarni
Interaction Diagrams (35)		10%	30%		10%	10%	30%
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¿ Map. Hardware (2)		100%					
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¿ Other (5)			20%		40%	40%	
Algos. and Structures (4)				100%			
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¿ Appearance (5)	100%						
¿ Prose Description (5)	100%						
Plan of Work (4)				100%			
References (2)				50%	25%	25%	

2 Glossary

Stock information provider A supplier of stock pricing data for the present (within the margin of some minutes). They are queried for all data regarding actual market numbers. Currently, *Yahoo* is the *stock information provider* (via its Yahoo Finance API).

PitFail Website - PWS An interface to pitfail composed of HTML, Javascript, CSS, and images which is designed to be rendered and accessed from within a modern webbrowser. This provides the most common interface for user interaction with the system.

Twitter text command interface - TTCI A system whereby a user of PitFail (or one who desires to become a user thereof) sends a message limited in size by the entity known as Twitter (pressently, the author notes this size to be 140 8bit characters) directed towards an account fully contolled by the PitFail software. PitFail then processes the text contained within this message via a deterministic non-backtracking parser to determine the user's intention. PitFail then exectutes the action it anticipates the user desired, possibly returning some acknowledgment or additionaly information to the user via the very same mechanize the user utilized to contact PitFail.

Simple HTTP Interface - SHI Presently utilized by the Android client. Provides bare-bones access to allow a workable beta.

Facebook text command interface - FTCI When a user posts to a particular Facebook wall, their posting is taken to be a request to the system and is processed in a manner similar to TTCI.

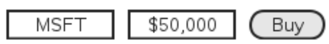
Android Application - AA Presently, the only code which does not run in the "server" context. Provides a simplistic interface to pitfail.

Stock Database - SD A library of code which provides featurful access to *Stock Information Providers*. It allows for simplified implimentations of caching, collating, quota enforcment, and fallback to be applied to incomming stock information from a variety of sources which provide heterogeneous APIs to access the *Stock Information*.

3 Interaction Diagrams

3.1 Performing actions (Buy/Sell/...) via the Web frontend

Suppose the user has filled out a form like this one:



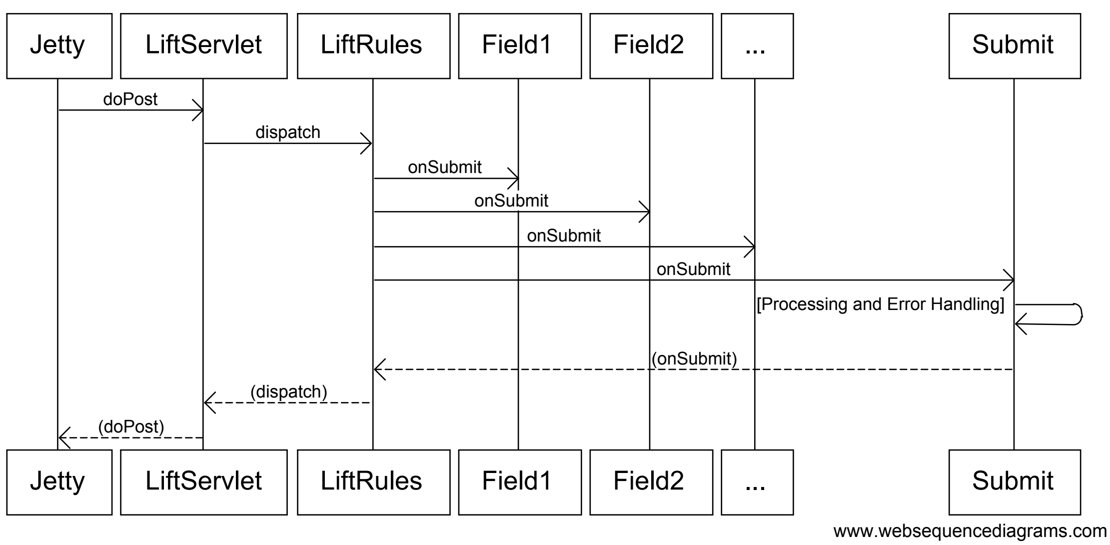
and presses "Buy".

In order to process that request, the following must happen:

1. An HTTP post is sent from the browser to the server (Jetty).
2. Jetty delegates the request to the web framework, Lift.
3. Form data is parsed and processed.
4. A call is made to the model to perform the operation.

These steps are described in more detail below.

3.1.1 When Lift gets an HTTP POST



PitFail is currently using jQuery to submit forms. Ideally we'd like our forms to work using either jQuery or traditional HTML forms, but we got this working first so it's what we're using for now.

When the user hits "Buy", JavaScript in the page generates an HTTP POST directed at PitFail's server. The server Jetty receives the POST, and calls LiftServlet.doPost() (actually there are some other steps involved because LiftFilter must first filter the requests but these are all internal to Lift). LiftServlet passes the request on to LiftRules to dispatch it.

LiftRules recognizes that this is an Ajax request coming from an HTML form, and extracts the form fields out of it. LiftRules keeps a table of onSubmit callbacks indexed by field name. For all the incoming fields, Lift calls the onSubmit callback, and then finally the onSubmit callback for the submit button -- that way, by the time the submit button's callback is invoked, all the fields will have been invoked first.

We are not sure why Lift handles forms this way -- in particular why it uses an onSubmit callback for things like text fields (that don't have an action associated with them) rather than just gathering all the data together into a single Map. This means that the only thing we use these onSubmit callbacks for is to save a single value which will be used later. We ended up writing a good deal of abstraction over Lift forms, because what we really want is to get all the data together as a single object.

3.1.2 Checking for Consistency

Scala is a statically typed functional language that has a lot in common with ML, where the philosphy is that you should use the type system to prove the consistency of your data at compile-time, eliminating the need for run-time checks.

Unfortunately, this is web programming, where your data is regularly sent to domains outside of your control. It appears that a strong type system relies a good deal on trust, which you simply can't do when half your program lives in a web browser. We found most of our work was spent meticulously pulling untrusted data back into a strongly typed format, only to have it be clobbered again at the next page reload.

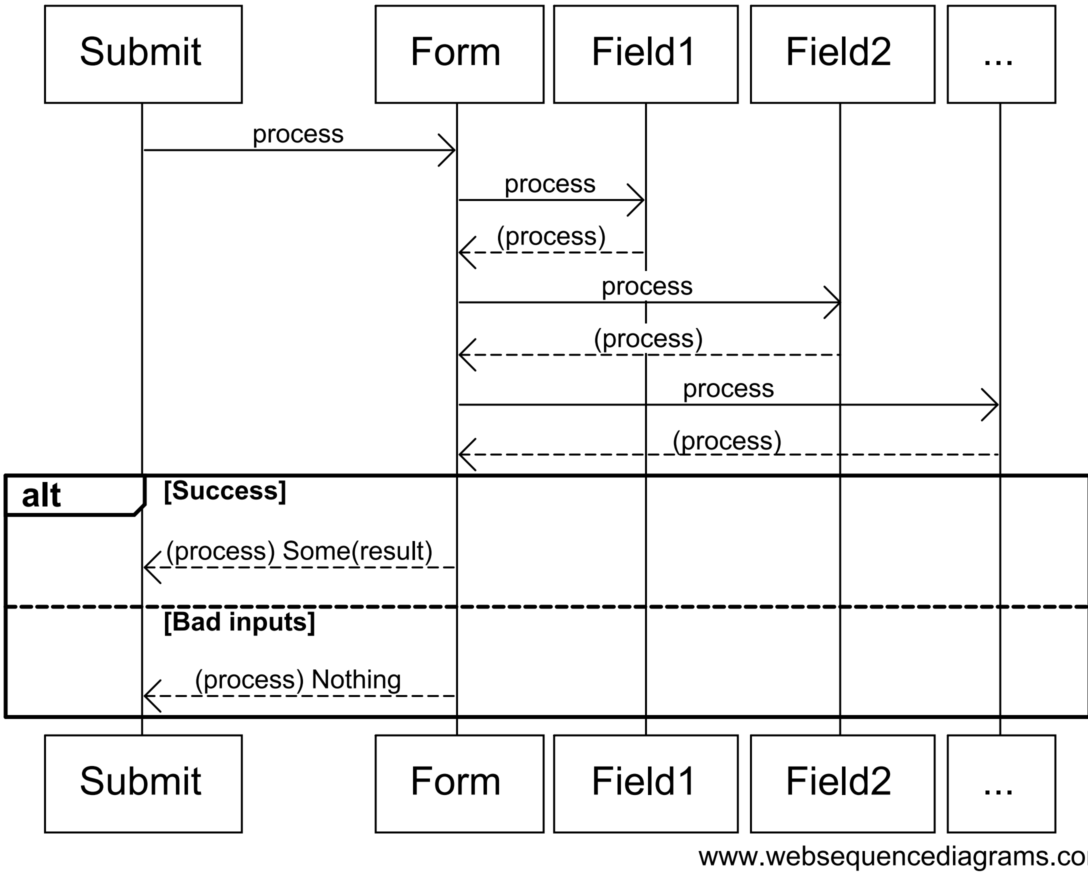
When a form is submitted, we have to do 2 things with the data:

1. Convert the user's loosely structured input into a strongly-typed internal representation.

2. Perform the action requested.

At either stage something can go wrong; we call errors in the first stage "input errors" and errors in the second stage "processing errors". The only real difference between the two is where in the code they occur -- either in the View or in the Model.

The process of structuring data and checking for input errors looks like this:

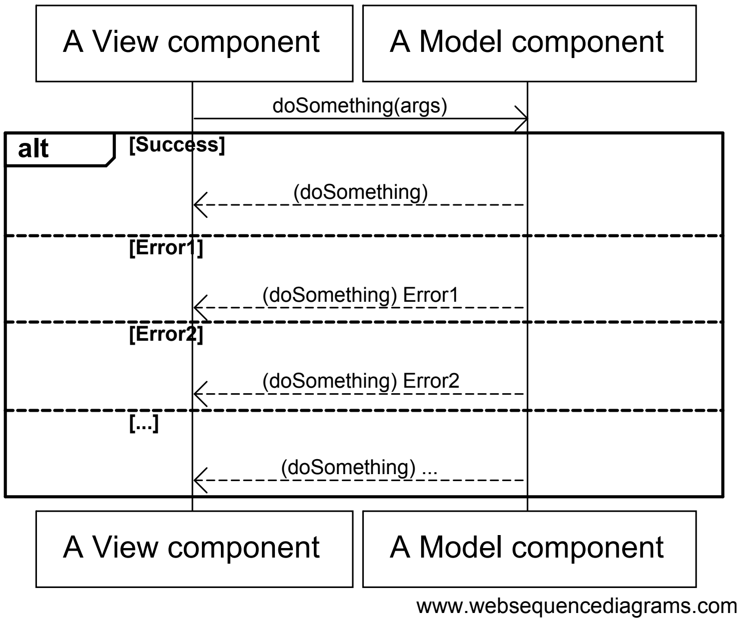


The Submit handler calls process() on the enclosing Form, which calls process() on all of its fields, which either succeed with Some[Result] or fail with Nothing (This is Scala's Option monad). The Options are then sequenced together into a single success or failure.

If the data makes it past input checking, a model operation must then be performed. It can be quite tricky to come up with an interface to model operations that

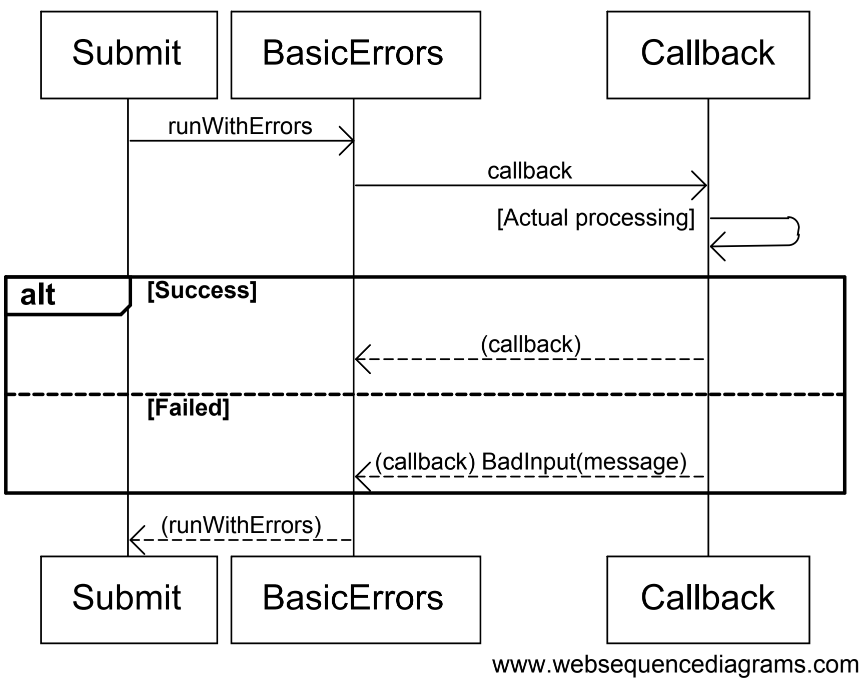
1. Is DRY (doesn't duplicate logic (especially checking) between the View and the Model).
2. Respects MVC by not requiring the View to make assumptions about the logic that goes on in the Model.

Our code succeeds OKish at these points. Places where that could be improved are described later (See for example Sell Stock). A typical model operation looks like:



That is, the View requests a single, atomic, high-level operation, which either succeeds entirely or fails with one of a collection of possible errors. The View is then responsible for turning the error into a human-readable message.

To get error messages back to the user, all calls into the model are wrapped in an additional error handler in a trait called BasicErrors:



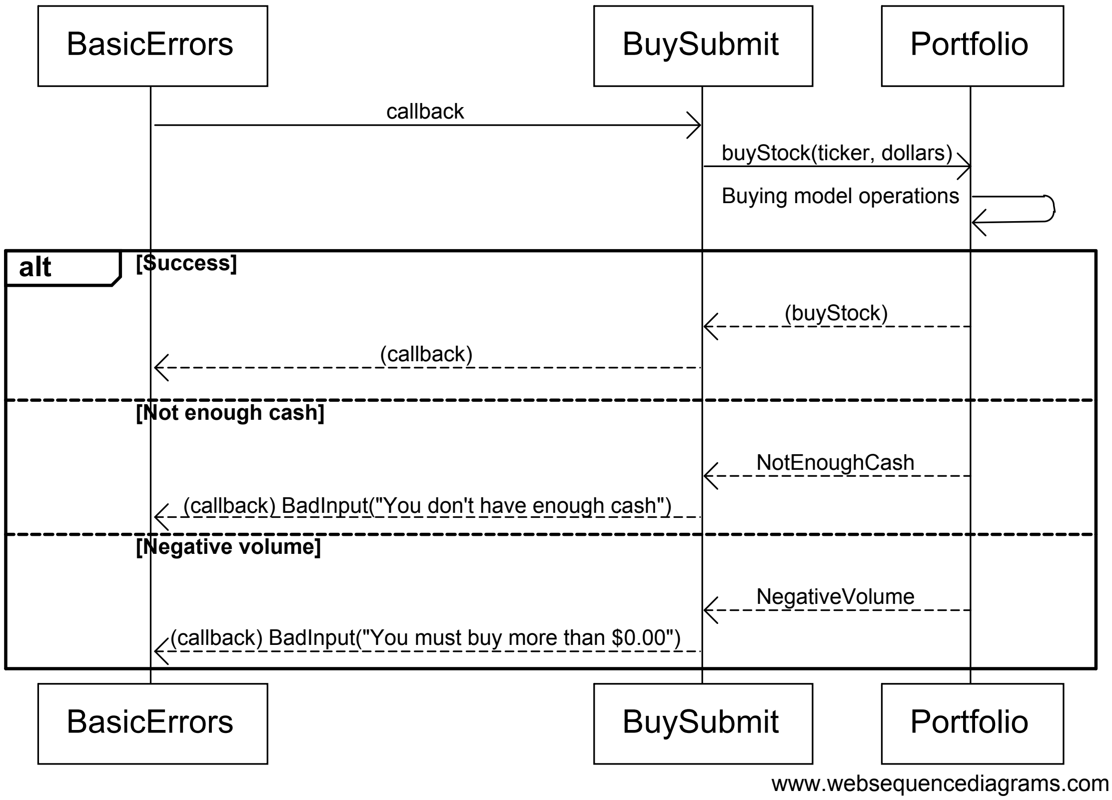
This captures errors to be returned to the user displayed on the page.

3.1.3 The actual operations

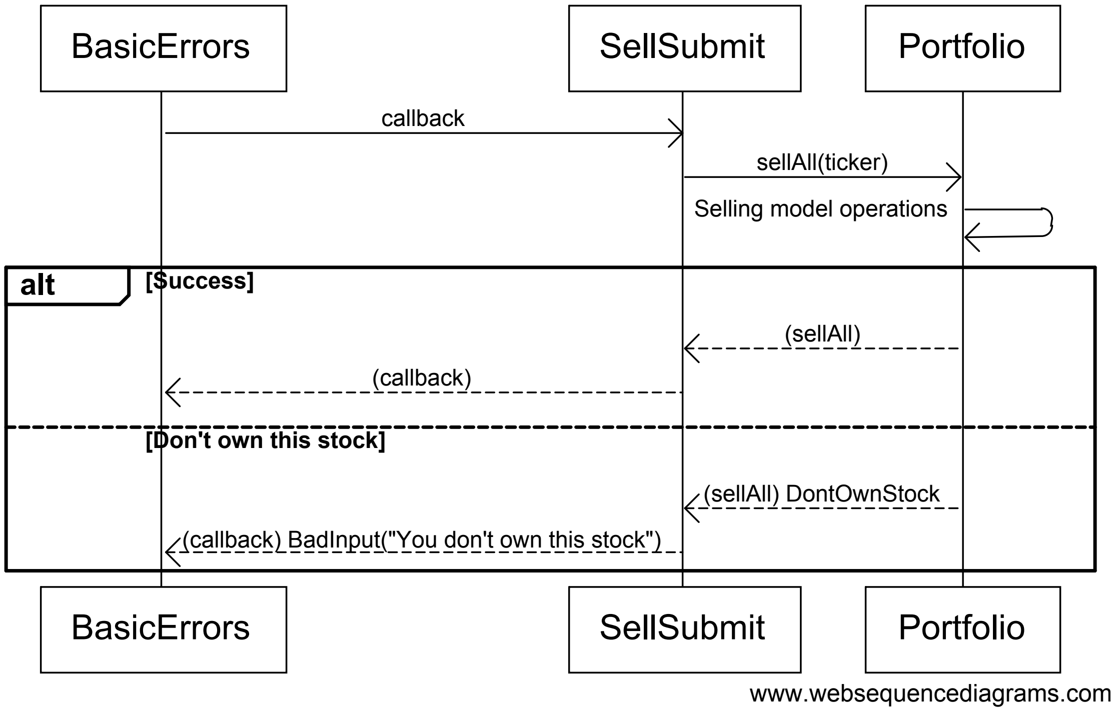
Compared to the above framework, the actual trading operations are comparatively simple. Unfortunately part of the reason for that is that they are comparatively incomplete.

The operations below are shown only from the side of the View; they also have corresponding Model operations, but because these are common to all frontends they are shown later.

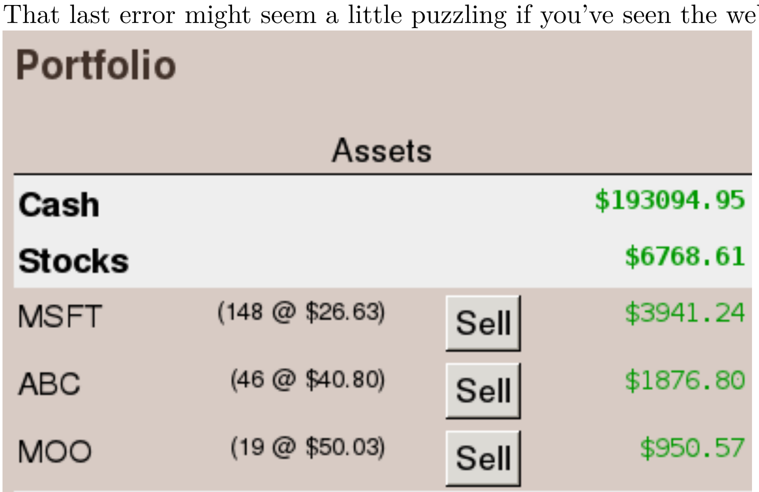
3.1.3.1 Buy Stock The web front-end side of the Buy operation looks like:



3.1.3.2 Sell Stock The web front-end side of the Sell operation looks like:



That last error might seem a little puzzling if you've seen the website:



We only let the user sell stocks they own; how can we possibly fail with DontOwnStock? There are two reasons:

1. The model has no way of knowing that we have already performed this check in the view.
2. After the page is rendered but before the user hits "Sell", there is a delay during which other asynchronous requests can come in and change the model.

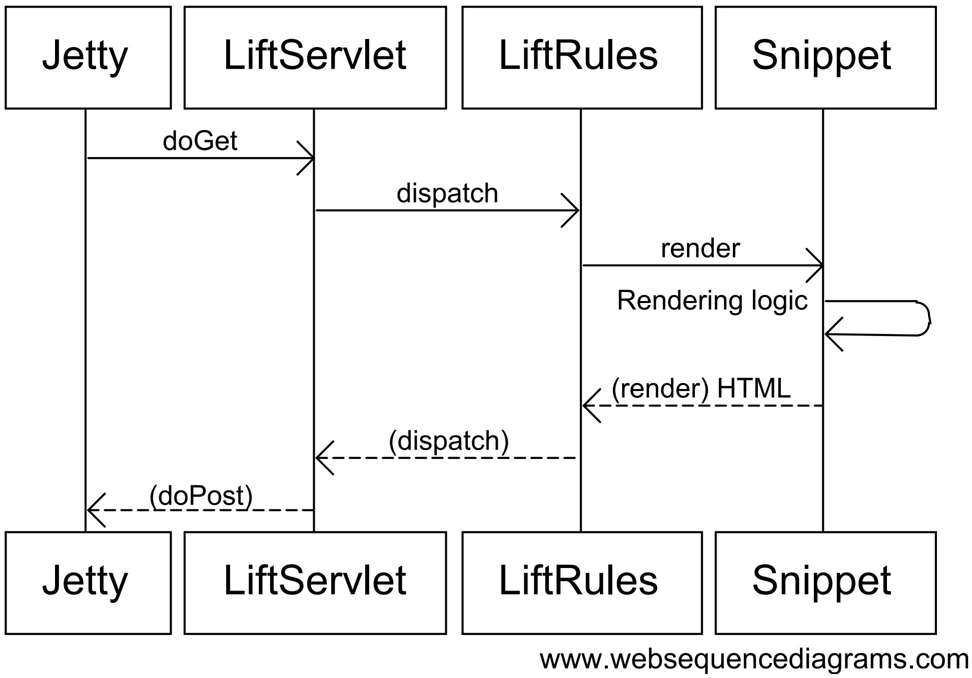
We cannot see a way to avoid this redundancy, but it is slightly concerning because it violates the two principles we are basing the model API on:

1. The "check" is performed in two places, implemented separately.
2. The View takes on some of the role of the Model in deciding which stocks it is possible for a user to sell.

It has not been a huge problem yet, but it does raise a question: which parts of the code are responsible for deciding what a user is permitted to do? Ideally that should be decided in the Model, but as we see here we limit the user's choices simply by how we present the information to them, and that is decided in the View.

3.2 Rendering Pages

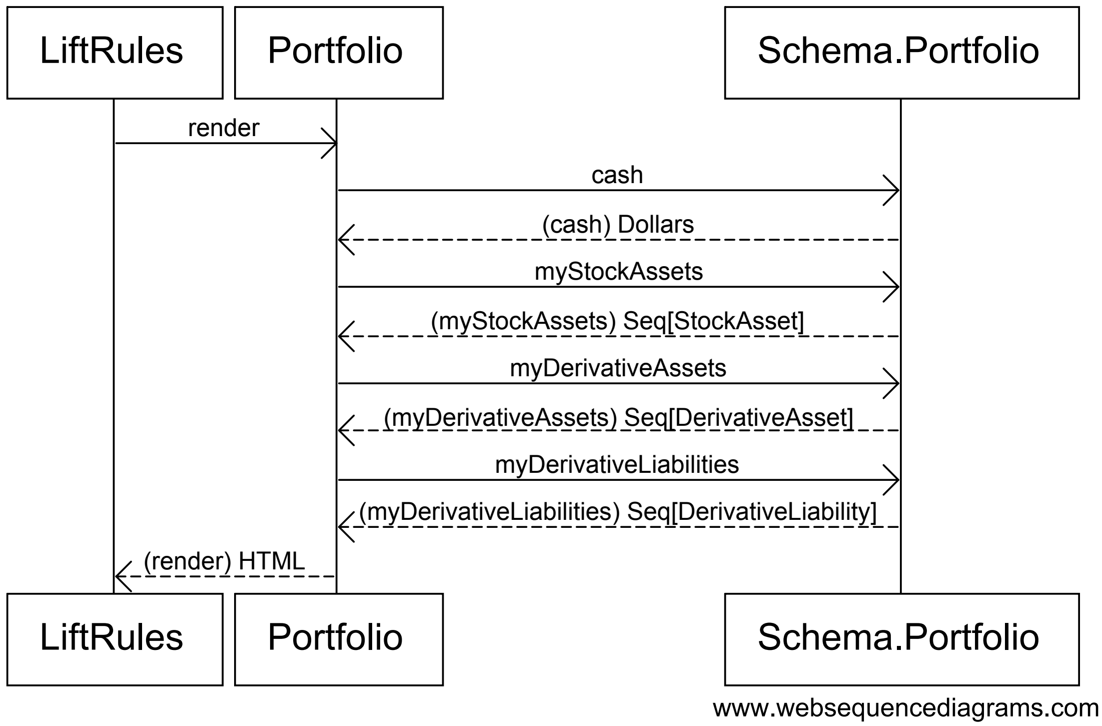
Pages don't perform actions and so they are accessed over HTTP GET. Lift handles GET like this:



That is, the request is delegated to a Snippet object's render() method, which returns the HTML for the generated page. The selection of which snippet to use is done based on a mapping stored in LiftRules.

3.2.1 View Portfolio

Viewing a portfolio is essentially a task of pulling information out of the model and converting it to HTML:


LiftRules
Portfolio
Schema.Portfolio
render
cash
(cash) Dollars
myStockAssets
(myStockAssets) Seq[StockAsset]
myDerivativeAssets
(myDerivativeAssets) Seq[DerivativeAsset]
myDerivativeLiabilities
(myDerivativeLiabilities) Seq[DerivativeLiability]
(render) HTML
LiftRules
Portfolio
Schema.Portfolio
www.websequencediagrams.com

3.3 BUY/SELL via the Android Cleint

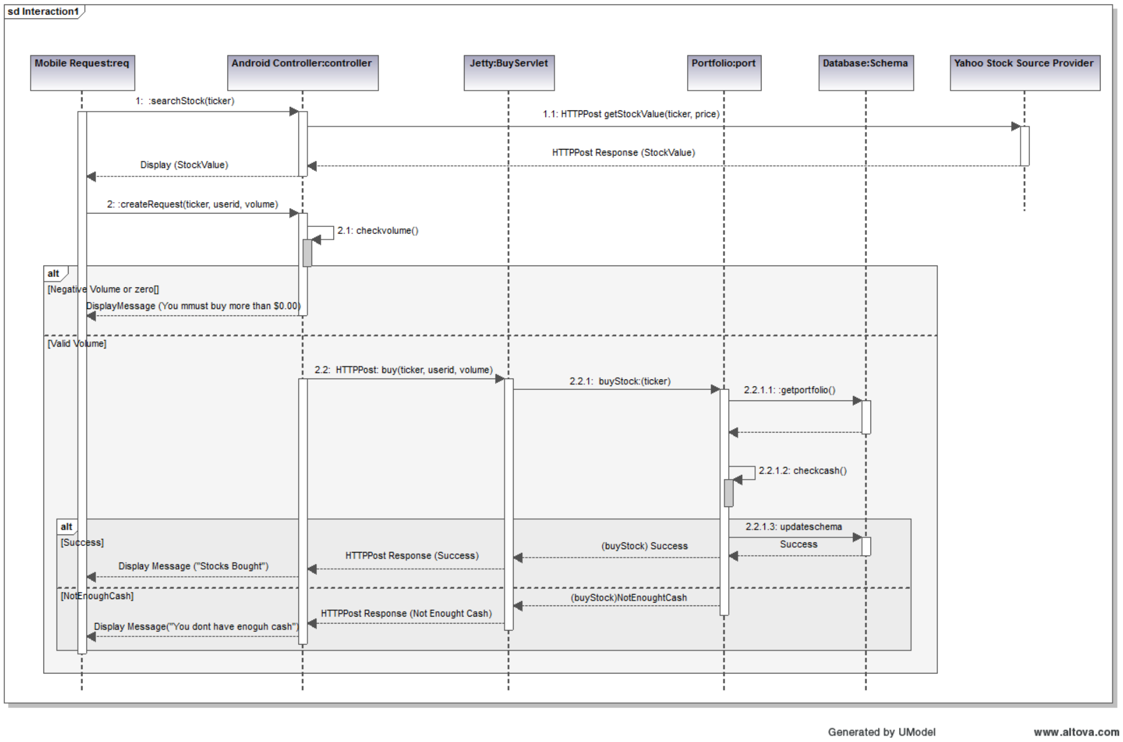


Figure 1: Buy Stocks via Android Client

The diagram above is the interaction sequence diagram for UC Buy Stocks from an Android Mobile Client. This Interaction diagram is the extension of System sequence Diagram for UC-1 Buy Stocks. As shown, first the search action is initiated by the Android Controller which requested by the Android user. The Android controller sends an HTTP Post request to Yahoo Stock Source. This request specifically asks for the Stock Value of the stock ticker by sending the corresponding tag with the request. Once the response is received, the Mobile Client creates the Buy request. The Android controller calls the BuyServlet using an HTTP Post request via the Jetty Server.The Jetty server has capability to support both Scala and Java sources as it runs on a JVM. All the servlets for Android are written in Java which internally calls functions from Scala classes. The reason for choosing Java for Android client is for its compatibility.The BuySerlvlet internally makes use of the Portfolio class the extract the user info from the Database. If the Volume to be bought is correct, user's portfolio is updated and results are sent back to the user.

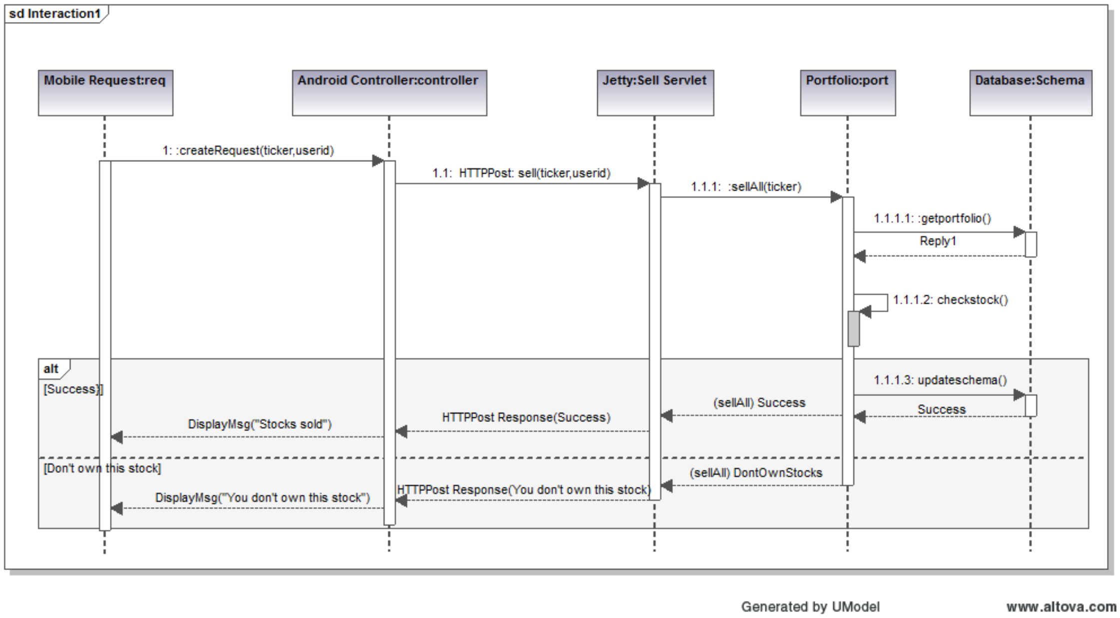


Figure 2: Sell Stocks via Android Client

The diagram above is the interaction sequence diagram for UC Sell Stocks from an Android Mobile Client. The user initiates the action by creating a request by providing the Stock ticker name he intends to sell off. The Android controller sends an HTTP Post request to SellServlet via the Jetty Server. The BuyServlet makes use of portfolio class and call the function to update the user profile.Because we expect asynchronous requests there is a possibility that by the time a SellStock is completely executed there can be another asynchronous call from some other client interface by the same user. Such a situation is handled by throwing back an exception message “You dont own this stock” and corresponding appropriate message back to the user.Currently, we sell off all the corresponding stocks. In the future, we do plan to give user an option of amount of volume he wants to sell off.

3.4 Buy/Sell Operations via FaceBook Interface

If a player wants to access PitFail via Facebook, he or she can post the request on PitFail’s wall.

The request has to be in format: Username: Operation(Buy/Sell):[volume]:Ticker

Currently FaceBook interface only supports two operations ¿ Buy or Sell securities.

To process this request : 1.This request should be listened to and FB app should be notified of the wall post

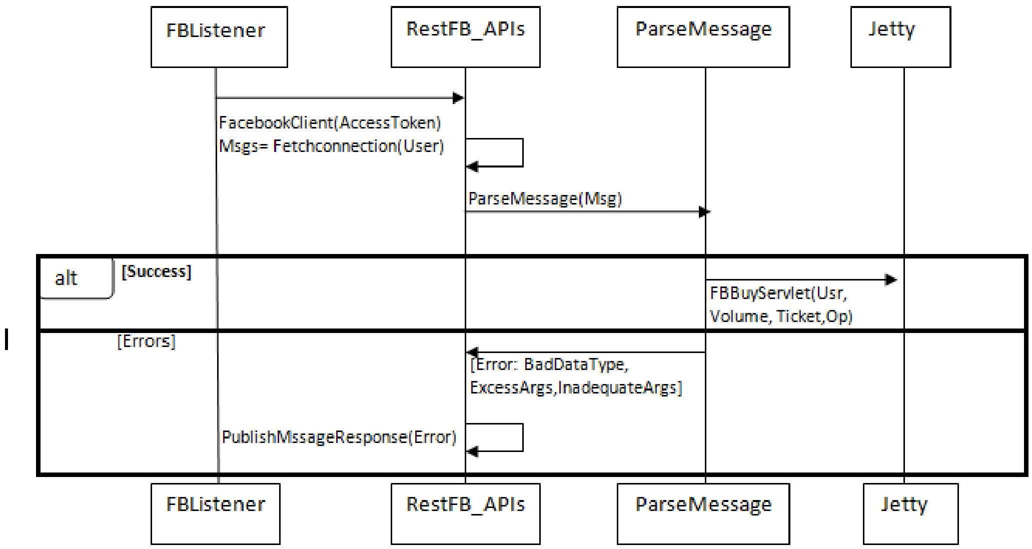
2.The wall post should be read and parsed.

3.The request should invoke appropriate module from server to get the operation done

4.The player should be notified of the status of the request (successful/failed) Here is a description in detail:

3.4.1 Parse Message:

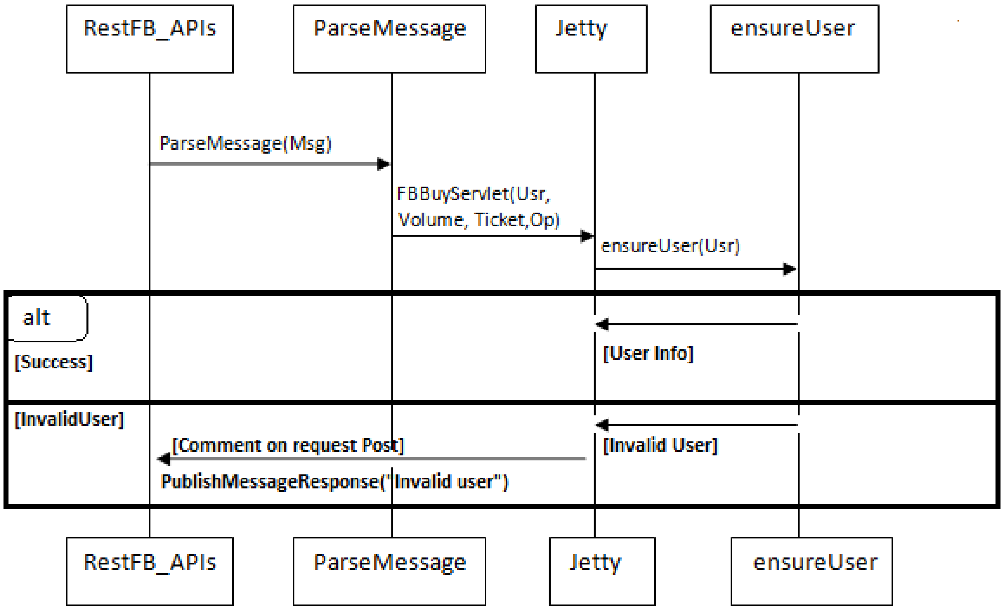
The first step is to read the wall post and parse it to a request that a server can handle.



FBListener listens to the wall post of our account and notifies pitFail FB app of any new wall post. We use RestFB APIs that access Facebook account of PitFail using the unique access token provided by FaceBook. API fetchConnection(User) reads the new wall post and passes it to ParseMessage module. ParseMessage processes the wall post, extracts the information required to process the request. It also checks for the right number of arguments and the data type (e.g. Volume has to be a number). If the message is good enough to be processed (no errors), the parsed request is sent to server , otherwise the player is notified of the error by commenting on player's wall post.

3.4.2 Ensure User:

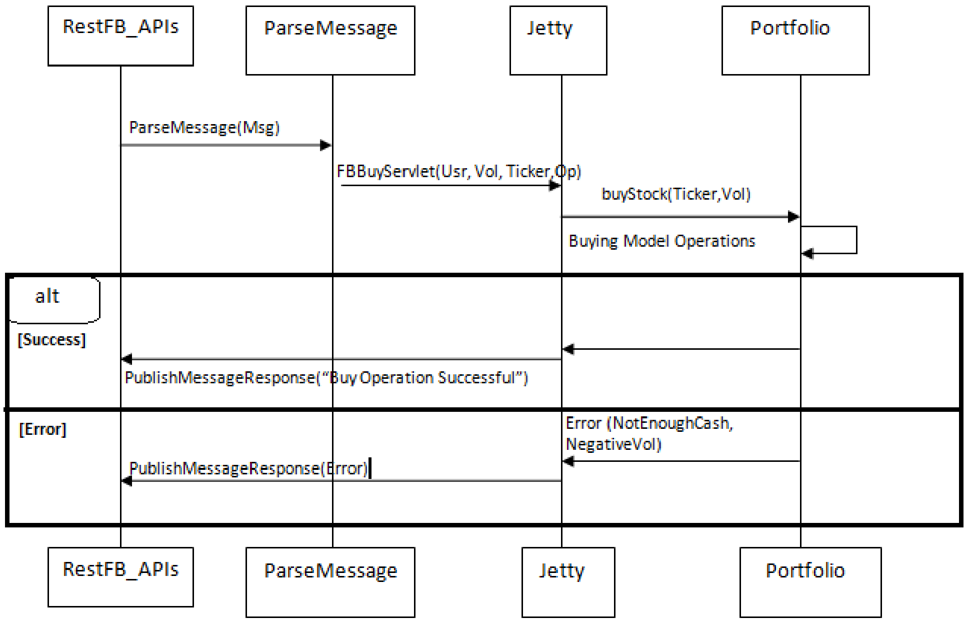
Now that the message is parsed, we need to check the authenticity of the user. Facebook interface of PitFail does not (for now) support registration. The player has to be already registered to the system to play the game via FB interface.



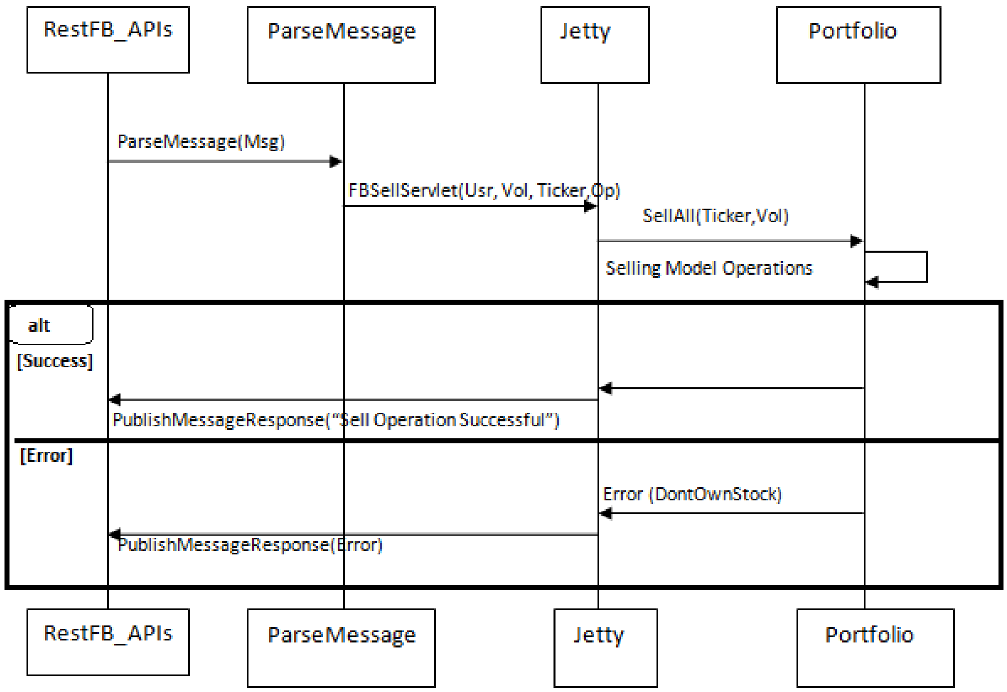
ensureUser ensures the existence of a user before the user's request tries to access portfolio. If the user exists, the request is processed further otherwise the player is notified of the error occurred by posting a comment on his wall post.

3.4.3 The Operations (Buy/Sell)

Once the wall post is parsed into a trade request and the existence of user is checked, the actual operation takes place.



3.4.3.1 Buy Stock:



3.4.3.2 Sell Stock: The working of a server is explained in detail in website section. When the server receives a valid request from a legitimate user, it accesses the portfolio of the user to perform the operation. Based on the value returned by user, FB App posts comment on the player's wall post saying "Successful" or "failed <reason>"

3.5 Interaction via the texttrading interface (Twitter)

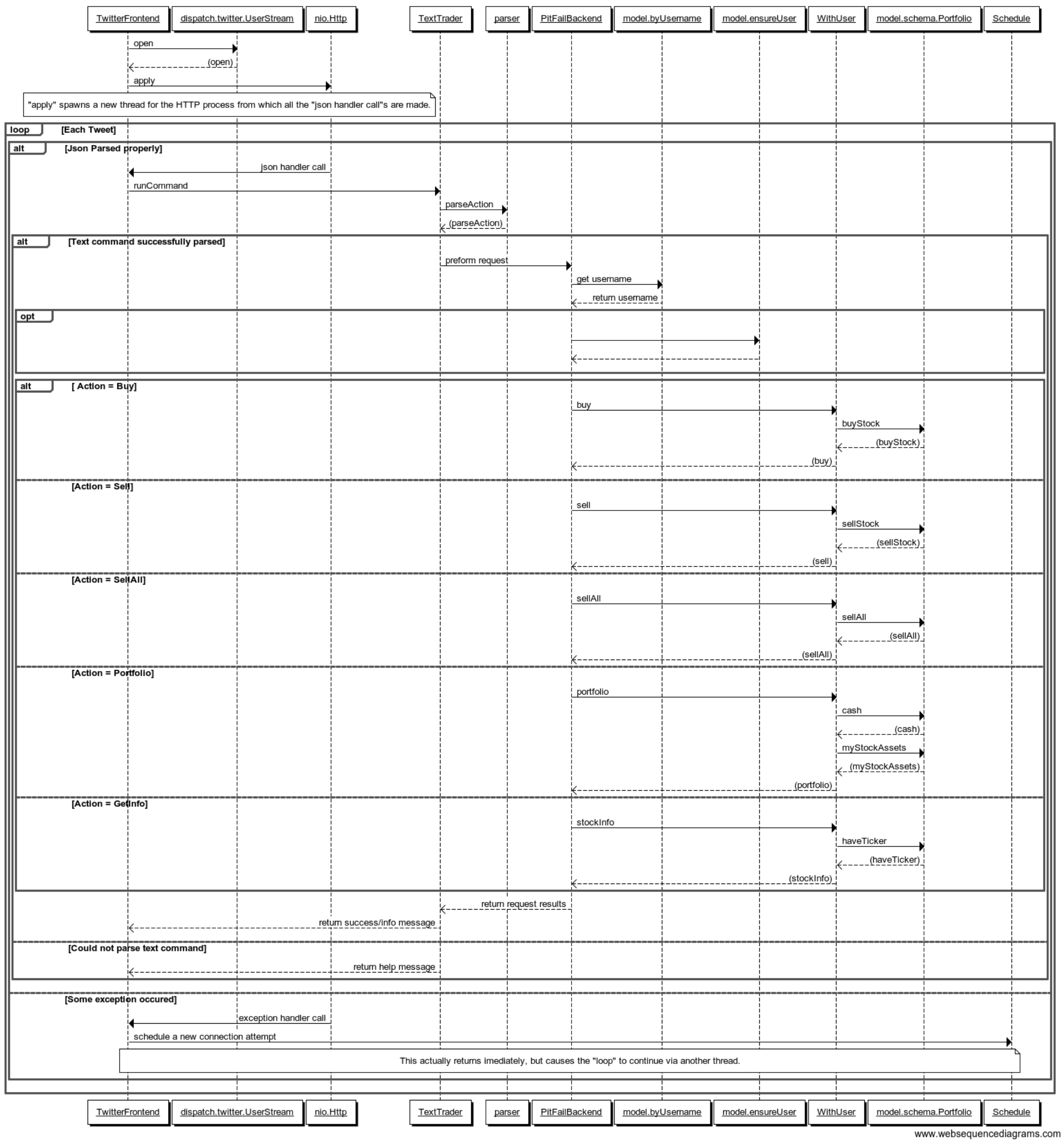
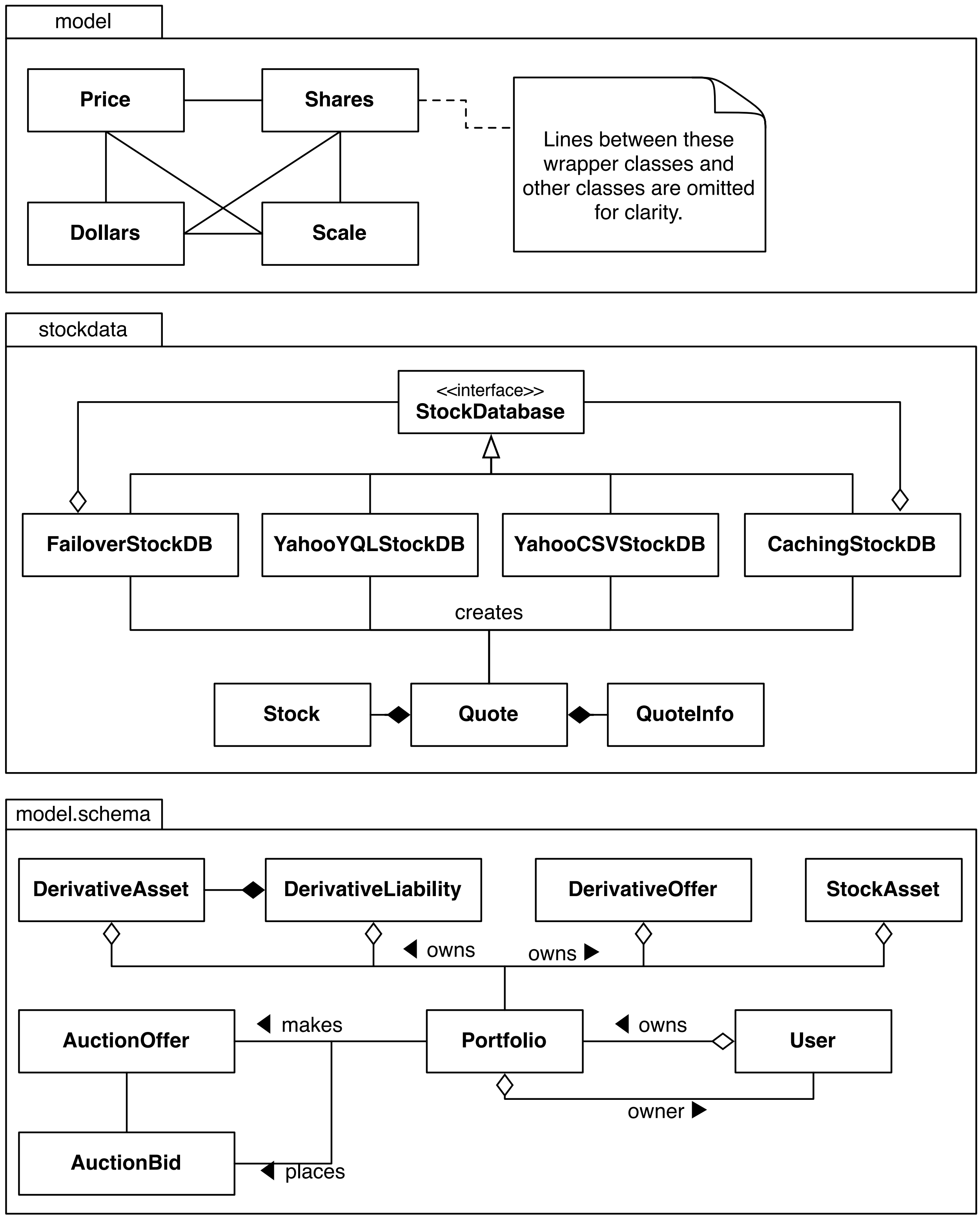


Figure 3: All use cases within text trading proceed along the same path initially, only to split later. Accordingly, this interaction diagram covers all the use cases interacting with the Twitter interface.

4 Class Diagram and Interface Specification

4.1 Class Diagram

The core class diagram for PitFail is shown below. It is discussed in Data Types and Operation Signatures.


model
Price
Shares
Dollars
Scale
Lines between these wrapper classes and other classes are omitted for clarity.
stockdata
<<interface>>
StockDatabase
FailoverStockDB
YahooYQLStockDB
YahooCSVStockDB
CachingStockDB
creates
Stock
Quote
QuoteInfo
model.schema
DerivativeAsset
DerivativeLiability
DerivativeOffer
StockAsset
owns
owns
AuctionOffer
makes
Portfolio
owns
User
owner
AuctionBid
places

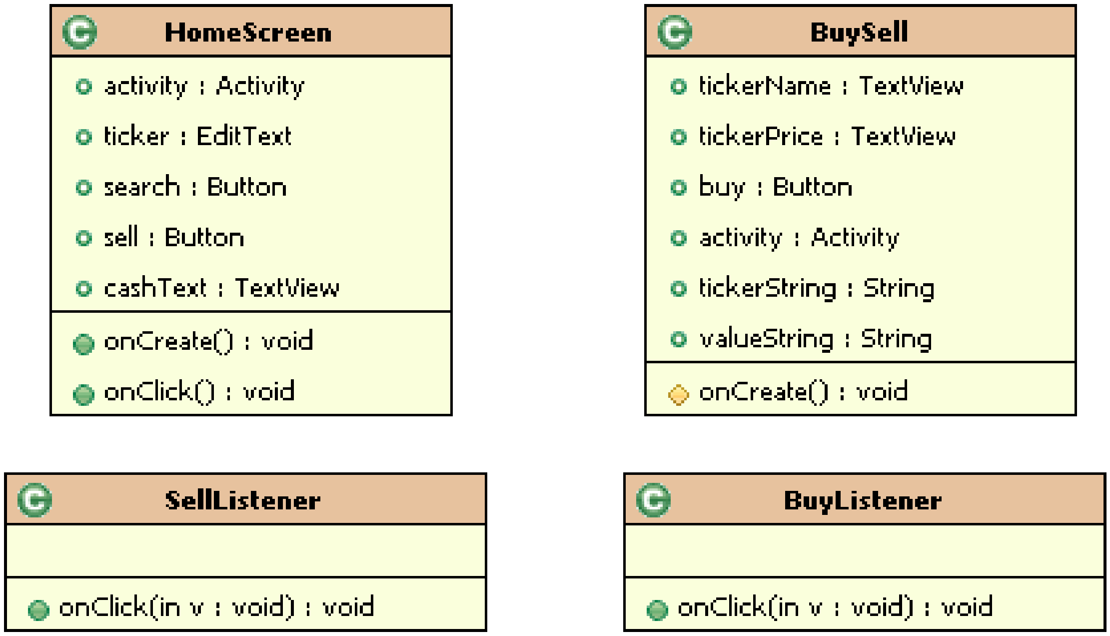
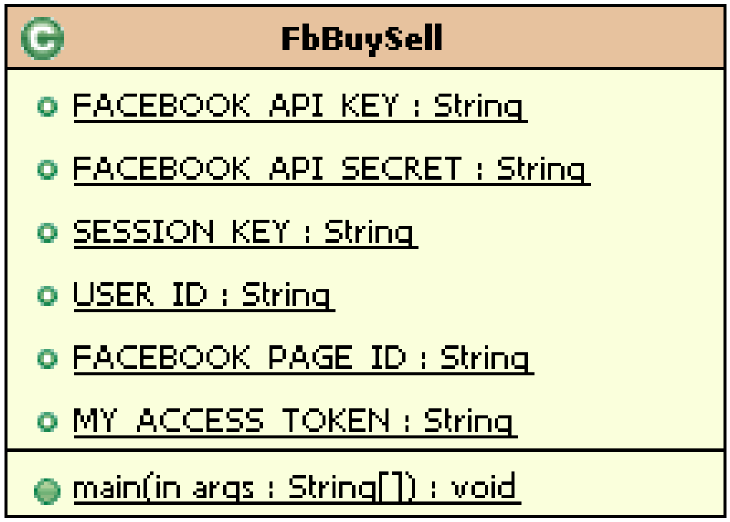


Figure 4: Class Diagram for Android Client



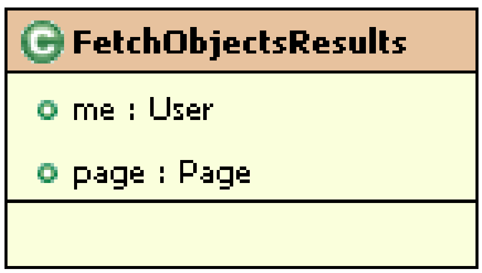
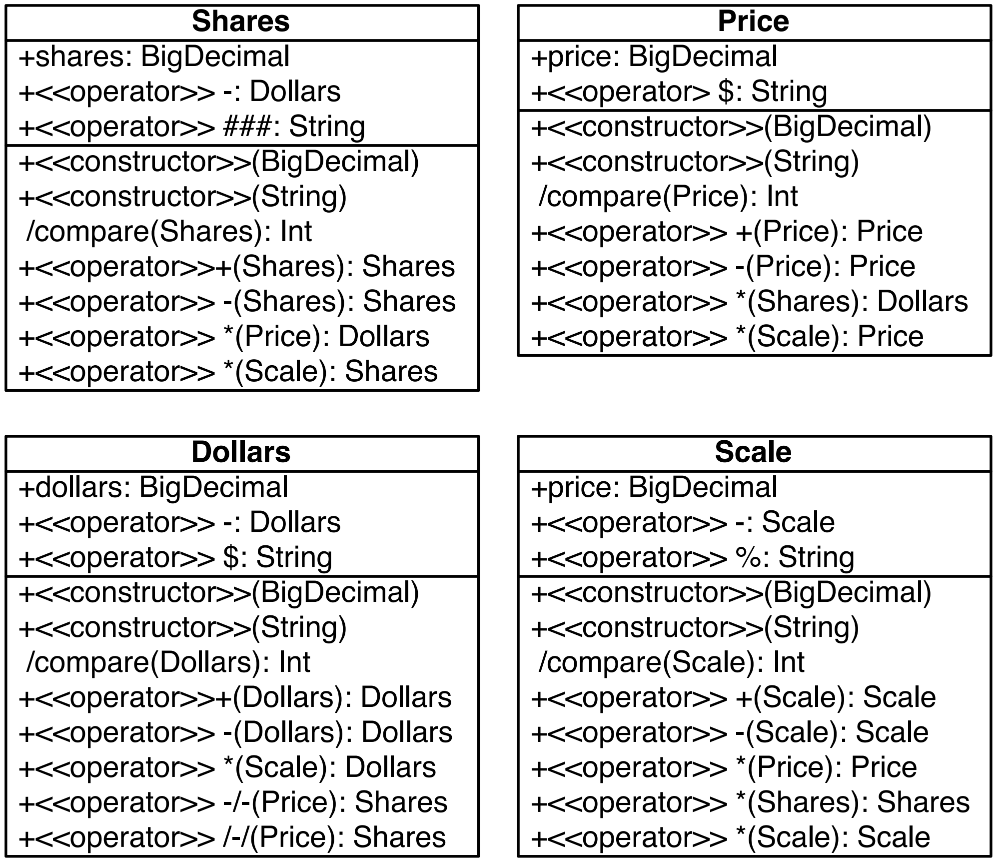


Figure 5: Class Diagram for FB Client

4.2 Data Types and Operation Signatures

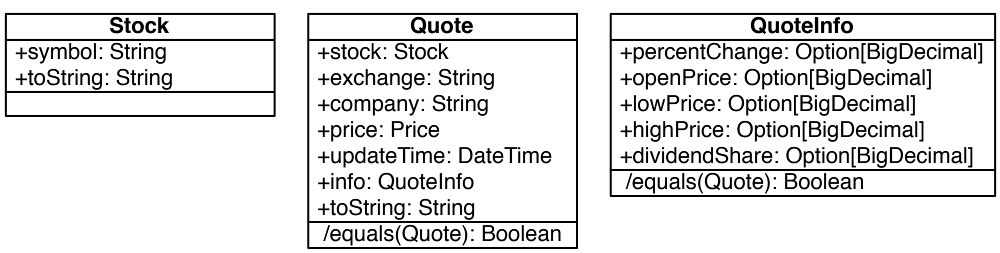
Mapping between Scala and UML is more difficult than mapping between a "traditional" object-oriented language such as C++ or Java and UML class diagrams. In particular, methods and attributes in Scala are often interchangeable and both may use symbols for their names. As such, any method that accepts zero parameters and has no side-affects is written as an attribute instead of a method. Any methods or attributes that contain symbols or punctuation, such as "$", are prefixed with «operator». Keep these conventions in mind when reading the following section.

As a financial simulator, PitFail requires interacting with several types of quantities: (1) volume of stock, (2) stock prices, (3) cash, and (4) fractional ownership of an asset. These concepts are represented by, respectively, the *Shares*, *Price*, *Dollars*, and *Scale* classes:



Using these special-purpose classes provides much more type safety than storing all four of these quantities as BigDecimals. This is especially important when performing mathematical operations on these types: some combinations of types are useful, while others are meaningless. The process of switching from a unilateral use of BigDecimal caught several bugs that would have otherwise gone

The next most important classes are those that represent individual stocks and stock quotes. In PitFail's object model, *Stock* is a something that can be purchased on a market, a *Quote* is a stock paired with it's current price, and a *StockAsset* is the number of shares of a stock owned by a particular user:



Immediately one is drawn to the peculiar decision of splitting *QuoteInfo* from *Quote*. This is intentionally done to isolate optional information about a stock, which may not always be available, from the information that is necessary to make a trade. By isolating this superfluous information it is possible to change its in-memory representation from an object to a sparse data structure if necessary.

Given a *Stock*, a *Quote* must be generated using a stock data provider such as Yahoo! Finance. This is encapsulated in the *StockDatabase* interface and its concrete implementations:

<<interface>> **StockDatabase**
+getQuote(Stock): Quote +getQuotes(Seq[Stock]): Seq[Quote]

YahooYQLStockDatabase
+queryService: HttpQueryService
+<<constructor>>(HttpQueryService) +getQuote(Stock): Quote +getQuotes(Seq[Stock]): Seq[Quote]

YahooCSVStockDatabase
+queryService: HttpQueryService
+<<constructor>>(HttpQueryService) +getQuote(Stock): Quote +getQuotes(Seq[Stock]): Seq[Quote]

CachingStockDatabase
+database: StockDatabase -cache: Map[Stock, Quote]
+<<constructor>>(StockDatabase) +getQuote(Stock): Quote +getQuotes(Seq[Stock]): Seq[Quote]

FailoverStockDatabase
+databases: Seq[StockDatabase]
+<<constructor>>(Seq[StockDatabase]) +getQuote(Stock): Quote +getQuotes(Seq[Stock]): Seq[Quote]

Most importantly, the *YahooCSVStockDatabase* and *YahooYQLStockDatabase* classes query Yahoo! Finance for updated stock quotes. These two classes are combined using the *CachingStockDatabase*, a in-memory cache that uses a hash table to memoize repeated queries for the same quotes. Finally, the *FailoverStockDatabase* tries a list of stock providers in series until one query succeeds: this is important because Yahoo! Finance's YQL interface provides the richest interface to stock data, but is notoriously unreliable.

Once a stock has been purchased by a user it is wrapped in a *StockAsset* and added to the user's portfolio. As the *User*, *Portfolio*, and *StockAsset* classes contain persistent data, all of these classes interact with the database using Squeryl:

User
+id: Long +username: String +mainPortfolio: Portfolio
+offerDerivativeTo(User, Derivative, Dollars) +acceptOffer(String) +declineOffer(String)

Portfolio
+id: Long +cash: Dollars +owner: User +loan: Dollars
+buyStock(String, Dollars): Unit +buyStock(String, Shares): Unit +buyStock(String, Shares, Dollars, Price): Unit +sellStock(String, Dollars): Unit +sellStock(String, Shares): Unit +sellStock(String, Shares, Dollars, Price): Unit +sellAll(String): Unit +acceptOffer(String): Unit +declineOffer(String): Unit +findOffer(String): DerivativeOffer +castBid(AuctionOffer, Dollars): Unit +liquidate(): Dollars +changeLoan(Dollars): Dollars

StockAsset
+id: Long +ticker: String +shares: Shares +portfolio: Portfolio

Similarly, a variety of database-wrapper classes are defined for derivatives:

DerivativeAsset
+id: Long
+peer: DerivativeLiability
+scale: Scale
+owner: Portfolio
+executeManually(): Unit
+executeOnSchedule(): Unit
#executeUnchecked(): Unit

DerivativeLiability
+id: Long
+name: String
+remaining: Scale
+exec: Timestamp
+owner: Portfolio
+reduceScale(Scale): Unit

DerivativeOffer
+id: Long
+handle: String
+from: Portfolio
+to: Portfolio
+price: Dollars
+expires: Timestamp

AuctionOffer
+id: Long
+handle: String
+offerer: Portfolio
+price: Price
+when: Timetamp
+expires: Timestamp
+goingPrice: Dollars
+highBid: Option[AuctionBid]
+actOn(AuctionBid): Unit
+close(): Unit

AuctionBid
+id: Long
+offer: AuctionOffer
+by: Portfolio
+price: Dollars

AuctionBid
+id: Long
+offer: AuctionOffer
+by: Portfolio
+price: Dollars

This set of classes is the primary interaction between the view, the model, and the database. Calling one of these methods, e.g. *buyStock()* on a *Portfolio*, causes Squeryl to accordingly update the database and to generate a new entry in the news feed (when appropriate). These entries are stored in the *Newsfeed* class, which is a simple chronological log:

NewsFeed
+id: Long
+when: Timestamp
+action: String
+subject: User
+recipient: User
+ticker: String
+shares: Shares
+dollars: Dollars
+price: Price

5 System Architecutre and System Design

5.1 Architectural Styles

PitFail is composed of a large number of pieces of code which provide a wide range of functionality. This necessitated using different achitectural styles for various portions of the program. Some sections of the code are independent of other portions to the degree that they can be viewed as libraries. This is particularly the case with the Stock Database code, which presents itself as a library from which different querying archetectures may be constructed.

The Stock Database library heavily follows the pipe and filter achitectural style. Each class (also called a Stock Database, SDB) either links other SDBs together or communicates with a concrete SDB. In practice, many more of the SDBs form the interior "filtering" functions rather than the endpoint "driving" functions. The filtering SDBs impliment collating of requests, caching of results, various forms of rate limiting, and fallback between different pipelines of SDBs.

Within the website, implimented via the Lift Webframework, View First MVC is utilized. Lift provides a "View First" interface for those devolping via it, meaning that control of the program's execution is in the hands of the View code, and can be passed off to other portions as needed. In the case of PitFail's website, model code is independent of the website itself (and thus Lift). Control code is specific bound to Lift's framework but clearly split from the view code. The control component within the website provides information such as authorization info to the view for processing.

5.2 Identifying Subsystems

The majority of the code for PitFail falls under the "server side" category. All code for controlling the WebPage, Twitter Iterface, Model, General Text Command Interface, and what shall be refered to as the Simple HTTP Request interface (a Java Servlet presently used for Android interaction) run within a single contexed on the server.

Key "client side" portions of the code are the Android application and the Javascript code generated by Lift which notifies server side handlers of some event/change or makes a request which runs a server side handler. None of the *WebPage* Javascript code should be considered a subsystem of PitFail

- Model. This includes database interactions. It is divoriced from any of the various frontend/interface subsystems, each of which make calls into it rather than modifying the DB directly.
- Main Webpage. Written using Lift. Is itself split into view and controll portions.
- Text Interface (TI). Provides a wrapper around the backend allowing for the execution of parsed text based commands which result in modifications or queries to the backend.
  - This addtionally encompasses the Twitter Text Command Interface (TTCI). TTCI utilizes the Text Interface code as a library, simply calling the Parser and Action Handler as possible commands are recieved via a continuous Twitter stream.
- SHI. Implimented as a Java Servlet which runs within the same server as Lift. Accesses the backend directly via the backend code. Is called via HTTP requests by the Android and Facebook(?) interfaces, neither of which run in the same context as the other subsystems.

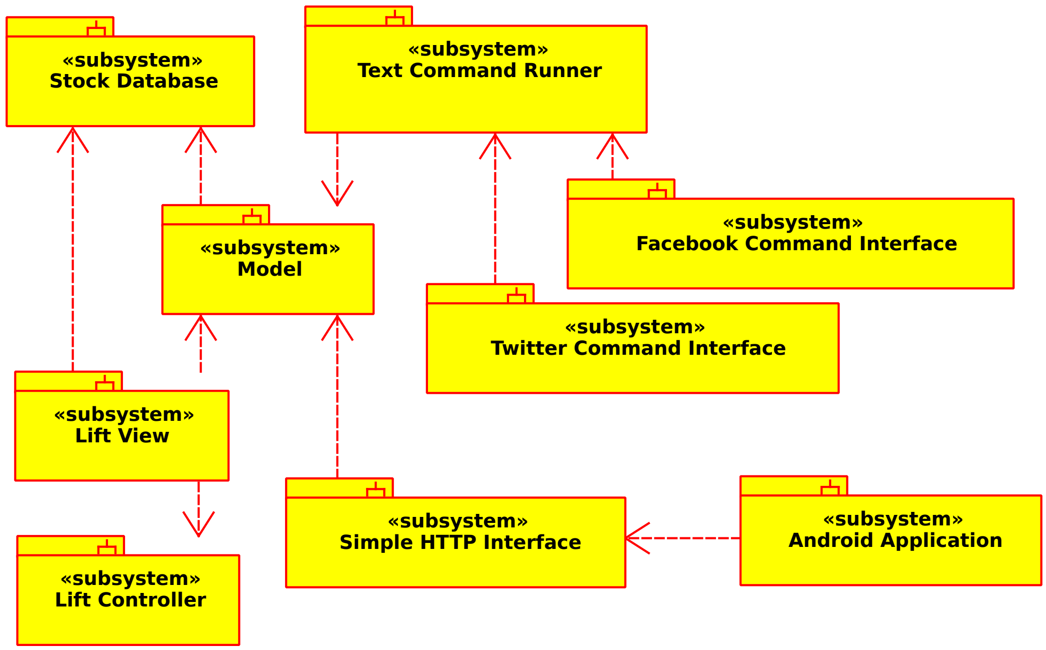


Figure 6: Major Subsystem Diagram of PitFail

5.3 Mapping Subsystems to Hardware

The majority of the subsystems are placed on the same server. Additionally, they all occupy the same Jetty server, and thus can directly access methods provided by the other subsystems. The subsystems which are in this unified group are the Backend, Lift webpage, TTCI, and SHI.

The Lift client side helpers (javascript which provides a link between user interaction with webpage via a webbrowser and the backing Lift webpage code) run within a connecting user's webbrowser, thus on their own hardware.

The Android client is running on a variety of platforms, including Cellular Telephones, Touchscreen tablets, emulators, and whatever the modding community ported Android to in the last hour or so. No control over this hardware is to be had, and as such the application must run flawlessly on all possible configurations.

5.4 Persistent Data Storage

PitFail does need to store data to outlast a single execution of the system since users will be playing PitFail for months or years at a time.

The persistent objects are the users' accounts, the users' transcations, and stocks' performances, and portfolios' performances over time. Each user will be associated with numerous buys, sells, and derivatives and these will all need to be stored in a medium for quick and reliable access. For each transcation, this data will increase. Each stock and portfolio will represent the true test of the data storage. These objects require performance data that the users require a visual graph for and statistics on. Depending on the sampling frequency of stock prices, this data can grow every five to thirty minutes.

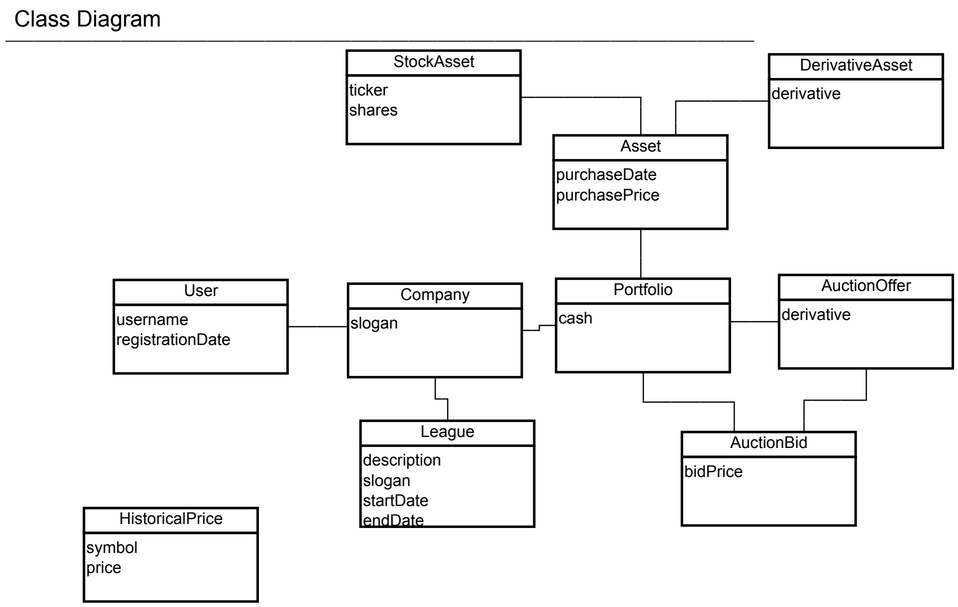
As an example to explain the data storage requirements, for a system with 50 users each holding 15 unique assets, a five minute sampling frequency over one year storing records as doubles would yield: (50 users) * (15 assets/user) * 260 working days * 6.5 hours/day * (60 minutes/hour) * (1/5 samples/(asset* minute)) * (8 bytes/sample) = 121.7 megabytes.

Since any of these figures can be increased to make the performance data more precise, storing this information can easily become overwhelming.

PitFail is stored in a light-weight and portable H2 relational database that takes advantage of the relations between users, portfolios, stocks, assets, leagues, companies, etc. It is scalable to handle the large amount of information needed to create performance charts and statistics.

5.4.1 Database Schema

The current version of PitFail does not have a model representation for leagues, companies, historical prices, or saving information about how or when an asset was purchased. The following Schema suggests how this could be augmented:



Below is the database schema for a MySQL implementation of the database, which is a possibiltiy in the future depending on the ability of H2 and Squeryl to model leagues, companies, auctions, orders, and other new uses.

Schema Follows:

```
CREATE TABLE user (
        userid INTEGER  AUTO_INCREMENT,
        PRIMARY KEY (userid),

        #leagueid INTEGER , #redundant. can get through Company entitiy
        #FOREIGN KEY (leagueid) REFERENCES league, #update on delete, on update
        companyid INTEGER ,
        FOREIGN KEY (companyid) REFERENCES company, ##update on delete, on update

        twitter VARCHAR(25), #currently not required
        username VARCHAR(25), #could make not null
        password VARCHAR(25), #could make not null

        registration_date DATETIME,
        first_name VARCHAR(30),
        last_name VARCHAR(30),
```

```
        email VARCHAR(50)
        );

CREATE TABLE company(
        companyid INTEGER  AUTO_INCREMENT,
        PRIMARY KEY (companyid),

        #portfolioid INTEGER , # not needed since portfolioid == companyid
        #FOREIGN KEY (portfolioid) REFERENCES portfolio,
        leagueid INTEGER,
        FOREIGN KEY (leagueid) REFERENCES league,
        #Relation - User - Stored in the User table

        name VARCHAR(25),
        slogan VARCHAR(100),
        registration_date DATETIME
        );

CREATE TABLE league(
        leagueid INTEGER AUTO_INCREMENT,
        PRIMARY KEY(leagueid),

        admin INTEGER ,
        #FOREIGN KEY(admin) REFERENCES user,
        #Relation - Company - Stored in the Company table
        #Relation - User - Stored in the User table

        name VARCHAR(25),
        description VARCHAR(500),
        slogan VARCHAR(100),

        start_date DATETIME,
        end_date DATETIME,
        start_cash DOUBLE(20,4),
        margin_limit DOUBLE(20,4)
        #more league options can be included here
        );

CREATE TABLE portfolio(
        portfolioid INTEGER , #the portfolio id == company id
        PRIMARY KEY (portfolioid),
        FOREIGN KEY (portfolioid) REFERENCES company,

        cash DOUBLE(20,4)

        #Relation - Asset - Stored in Asset Table#
        );

CREATE TABLE asset(
        ticker VARCHAR(25) ,
        FOREIGN KEY (ticker) REFERENCES stocks_derivatives,
```

```
        portfolioid INTEGER ,
        FOREIGN KEY(portfolioid) REFERENCES portfolio,

        #need to say if it is a stock or derivative and then what type of derivative
        typed VARCHAR(10),

        shares DOUBLE(10,4), #NOT NULL,
        purchase_value DOUBLE(20,4), #NOT NULL,
        purchase_date DATETIME,
        sold_value DOUBLE(20,4),
        sold_date DATETIME,

        PRIMARY KEY (ticker, portfolioid, purchase_date) #this allows multiple purchases of the sam
        );

CREATE TABLE auction(
                auctionid INTEGER AUTO_INCREMENT,
                PRIMARY KEY(auctionid),
                portfolioid INTEGER,
                FOREIGN KEY (portfolioid) REFERENCES portfolio,
                ticker VARCHAR(25),
                FOREIGN KEY (ticker) REFERENCES stocks_derivatives,
                winning_offer INTEGER,
                FOREIGN KEY (winning_offer) REFERENCES auction_offers,
                price_start DOUBLE(20,4),
                price_close DOUBLE(20,4),
                time_open DATETIME,
                time_closeDATETIME
                );

CREATE TABLE auction_offers(
                auctionid INTEGER,
                FOREIGN KEY (auctionid) REFERENCES auction,
                portfolioid INTEGER,
                FOREIGN KEY (portfolioid) REFERENCES portfolio,
                offer DOUBLE(20,4),
                time_offer DATETIME,

                PRIMARY KEY(auctionid,portfolioid, time_offer)
                );

CREATE TABLE stocks_derivatives(
        ticker VARCHAR(25) ,
        PRIMARY KEY (ticker),

        num_holders INTEGER #optional increment/decrement this. If this == 0, then do not update si
        );

CREATE TABLE historical_price(
        ticker VARCHAR(25),
```

```
FOREIGN KEY (ticker) REFERENCES stocks_derivatives,

date_time DATETIME,
price DOUBLE (10,4),

PRIMARY KEY(ticker,date_time)
);
```

5.5 ORM

PitFail uses the Squeryl ORM to access the database. Squeryl works by implementing a domain-specific language (DSL) to build literal SQL queries. This means that Squeryl code has Scala syntax, but SQL semantics. For example:

```
from(users) (u =>
    where(u.username === name)
    select(u)
) headOption
```

PitFail opted for an ORM for two reasons:

- This ensures consistency between our in-memory model objects and their on-disk counterparts.
- This makes our model code database agnostic.

However, now that we have actual experience with the Squeryl ORM, we realize there are some pitfalls that have to be weighed against the benefits. First, because an ORM makes it so easy to get actual Scala objects out of our table rows, it encourage most of the logic to be written in Scala. At first sight this might seem to be a benefit, as we enjoy writing Scala more than we enjoy writing SQL. But what we did not realize was that by making the transition from SQL to Scala as painful as it is with raw JBDC, it forces you to put more of your logic in stored procedures, where importantly *everything is in sync*. The instant you bring a table row into the program, you risk forgetting that it might not be in sync anymore. And even if you wrap your code in database transactions, it doesn't help, because transactions have no control over what goes on in memory.

PitFail will probably continue to use the Squeryl ORM, but with these caveats in mind.

5.6 Network Protocol

PitFail has multiple clients like Website, Twitter, Android and Facebook. All these clients communicate with the PitFail server via HTTP (Hyper Text Transfer Protocol) over TCP/IP sockets. Another network protocol which PitFail uses is JDBC (Java Database Connectivity) to communicate with the H2 database which is a Open Source Java based database. Following is a brief description of both the protocols.

HTTP (Hyper Text Transfer Protocol): HTTP is well known internet protocol and is used by most of systems communicating over the internet. HTTP defines how messages should be defined, packaged and transmitted over the internet. HTTP is a stateless protocol and does not maintain any state of messages sent over it. HTTP makes use of "Request" and "Response" headers to transfer data.

Message format: The request message consists of the following: a.Request line, such as GET /pitfail/index.html HTTP/1.1, which requests a resource called /pitfail/index.html from server. b.Headers such as Accept-Language: en c.An empty line. d.An optional message body.

HTTP defines nine methods indicating the desired action to be performed on the identified resource out of which PitFail uses its POST method for almost all its communication with the server.

JDBC (Java Database Connectivity): JDBC provides methods for querying and updating data in a database. JDBC is oriented towards relational databases. JDBC allows multiple implementations to exist and be used by the same application. The API provides a mechanism for dynamically loading the correct Java packages and registering them with the JDBC Driver Manager.The Driver Manager is used as a connection factory for creating JDBC connections. JDBC connections support creating and executing statements. These may be update statements such as SQL's CREATE, INSERT, UPDATE and DELETE, or they may be query statements such as SELECT.

5.7 Global Control Flow

Requests can come into PitFail at any time from Twitter, Facebook, Android, and the Website. This version of PitFail gives essentially no thought to how we would like performance to degrade under heavy load, except for two limited areas:

1. Stock prices retrieved from Yahoo are cached for 5 minutes, which, if no *new* stocks are introduced, will limit the total rate of requests to Yahoo to {number of unique ticker symbols} / {5 minutes}. But if new ticker symbols are introduced, there is no limit to how many requests PitFail will attempt (and likely fail) to make to Yahoo.

2. The framework PitFail is built on already has some flow-control features: HTTP requests are handled by a thread pool, as are some of the internal messages in the system (via Lift Actors).

To see whether one client making requests in rapid succession to PitFail would starve out another client we timed how long it took the server to respond to isolated requests with and without background spam. The results (in seconds):

Load	**Q1**	**Med**	**Q3**
Quiet	.15	.17	.23
Spammy	.11	.13	.23

Apparently the not-spamming client does not starve, not even the least bit, so Lift must be performing some flow control, but we do not know what. We are very impressed with Lift; this performance has certainly nothing to do with our design.

5.8 Hardware Requirements

PitFail requires Jetty server to be running which does not pose any strict hardware requirements. However, having a following hardware specification is recommended for a better and smooth experience for the user.

Processor: Intel Pentium III with 1GHZ or above (or an equivalent configuration). We used machines with Intel.

Memory: 1GB or more of RAM

System type: 32 or 64 bit Operating System

Disk Space: Minimum 150 MB for complete installation

Network: Network bandwidth > 56kbps

The three client interface of Pitfail which are Website, Twitter and Facebook can be accessed from any device which has web browsing capabilities. For the Android Application for Pitfail, any mobile device running android and connected to the internet can execute the application.

6 Algorithms and Data Structures

6.1 Algorithms

6.1.1 Buying on Margin

All PitFail users will start with a predetermined amount of capital cash that is their money to use. In order to trade for more stocks, PitFail users can buy/sell on margin, which is performing stock actions with money on loan. This money will require the user to pay interest on the loaned money each day until it is returned and paid in full, including total interest.

PitFail uses the Simple Interest Formula to compute the money users owe due to interest. The loan will cos

Interest/Day = Principal * Rate where Rate is determined by the going market rate

The amount of margin for a user is also an algorithm. Since a user owns the capital money he starts with and can borrow additional money from lenders, a user should be able to pay back his lenders at any moment. Therefore, the margin offered per user will be no more than the total capital cash the user would have if he liquidated all of his assets at current market value. For example, if a user owns 500 shares of stock ABC @ $25 and has $10,000 unused capital cash, the user is able to buy 1,000 shares of stock BCD @ $22.5, resulting in $0 capital cash and $0 for margin buying. Therefore, if stock ABC's price increases to $30 a share, this user would now have $2,500 available on margin.

6.1.2 High Frequency Trading and Automatic Drone Traders

High Frequency Trading is a power player in today's current stock market. As a side project, PitFail will try to implement such a system that is automated and performs many transactions (in our case) per minute. To allow for a productive experiment, brokerage fees will be turned off for high frequency trading accounts. The goal of such a system will be to break even. These will be called Automatic Drones Traders and can be programmed to be high frequency traders. They will be created to simulate additional buying and selling. They will be based on the following: * buying a rising stock * selling a stinking stock * buying a random stock and holding it until the stock moves by +/- 1% and then selling it * buying the stocks of the top performers on PitFail * buying recently bought stocks on PitFail * etc...

6.1.3 Cover's Universal Algorithm

This algorithm will be impemented by an Automatic Drone. It begins by buying nearly all the stocks available in the stock exchange and creating ratios amongst the stocks (in Pitfail's case, constant). By the end of the day, some stocks will increase and some stocks will decrease in price, changing the ratio between the stocks. This drone will sell/buy stocks to rebalance the ratios in the portfolio for the start of the next day.

6.2 Concurrency

PitFail is built on the Lift web framework, which uses Erlang's Actor model to provide concurrency. An Actor is essentially an event loop witha synchronized queue: actors can respond to messages on their own queue, or send messages to other queues.

PitFail makes real use of actors in a small handful of places. Background tasks are run in an actor because Lift actors run in a threadpool; that way background tasks don't hog a whole thread and can merely pull one off the thread pool periodically. The other place PitFail uses an actor is to send notification emails, because the operation can block for a long period of time and the rest of the page request (updating the model, responding with a repyl page) needs to be able to continue without waiting for the email to be sent.

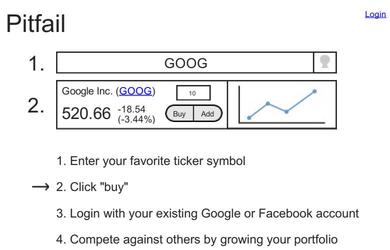
6.3 Data Structures

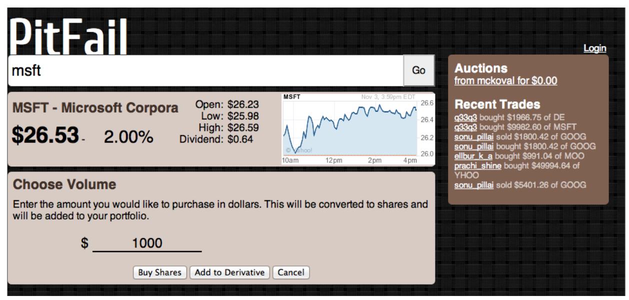
7 User Interface Design and Implementation

PitFail's overall user interface closely resembles the interface depicted in its mockups: most of the changes were merely cosmetic. Most of the functional changes are because the current implementation of PitFail is missing features that were included in the mockup: e.g. companies, leagues, and social interaction. These changes are grouped into general categories, described in detail, and justified in the following sections.

7.1 Welcome Page for New User

PitFail was originally described as having a "guided registration" process where the user registers as part of purchasing his or her first stock. While the user can still explore the stock purchasing interface before logging in, the current implementation of PitFail does not support this "zero effort" registration because of a technical limitation. As such, guided messages no longer are displayed next to each step in the purchasing pipeline:



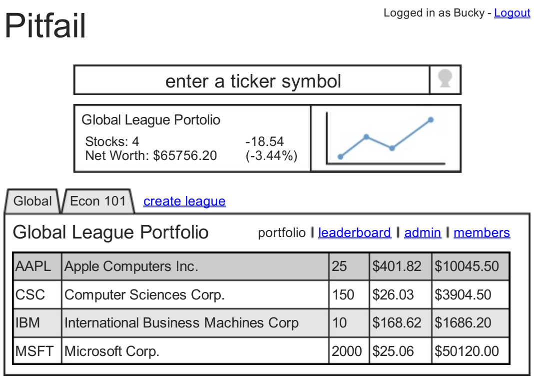


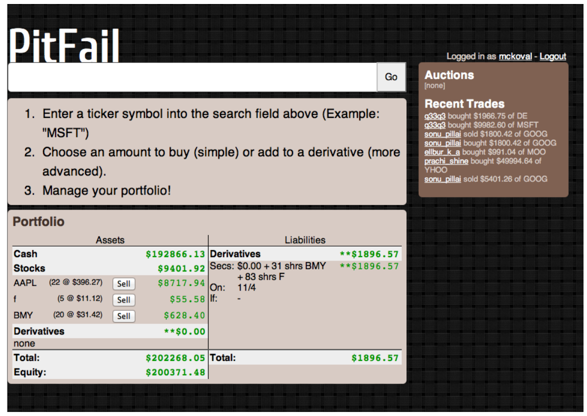
Note that the list of steps is not visible and the current step is not indicated with an arrow. Some form of guided registration will be implemented in the next version of PitFail. Thankfully, this doesn't change user effort: the user simply must login *before* selecting a stock instead of *after* selecting a stock.

7.2 Portfolio Management

Perhaps the largest change from the original mockups to the current implementation is the user's portfolio. This was planned to be displayed as a single large table containing the all of the user's assets: a combination of cash, stocks, and derivatives. This design made it difficult to visually differentiate between types of assets and to locate an asset of interest.

Instead, the portfolio displayed as a "T"-chart, splitting assets and liabilities into two separate columns. The assets column is further subdivided by the type of asset: cash, stocks, and derivatives. These subdivisions allow the user to quickly locate an asset of interest, for example, when selling a stock. Each column is summarized with a "total" row that estimates the current value of his or her portfolio by approximating the value of derivatives as if they were immediately executed. While none of these changes dramatically alter user effort relative to the mockup, reformatting the portfolio as a "T"-chart and adding this additional information makes it much easier for a user to view his or her current assets at a glance:

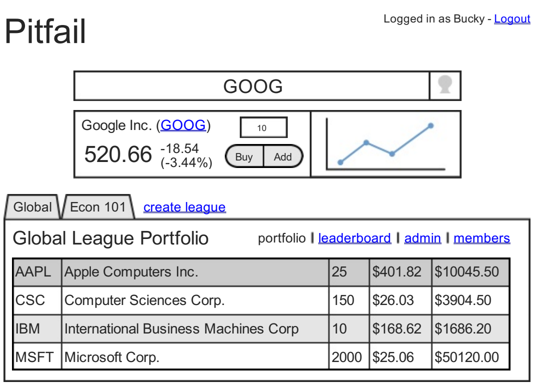


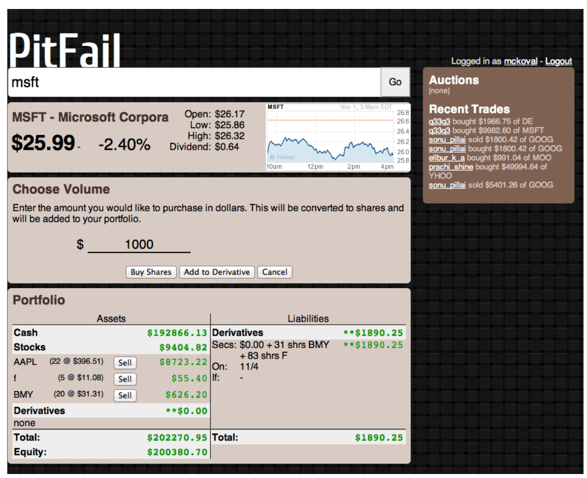


Besides the changes to the table of assets, there are clearly several features missing from the implementation: (1) historic portfolio performance, (2) multiple portfolios, and (3) league navigation. These missing interface elements will be restored after companies, leagues, and logging of historic prices are implemented in the next iteration of PitFail.

7.3 Buying Stocks

Purchasing stocks is one of the fundamental activities on PitFail. The interface for buying stocks is very similar to the interface shown in the original mockups: when the user enters a valid ticker symbol in the large search bar, a small stock quote expands below the search bar. This quote includes a few statistics about the stock's daily performance and a graph of the stock's performance over time.



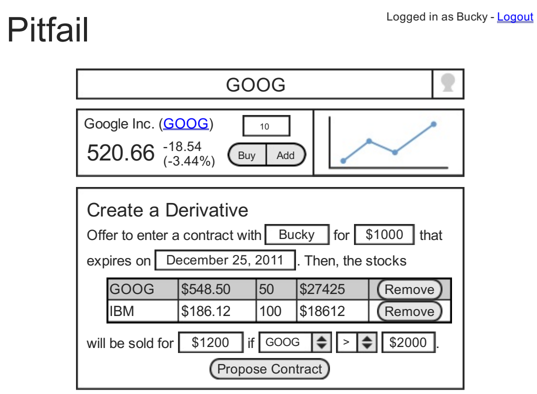


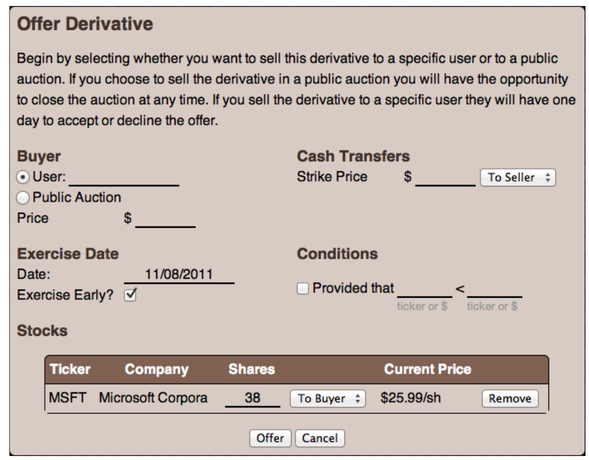
Unlike the original mockup, the options for interacting with the stock are not embedded in the stock quote. Instead, they are displayed in a dedicated section of the webpage. This extra space is used to display a short description of stock trading and helps guide new users through the process: something that will be even more important once options are supported. While the original mockups allowed the user to enter an amount in either shares or dollars, this was found to be confusing and was removed in the current version of the user interface.

Neither of these changes do not considerably effect user effort.

7.4 Trading Derivatives

If the user clicks the "add to derivative" button instead of the "buy stock" button, he or she is presented with the derivative offering page. In the original mockups this was shown as a prose-like description of a derivative with a number of blanks. Originally intended to guide the user through the derivative creation process, this was found to be unfeasible with the number of derivative configuration options supported in PitFail. As such, this was redesigned to resemble a traditional form: a prose description followed by a table of input fields.

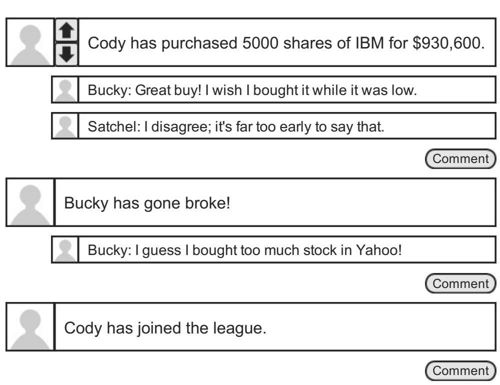


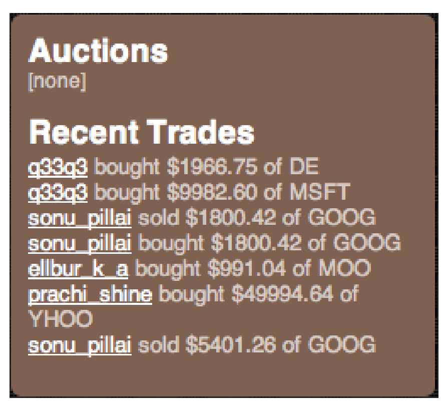


Once the derivative has been created it can either be offered to a specific user or to a public auction. If a buyer is specified, that user is prompted to accept or decline the offer using a special form in his or her portfolio. If the derivative is offered to a public auction, a link to the auction page is added to the sidebar and other users have an opportunity to bid. These features were not included in the mockups, so see the User Effort Estimation section below for a detailed usability analysis.

7.5 Social Features

PitFail's original mockups included a real-time newsfeed at the bottom of every page. This news feed was a log of trading history and served as a hub for social interaction between users. A limited implementation of this newsfeed is included in the current version of PitFail. Unlike the mockup, the newsfeed is included in every page's sidebar instead of the footer. This is similar to the real-time feed that was recently added to Facebook and will be familiar to the majority of PitFail's users.





Besides the different location, much of the functionality displayed in the mockups has not yet been implemented. Notably, this includes: (1) user-specific newsfeeds, (2) voting, (3) commenting, (4) messages for derivative trades, and (5) messages for a users going broke. These features will be implemented in the next version of PitFail and do not effect user effort.

7.6 User Effort Estimation

Several of the most common usage scenarios for the PitFail website are evaluated below. In particular, note that common scenarios (e.g. buying a stock) are much easier to perform than rare scenarios (e.g. creating a new league):

Usage Scenario	Clicks	Keystrokes
purchase a stock	3	7
create a derivative	4	27
act on a pending derivative offer*	1	1
bid on a derivative auction*	4	5
close a derivative auction*	1	1
sell a stock	3	2
create a new league	n/a	n/a
modify an existing league	n/a	n/a
invite a user to a league	n/a	n/a

Features that are not currently implemented are shown as empty rows and actions that have been added since the original mockups are marked with asterisks. Both these new usage scenarios and existing usage scenarios that were modified are analyzed in detail below. This includes buying and selling stocks because of the lack of league support in the current version of PitFail.

7.6.1 Purchase a Stock

Assume the user wishes to purchase 10 shares of Google stock. The user must:

- **Navigation:** total of one click, as follows
  1. Click on "login".
- **Data Entry:** total of two clicks and seven keystrokes, as follows
  1. Click on the "enter a ticker symbol" text field.
  2. Press the keys "G", "O", "O", and "G".
  3. Press "enter" to load the quote.
  4. Press the keys "1" and "0" to specify 10 shares.
  5. Click the "buy" button to confirm the purchase.

Note that the user could press "enter" instead of clicking the "buy" button.

7.6.2 Creating a Derivative

Assume the user wishes to offer a call option to Bucky that includes 10 shares of Google stock and expires on December 25, 2011. This option costs $1000 to begin active and one can buy the shares for $10,000 if and only if the market rate for Google stock is greater than $1000 per share. The user must:

- **Navigation:** total of one click, as follows

1. Click on “login”.

- **Data Entry:** total of 3 clicks and 27 keystrokes, as follows

  1. Click on the “enter a ticker symbol” text field.
  2. Press the keys “G”, “O”, “O”, and “G”.
  3. Press the “enter” key to load the quote.
  4. Press the keys “1” and “0” to specify 10 shares.
  5. Click the “add” button to begin creating a derivative.
  6. Press the “B”, “u”, “c”, “k”, and “y” keys to enter the recipient’s name.
  7. Press “tab” to move to the “premium” field.
  8. Press the keys “1”, “0”, “0”, and “0” to enter $1000.
  9. Press “tab” to move to the “expiration date” field.
  10. Press the “1”, “2”, “/”, “2”, and “5” keys to select December 25th of the current year.
  11. Press “tab” to move to the “strike price” field.
  12. Press the “1”, “0”, “0”, “0”, and “0” keys to enter $10000.
  13. Click on the “Propose Contract” button to complete the transaction.

7.6.3 Sell a Stock

Assume the user wishes to sell 10 shares of Google stock from his or her Global League. The user must:

- **Navigation:** total of one clicks, as follows

  1. Click on “login”.

- **Data Entry:** total of two clicks and two keystrokes, as follows

  1. Click on the text input in the row corresponding to Google.
  2. Press the keys “1” and “0” to specify 10 shares.
  3. Click the “sell” button to confirm the purchase.

  Note that the user could press “enter” instead of clicking the “sell” button.

7.6.4 Act on Derivative Offer

Assume the user wishes to accept a derivative that was directly offered to him or her:

- **Navigation:** total of one click, as follows

  1. Click on “login”.

- **Data Entry:** total of one click, as follows

  1. Click on the “accept” button next to the correct derivative.

7.6.5 Bid on Derivative

Assume the user wishes to bid $50,000 on a derivative that is being sold in a public auction:

- **Navigation:** total of two clicks, as follows
  1. Click on “login”.
  2. Click on the correct derivative link in the sidebar.
- **Data Entry:** total of two clicks and five keystrokes, as follows
  1. Click on the “your bid” field.
  2. Press the keys “5”, “0”, “0”, 0“, and ”0“.
  3. Click the ”Cast Bid“ button.

7.6.6 Close Derivative Auction

Assume the user wishes to close an auction that he or she posted:

- **Navigation:** total of one click, as follows
  1. Click on ”login“.
- **Data Entry:** total of one click, as follows
  1. Click on the ”close“ button next to the correct auction.

8 Progress Report and Plan of Work

8.1 Progress Report

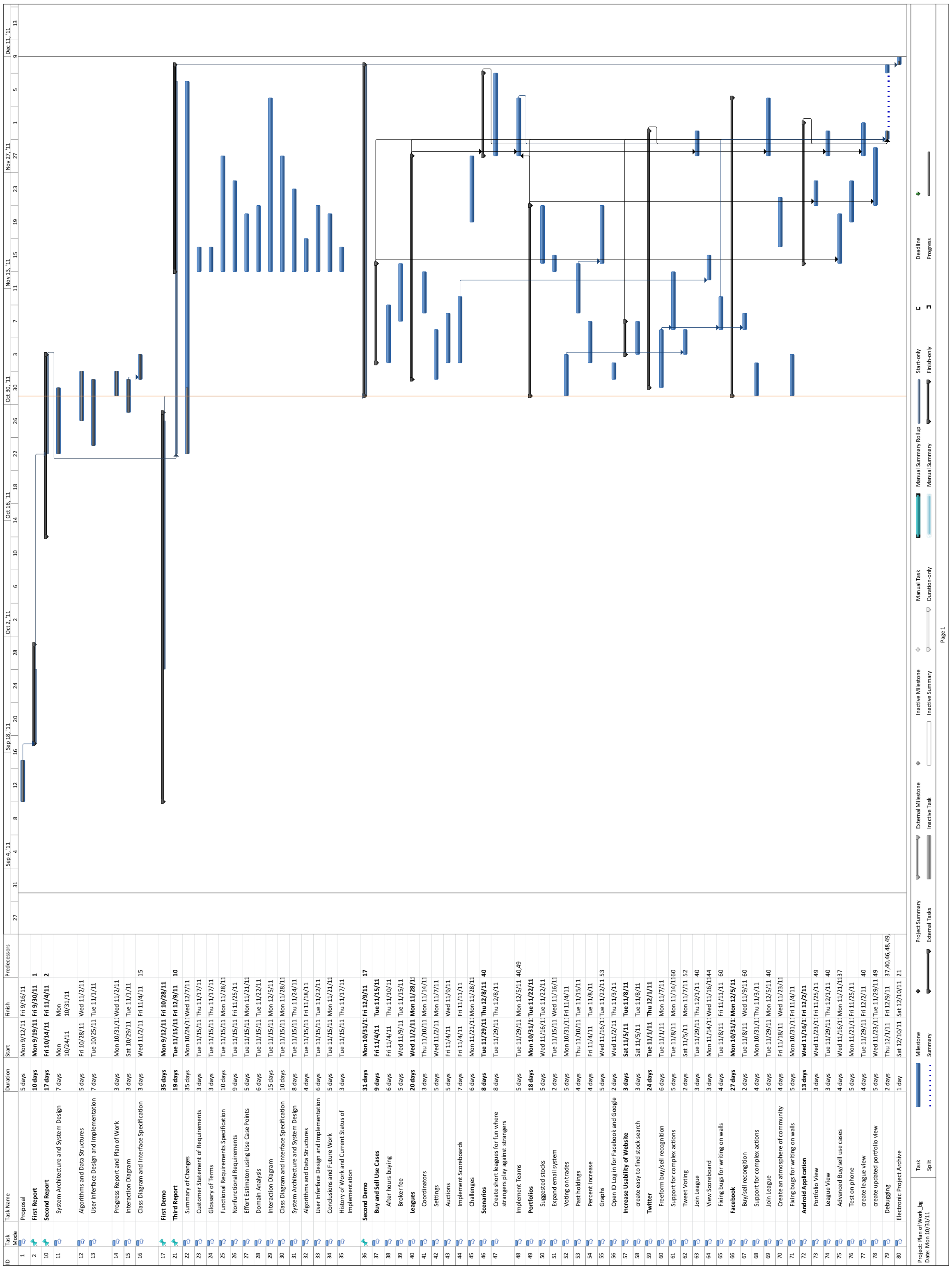
All use cases still need more implementation to allow for increased functionality. In particular, Leagues and Teams need to be implemented while the actual interactions with the stock exchange need to expand to address exceptions usability requirements.

UC#	Use Case Short Name	% Completed	Comments
UC-1	Buy	50%	Functionality needs to be increased and made uniform across varying interfaces. Smaller details like after hours buying, orders, and brokerage fees need to be added.
UC-2	Sell	50%	Functionality needs to be increased and made uniform across varying interfaces. Smaller details like after hours selling, orders, and brokerage fees need to be added.
UC-3	Join League	0%	Leagues have not been implemented yet.
UC-4	View Portfolio	75%	Current portfolios can be viewed, but this use case will be expanded when a portfolio will need to hold more items.
UC-5	Get Security	50%	Needs more functionality, like Buy and Sell.
UC-6	View League Stats	0%	Leagues have not been implemented yet.

... continued on next page

UC#	Use Case Short Name	% Completed	Comments
UC-7	Buy via Twitter	60%	Users can buy only stocks according to a strict input guidelines. There are some bugs that need to be fixed.
UC-8	Sell via Twitter	60%	Users can sell only stocks according to a strict input guidelines. There are some bugs that need to be fixed.
UC-9	Portfolio Info	75%	Users can see other user's portfolios, but additional information should be displayed, e.g. graphs, creation date, percent increased...
UC-10	Change Default	0%	Leagues have not been implemented yet.
UC-11	Make League	0%	Leagues have not been implemented yet.
UC-12	League Settings	0%	Leagues have not been implemented yet.
UC-13	Add Coordinator	0%	Leagues have not been implemented yet.
UC-14	Remove Coordinator	0%	Leagues have not been implemented yet.
UC-15	Delete League	0%	Leagues have not been implemented yet.
UC-16	Manage League	0%	Leagues have not been implemented yet.
UC-17	Invite to League	0%	Leagues have not been implemented yet.
UC-18	Authentication	75%	Currently done through Twitter, will need to be increased for additional logins.
UC-19	Create User	75%	Users can be created only if they have a Twitter account.
UC-20	Vote	0%	Voting has not been implemented yet.
UC-21	Vote by Tweet	0%	Voting has not been implemented yet.
UC-22	Derivative Designer	25%	Partially implemented, but not lacks important functionalities and an intuitive design.
UC-23	Accept derivative	75%	Basic functionality is present. Need to expand to allow counter-offers and to be updated for newer versions of the implemented derivatives.

8.2 Plan of Work



8.3 Breakdown of Responsibilities

Modules	**Owner**
Website	Michael, Owen
Android	Roma, Sonu
Facebook	Avanti, Sonu
Twitter	Cody
Database	Brian
Back-end Functions	Michael, Owen, Brian

The integration of the system and testing will not require a primary coordinator. Since each module relies on only the database and back-end functions and is independent of the other modules, the chances of one module affecting the others are low. Each auxiliary module developer is responsible for communicating with the database and back-end functions developers to ensure their code is using the database and back-end functions correctly. During team meetings, the features being employed on each auxiliary module will be discussed to ensure that common features are being deployed across all systems. Testing will be the responsibility of each module developer.

9 References

Marsic, Ivan. *Software Engineering.* Piscataway: Rutgers University, 2011. PDF. Miles, Russ and Kim Hamilton. *Learning UML 2.0.* Ed. Eric McLaughlin and Mary O'Brien. Sebastopol: O'Reilly, 2006.

`http://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol`

`http://en.wikipedia.org/wiki/Java_Database_Connectivity`