Bills of Material Replace Material Recommendation System

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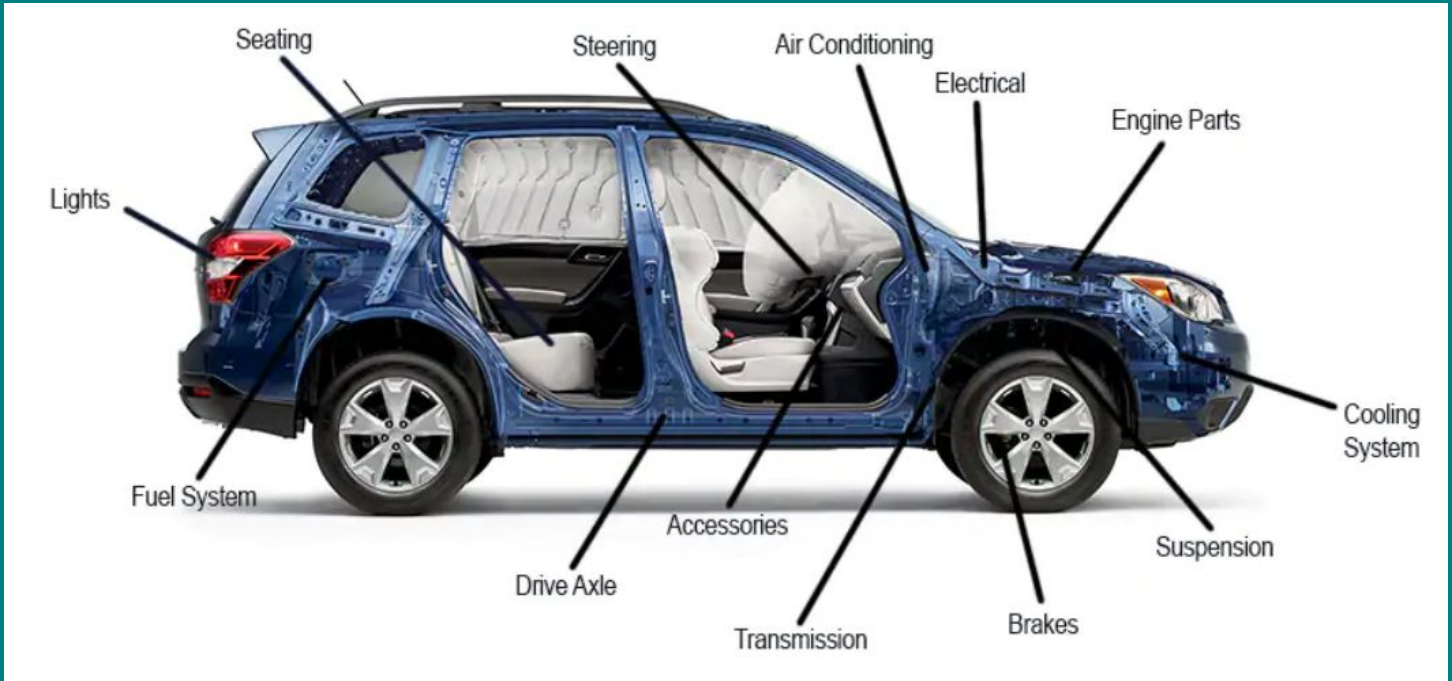
What is “Bills of Material“ ?



Agenda for Presentation

1. Overview of the existing system
2. Requirement Analysis
3. Scope
4. Software Engineering Model
5. System Architecture – Model, View, Controller
6. Progress so far

Problem

1. Manufacturing Industry constantly replace materials used in their products.

2. Solutions for ‘Change Management’ are either expensive or do not consider all the parameters that contribute for the best replacement

3. Existing solutions are not scalable or system independent.

Existing Solution

1. Considers 3 parameters: Stock, Availability and Location
2. Naive Implementation with basic selects and manual logic for best recommandation
3. No Machine Learning techniques incorporated for premium recommendation
4. Not scalable and on premise solutions per industry

Requirement Analysis

1. The system should be able to suggest recommendations that may be a suitable alternative.

2. The system should help the user complement his domain expertise in choosing the best replacement.

3. Optional extras:
    - Provide UI for demonstration purposes

Scope

1. Build a recommendation system for the replace materials in BOMs using a machine learning approach

2. Approach includes feature engineering and evaluating against test data

3. Experiment with different machine learning algorithms such as Logistic Regression, Naive Bayes, Support Vector Machines, Bagged Decision Trees and Deep Learning.

Software Engineering Model

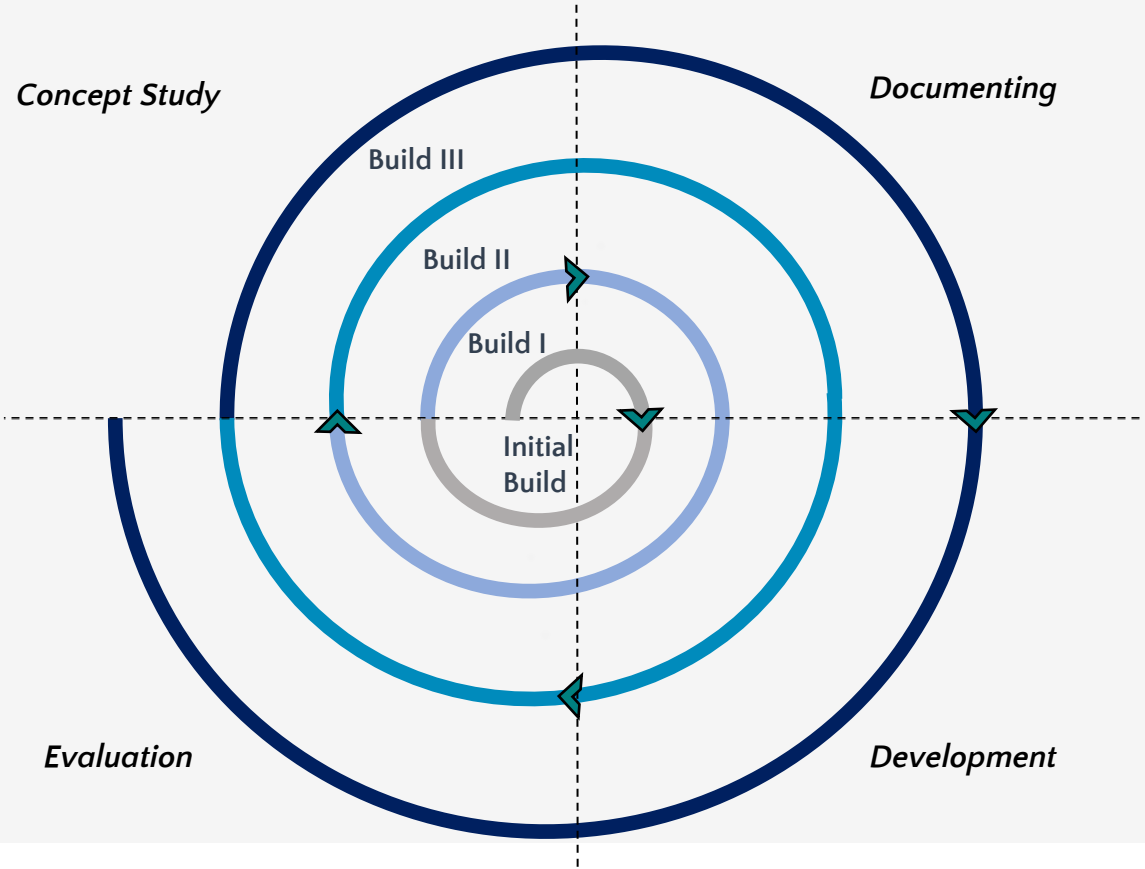
Agile

+

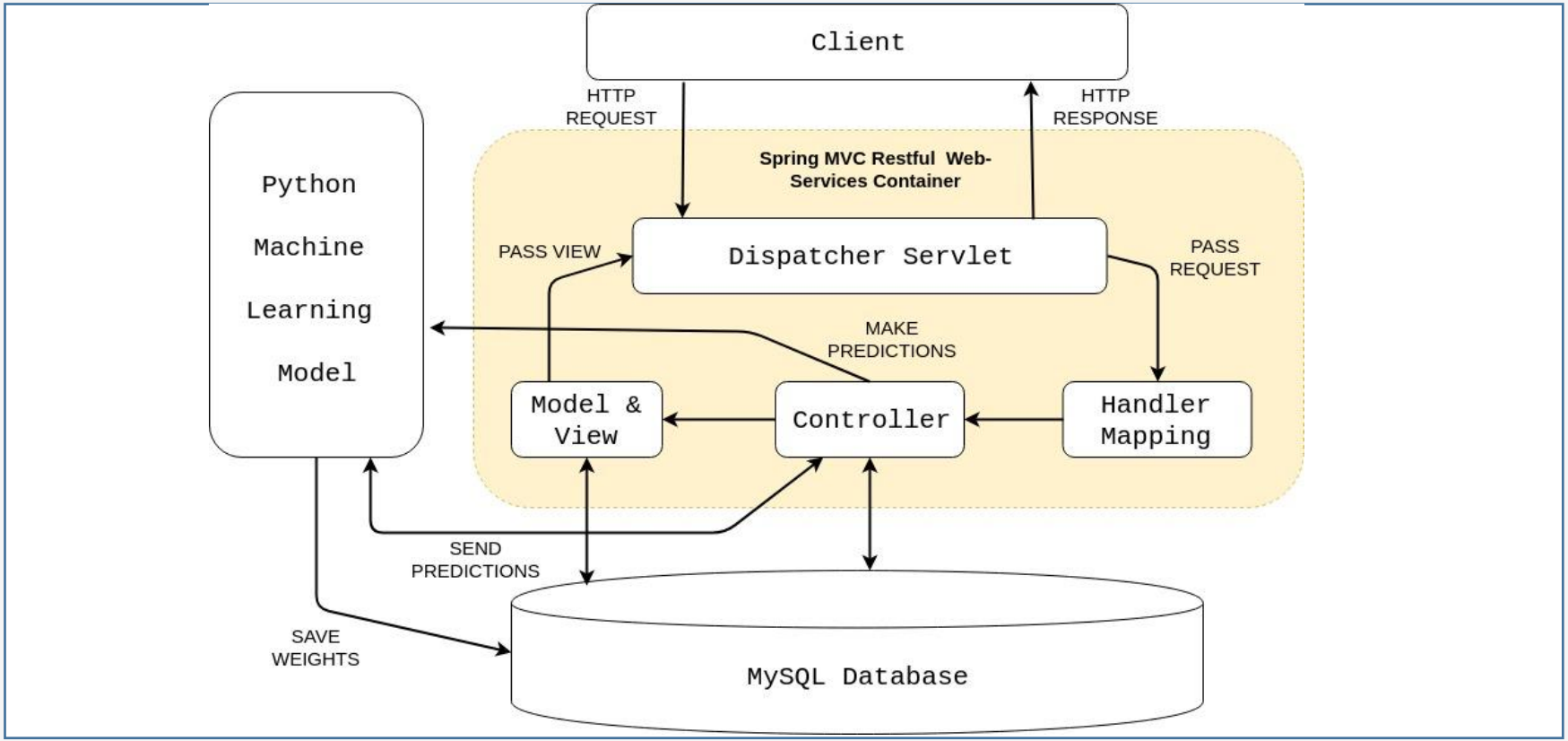
Iterative

Refinement

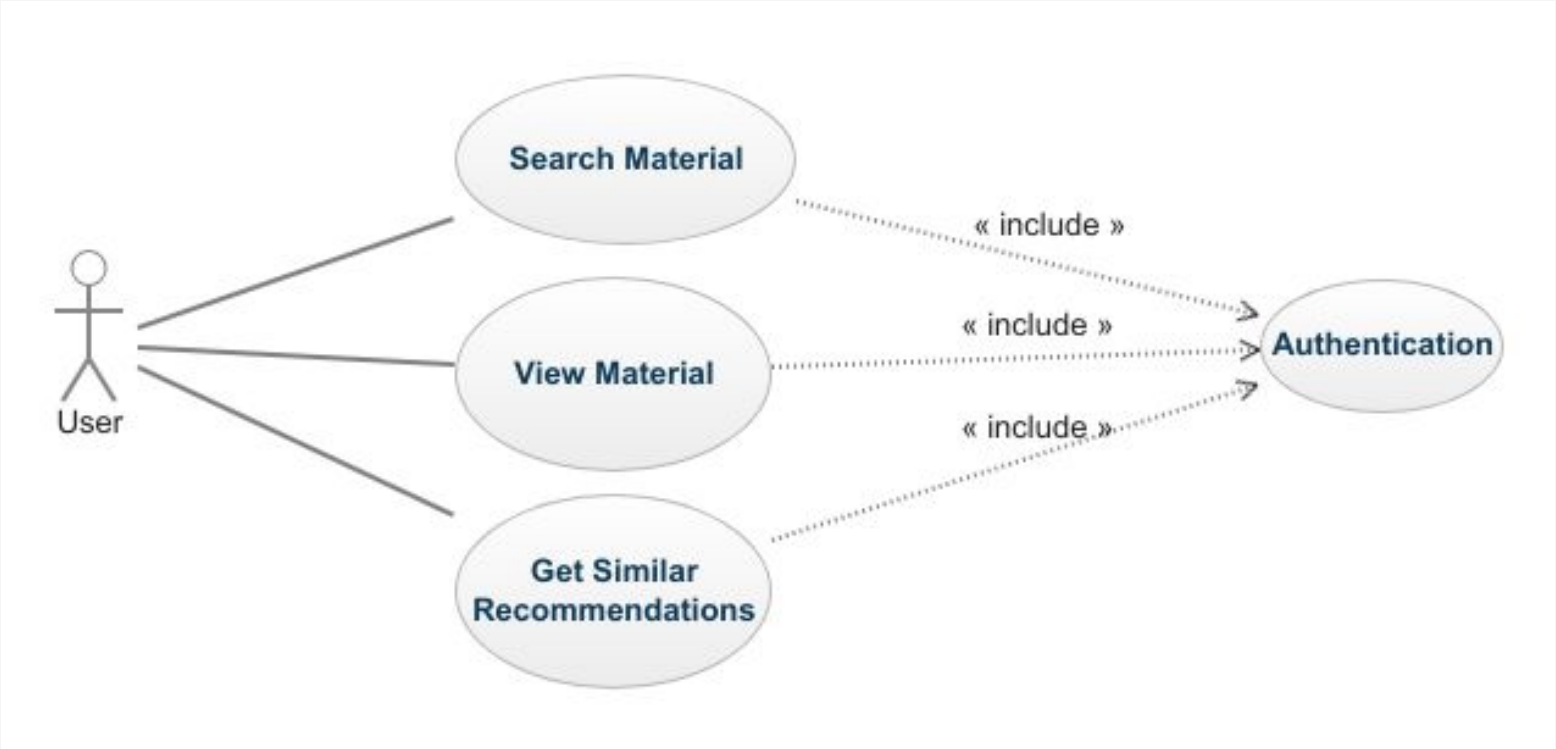
Link to meeting notes.



Overall Pipeline



Use Case Diagram

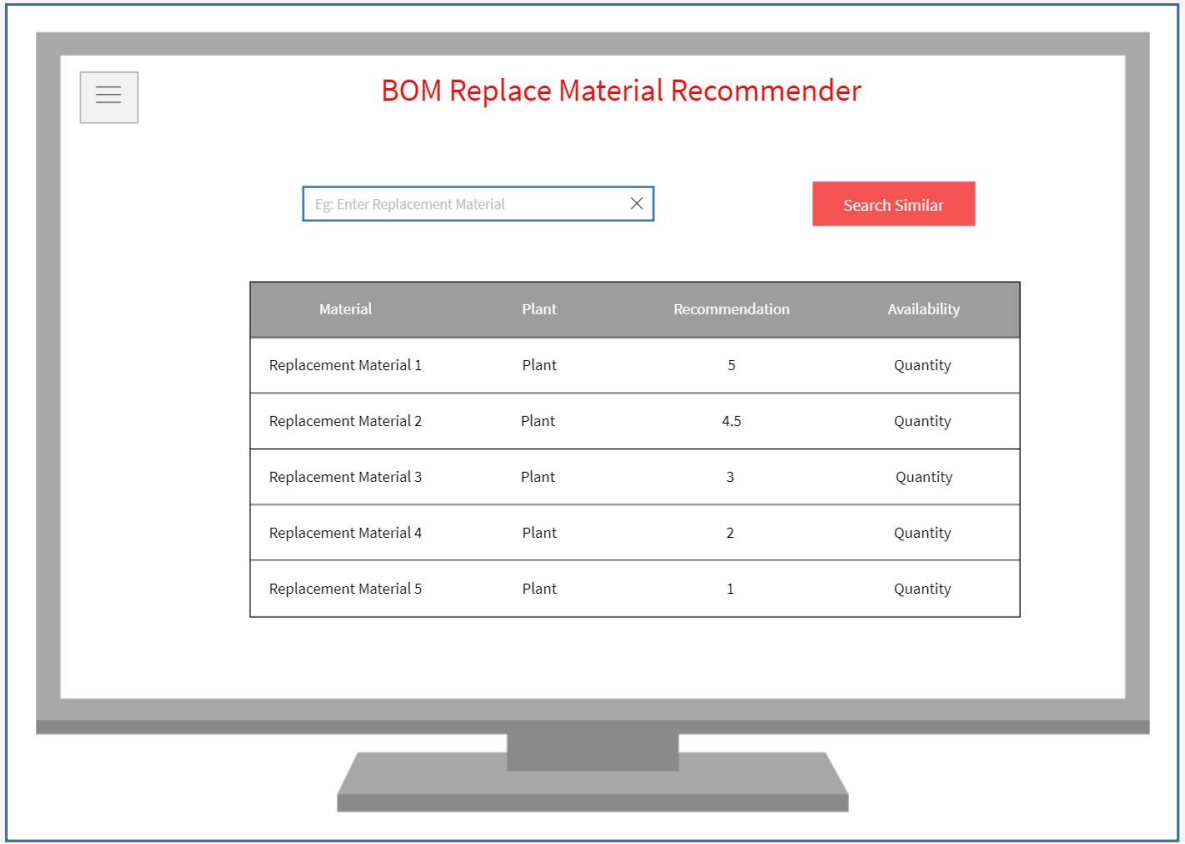


User Interface - View

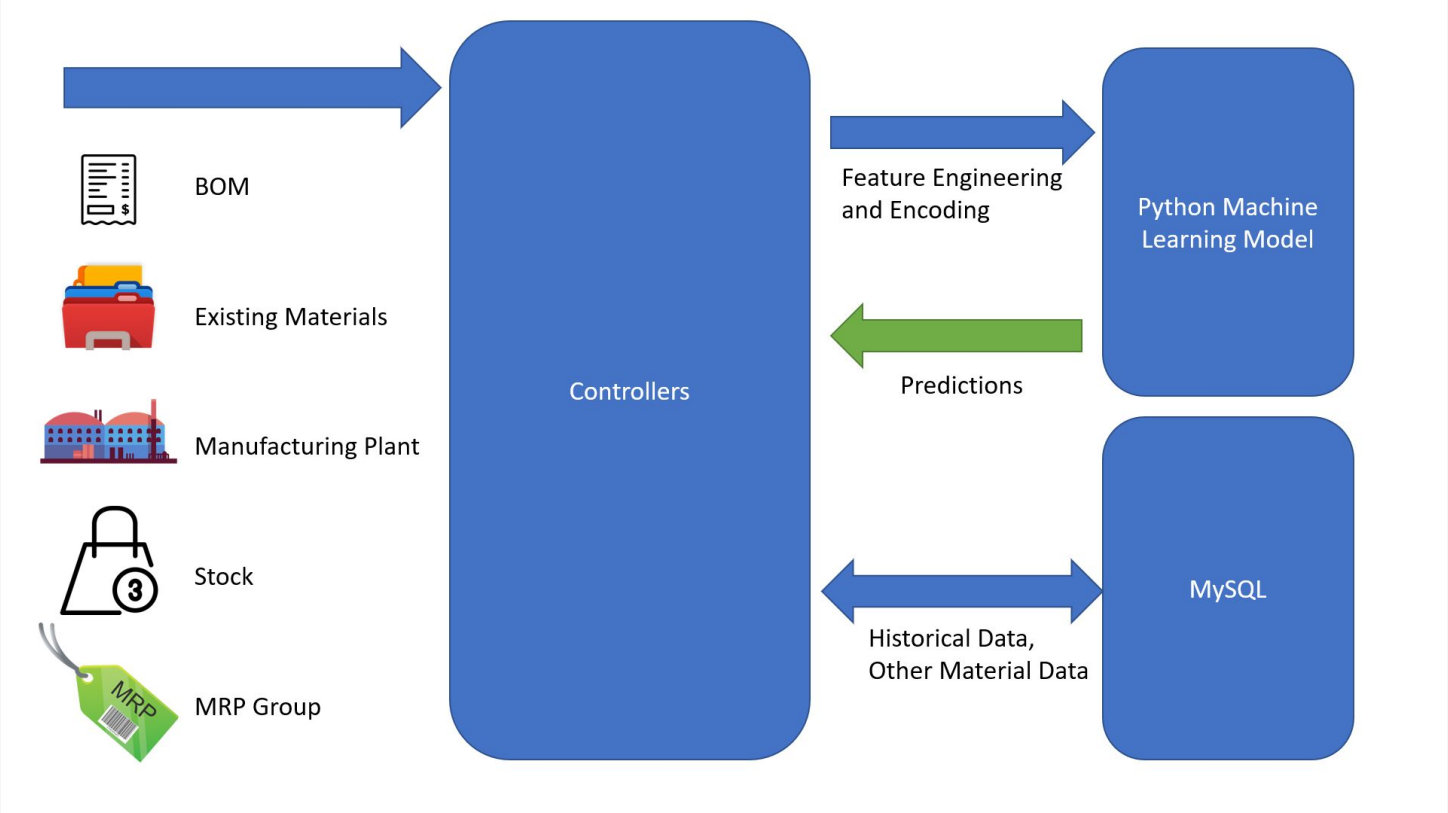
Design Principles Used:

1. Minimal
2. Familiar
3. Simple to use

https://wireframepro.mockflow.com/view/M093b7fbee22910a00a75fc8db4ab45ad1551833172836

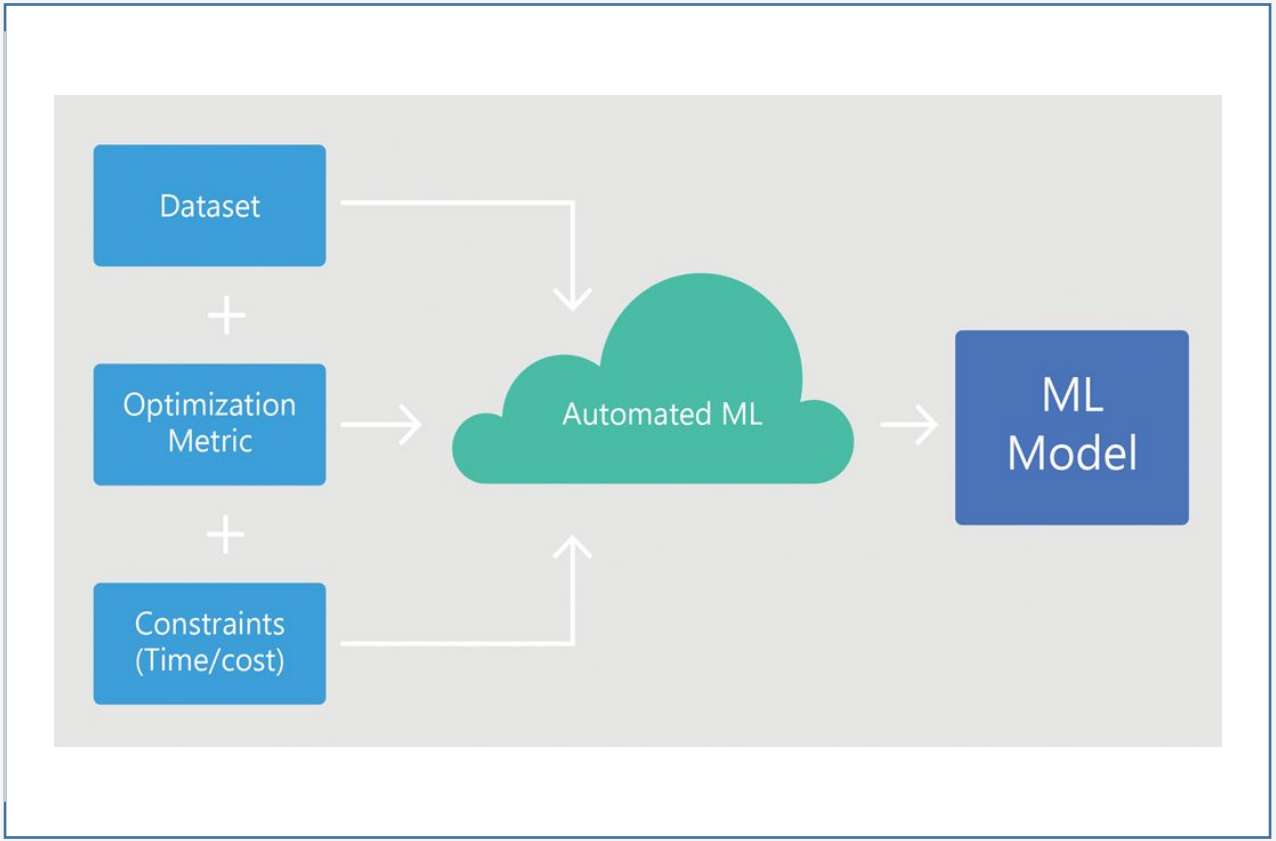


Controller

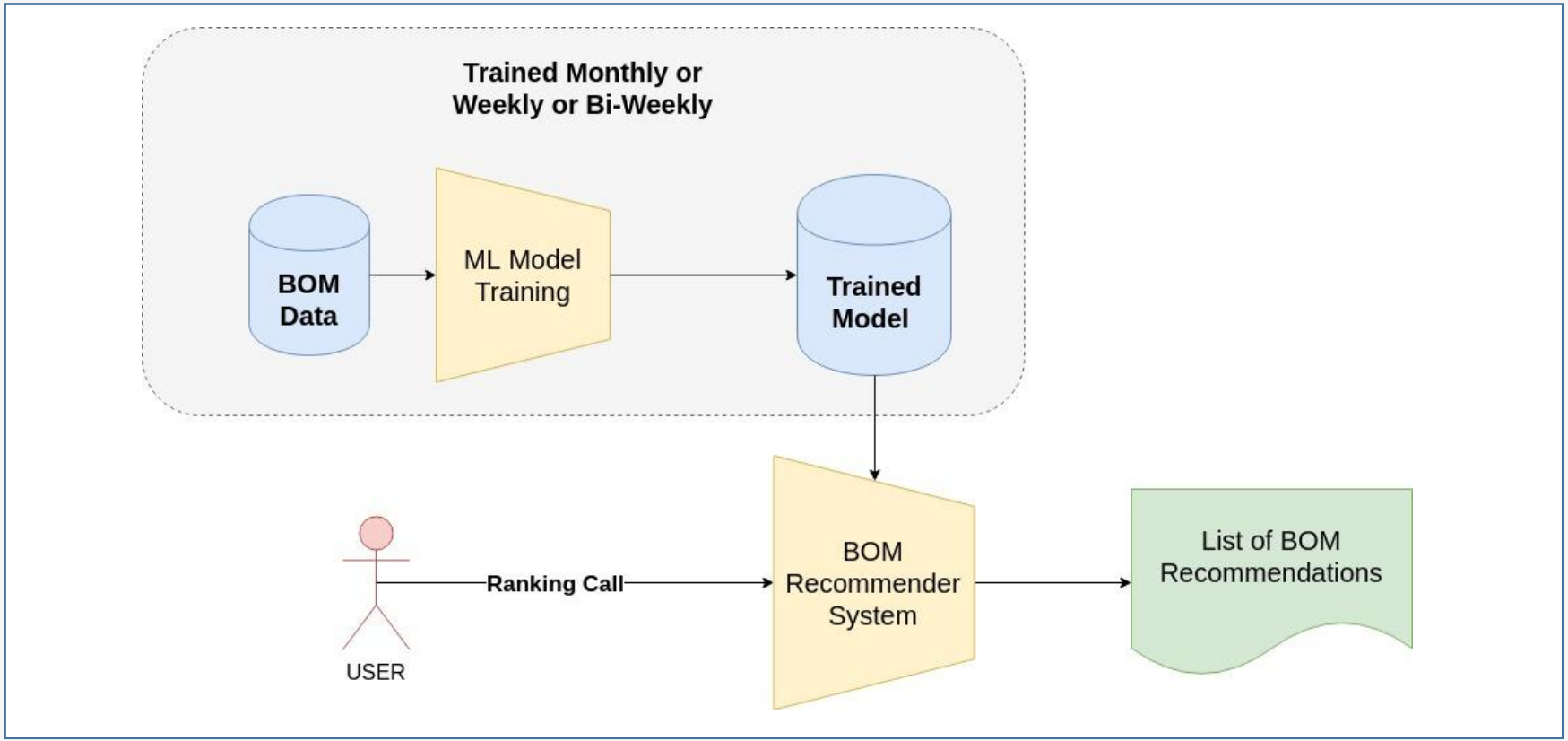

BOM
Existing Materials
Manufacturing Plant
Stock
MRP Group
MRP
Controllers
Feature Engineering and Encoding
Predictions
Historical Data, Other Material Data
Python Machine Learning Model
MySQL

Machine Learning Pipeline - Conventional Design

1. 3 Step Pipeline
2. Most often used



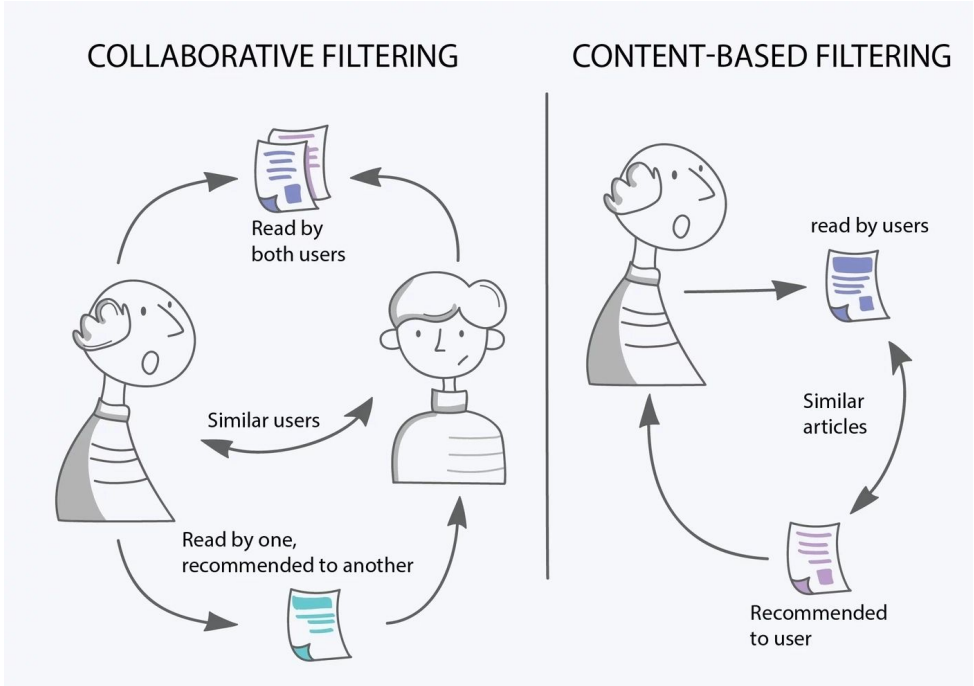
BOM Recommender ML Design



Collaborative Filtering (Content Based)

Characteristics:

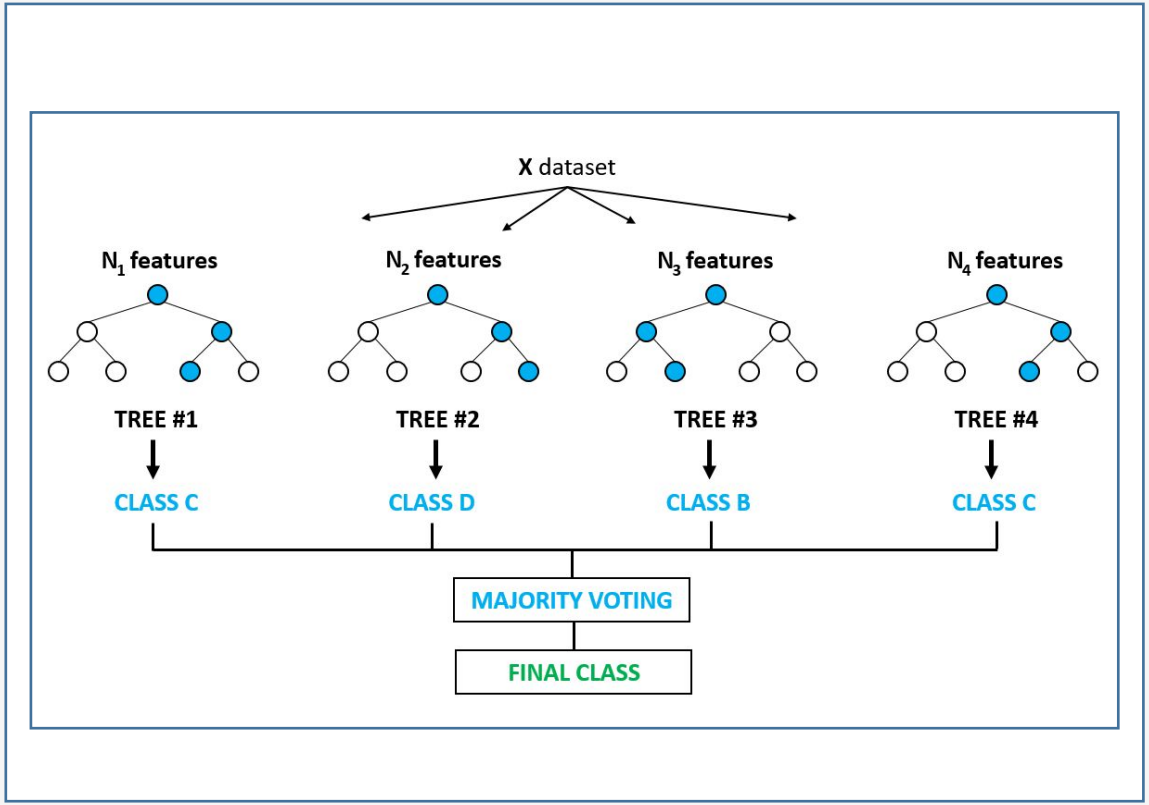
1. Cosine Similarity
2. Check Scores
3. Higher score, better recommendation



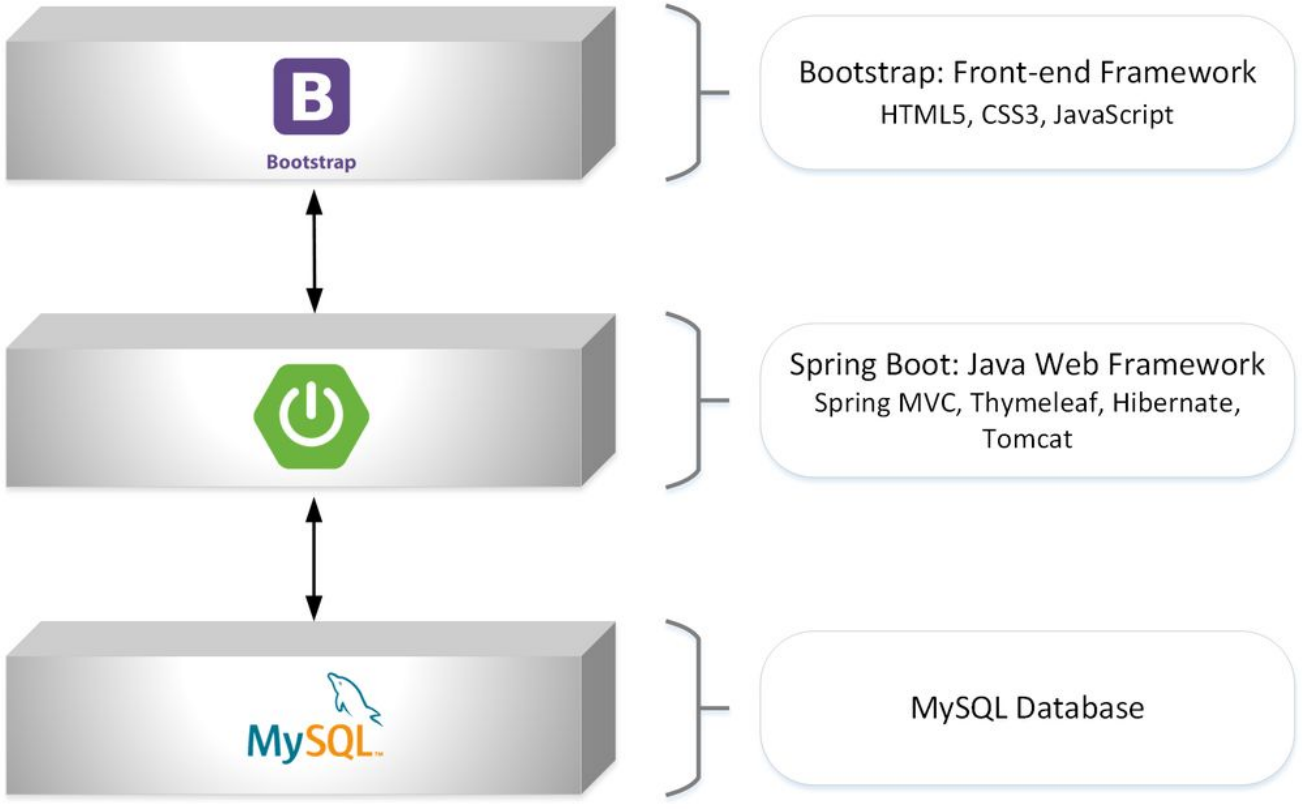
Random Forest

Steps Involved:

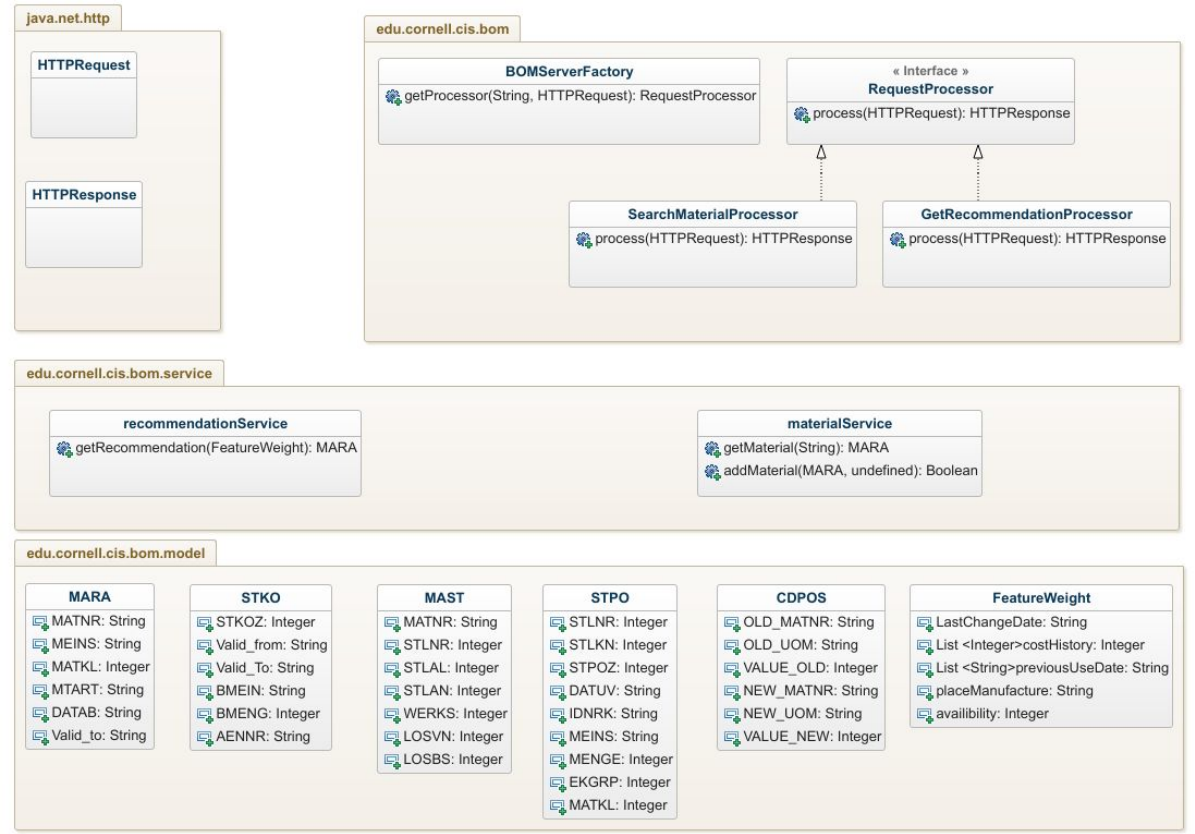
1. Bootstrap Sampling
2. Training models
3. Bootstrap Aggregating



Technology Stack



UML Diagram


java.net.http
HTTPRequest
HTTPResponse
edu.cornell.cis.bom
BOMServerFactory
getProcessor(String, HTTPRequest): RequestProcessor
« Interface »
RequestProcessor
process(HTTPRequest): HTTPResponse
SearchMaterialProcessor
process(HTTPRequest): HTTPResponse
GetRecommendationProcessor
process(HTTPRequest): HTTPResponse
edu.cornell.cis.bom.service
recommendationService
getRecommendation(FeatureWeight): MARA
materialService
getMaterial(String): MARA
addMaterial(MARA, undefined): Boolean
edu.cornell.cis.bom.model
MARA
MATNR: String
MEINS: String
MATKL: Integer
MTART: String
DATAB: String
Valid_to: String
STKO
STKOZ: Integer
Valid_from: String
Valid_To: String
BMEIN: String
BMENG: Integer
AENNR: String
MAST
MATNR: String
STLNR: Integer
STLAL: Integer
STLAN: Integer
WERKS: Integer
LOSVN: Integer
LOSBS: Integer
STPO
STLNR: Integer
STLKN: Integer
STPOZ: Integer
DATUV: String
IDNRK: String
MEINS: String
MENGE: Integer
EKGRP: Integer
MATKL: Integer
CDPOS
OLD_MATNR: String
OLD_UOM: String
VALUE_OLD: Integer
NEW_MATNR: String
NEW_UOM: String
VALUE_NEW: Integer
FeatureWeight
LastChangeDate: String
List <Integer>costHistory: Integer
List <String>previousUseDate: String
placeManufacture: String
availibility: Integer

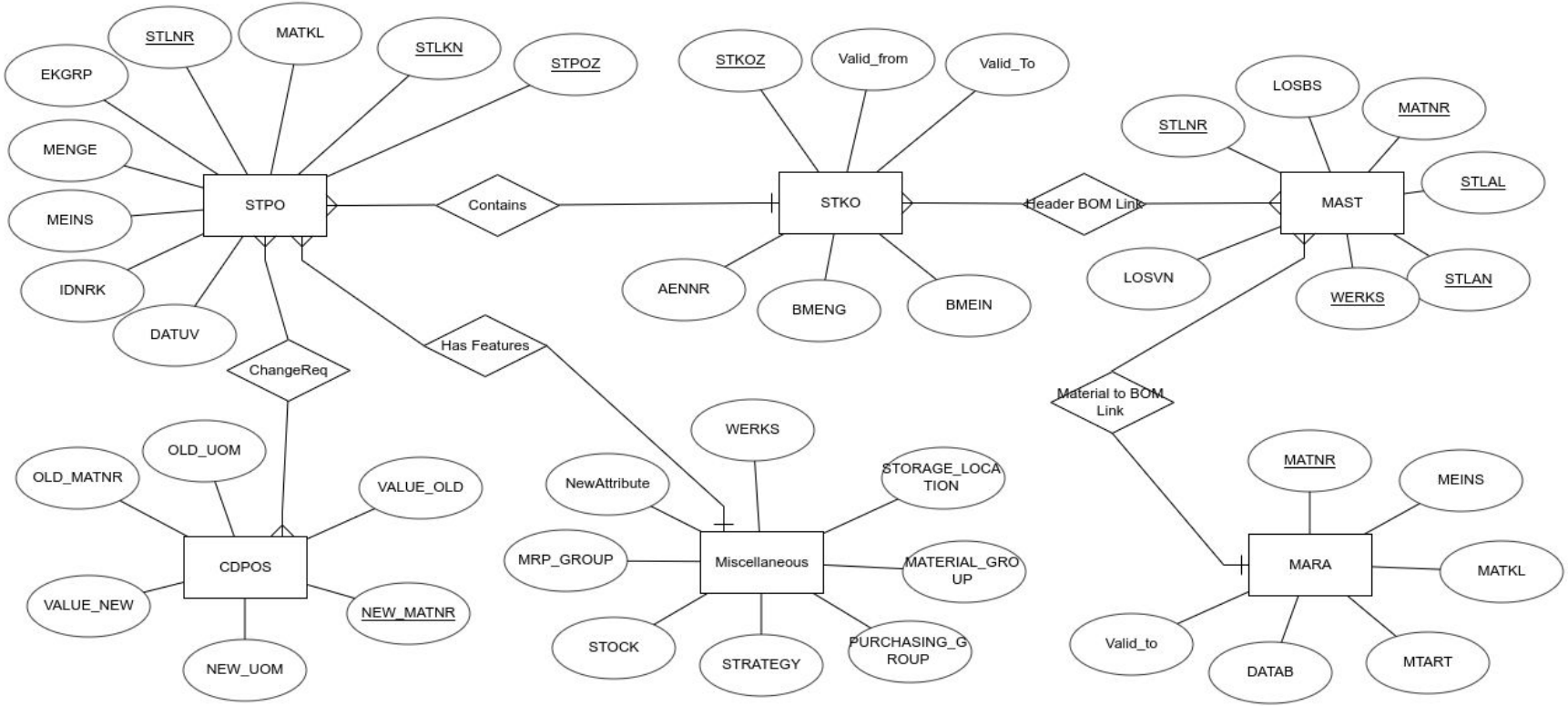
Data Modelling

- We model the data in the form of 6 proprietary tables and 1 intermediate table.
- Each of the 6 tables just contain attributes which are important to our use case only.
- We are implementing this database in the form of MySQL server version 5.7.0
- We are using some mock data (relevant to our use case) for the purpose of development.

Tables Overview

- MARA: Material table and its properties.
- MAST: Relationship between material and BOM.
- STKO: Details of headers.
- STPO: Details of items & parameters for items.
- CDPOS: Historic Information about items and replacements.
- MISC: Additional properties of materials

ER Diagram


STLNR
MATKL
STLKN
STPOZ
EKGRP
MENGE
MEINS
IDNRK
DATUV
STPO
Contains
STKOZ
Valid_from
Valid_To
STKO
AENNR
BMENG
BMEIN
Header BOM Link
LOSBS
MATNR
STLNR
STLAL
MAST
LOSVN
WERKS
STLAN
ChangeReq
Has Features
Material to BOM Link
OLD_UOM
OLD_MATNR
VALUE_OLD
CDPOS
VALUE_NEW
NEW_MATNR
NEW_UOM
WERKS
NewAttribute
STORAGE_LOCATION
MRP_GROUP
Miscellaneous
MATERIAL_GROUP
STOCK
STRATEGY
PURCHASING_GROUP
MATNR
MEINS
MARA
MATKL
Valid_to
DATAB
MTART

Model Example

- Bills of Material structure
  - List of materials needed to manufacture item
    - Header: Car
    - Item 1: Wheels
    - Item 2: Engine
    - Item 3: Battery
- 7 Tables

Table 1: MARA

MATNR	Material Name	Car
MEINS	Unit of measure	EA (each)
MATKL	Material group	000000001 (9 digit #)
MTART	Material Type	FERT (finished product)
DATAB	Valid from Date	02-02-2019
Valid_To	Valid to date	20-02-2019

Table 2: MAST

MATNR	Material Name	Car
STLNR	Bill of Material	000000005 (same as BOM)
STLAL	Alternative BOM	01
STLAN	BOM Usage	01
WERKS	Plant	0001
LOSVN	From lot size	0
LOSBS	To lot size	100

Table 3: STKO

STLNR	Bill of Material	000000005 (same as BOM)
STKOZ	Unique identifier for table (primary keys)	00000001
DATUV	Date from which item is valid	02-02-2019
Valid_To	Date until item is valid	05-02-2019
BMEIN	Unit of measure (EG kg or lb)	KG
BMENG	Quantity in unit of measure given by BMein	10
AENNR	Change #, for replacement	CHANGE_10

Table 4: STPO

STLNR	Bill of Materials	00000005 (Same as BOM)
STLKN	BOM Item Node Number	00000034
STPOZ	Internal Counter	00000007
DATUV	Valid from date	05-02-2019
IDNRK	Name of Item	ENGINE
MEINS	Unit of Measure	EA
MENGE	Quantity	10

Table 4: STPO (Continued)

EKGRP	Purchasing Group	00000001
MATKL	Material Group	00000001

Table 5: CDPOS

OLD_MATNR	Old BOM Material Number	VISIBLE_V8_ENGINE
OLD_UOM	Unit of measure	KG
VALUE_OLD	Quantity of old material	20
NEW_MATNR	BOM Material Number	HAYNES_V8_ENGINE
NEW_UOM	Unit of measure	KG
VALUE_NEW	Quantity of new material	20
AENNR	Change #, for replacement	CHANGE_10

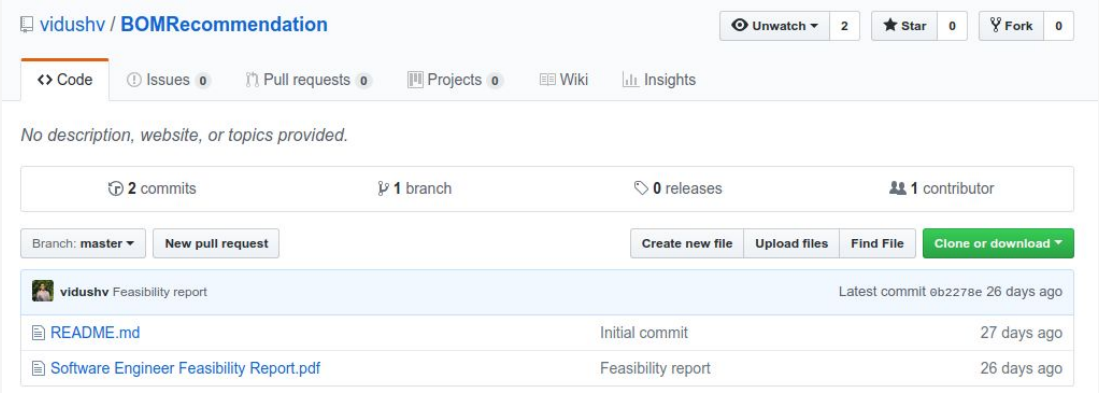
Table 6: Miscellaneous

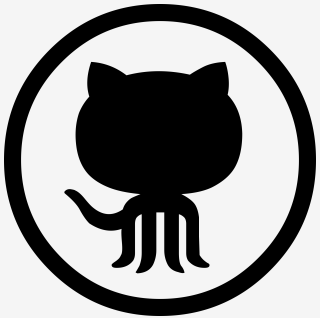
WERKS	Plant	0001
STORAGE_LOCATION	Place where item is stored	1010(Unique Location)
MATERIAL_GROUP	A particular group to which it belongs	00000001
PURCHASING_GROUP	A particular group to which it belongs while purchasing	0001
STRATEGY	Decision of Make-to-Stock/ Make-to-Order	10/20
STOCK	Available Quantity per plant	50
MRP_GROUP	A particular group of MRP to which it belongs	0001

Table 7: Intermediate Table

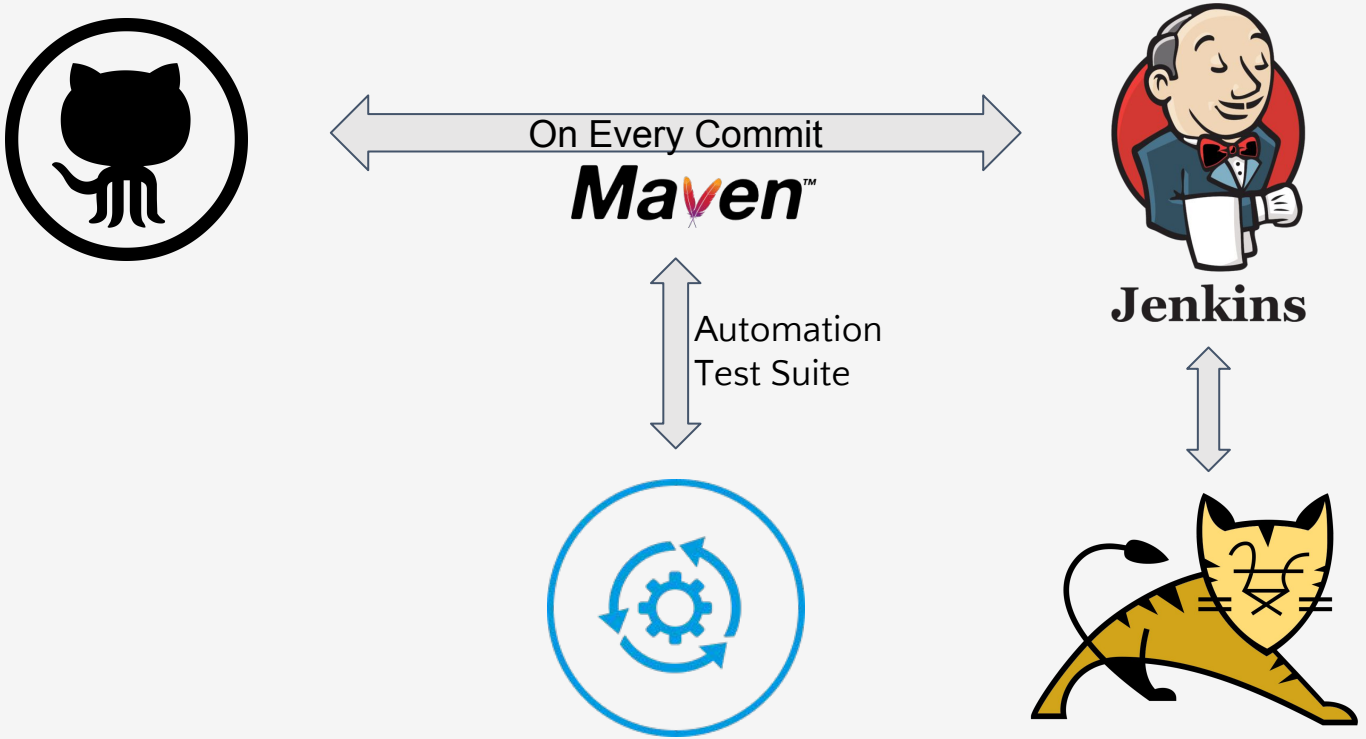
- Feature weights.
- Updated as part of batch jobs.
- Feature engineering is performed daily.

Version Control & Source Code





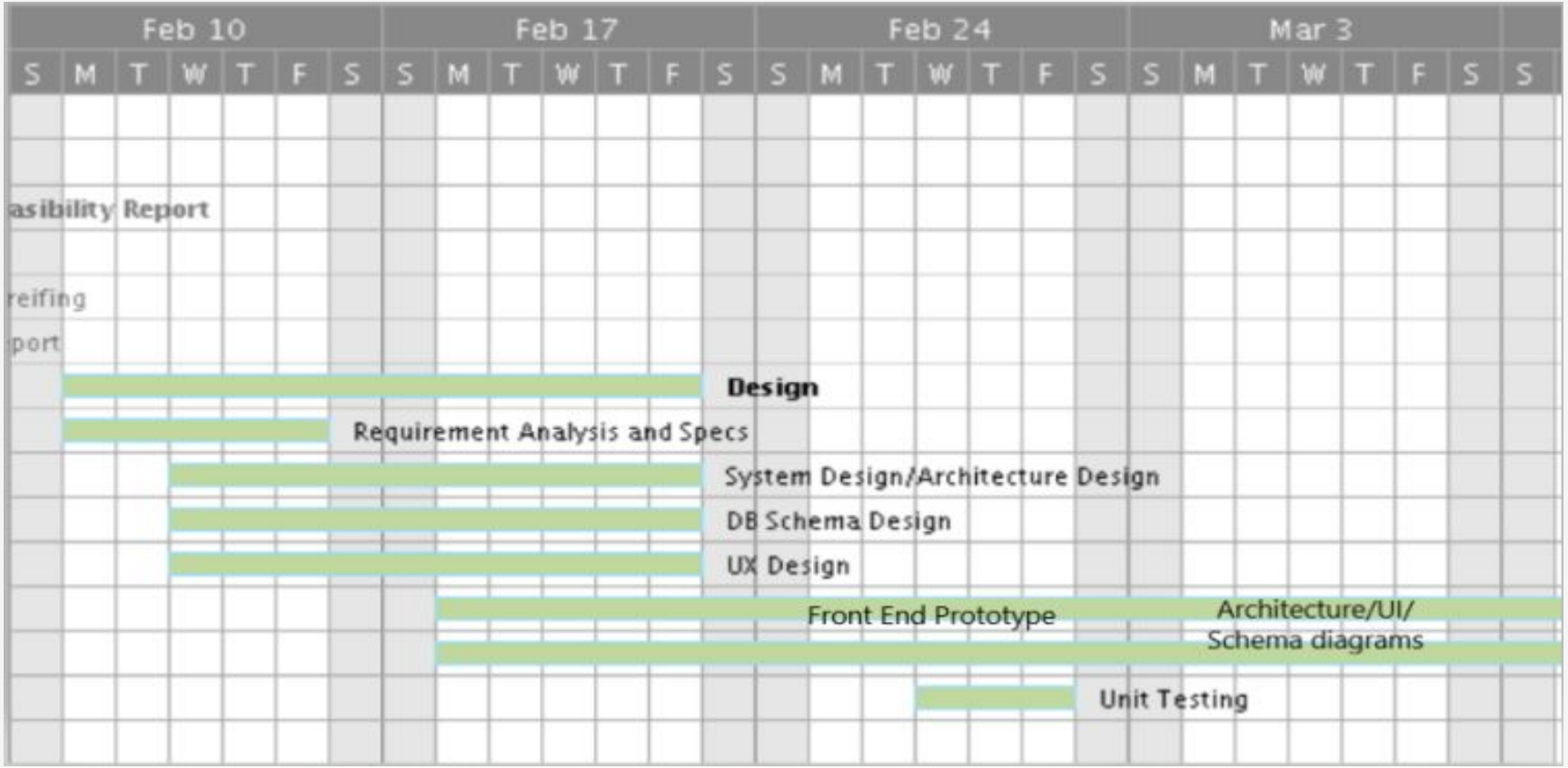
Deployment and Continuous Integration



What is done?

- Requirement Analysis and Steps
- System Design/Architecture Design
- DB Schema Design
- UX Design
- Front-End prototype for feedback
- Unit Testing for prototype is basic evaluation of screen navigation between pages.

Timeline


Feb 10
Feb 17
Feb 24
Mar 3
S M T W T F S S M T W T F S S M T W T F S S M T W T F S S
asibility Report
reifing
port
Design
Requirement Analysis and Specs
System Design/Architecture Design
DB Schema Design
UX Design
Front End Prototype
Architecture/UI/
Schema diagrams
Unit Testing

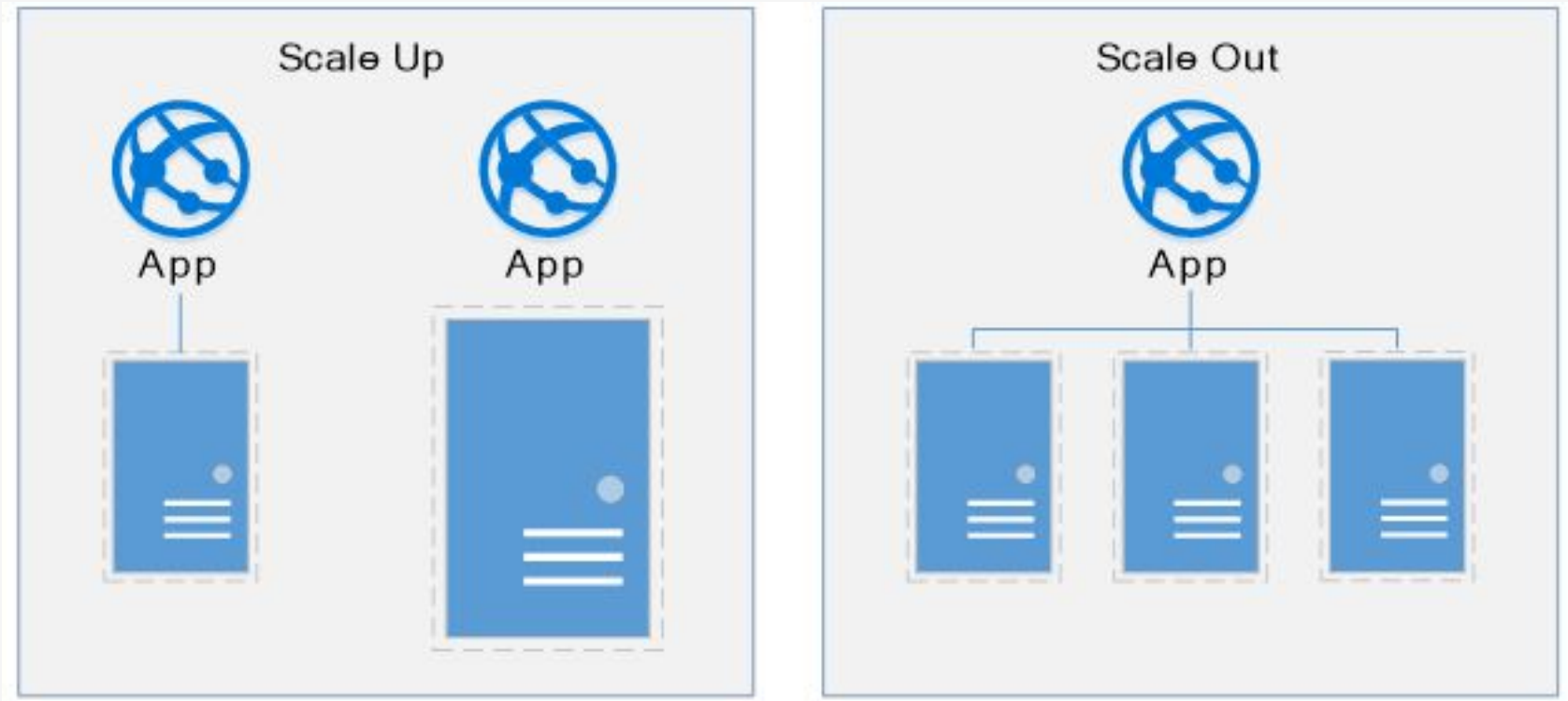
Next Steps - Development

- Development
  - First Iteration of Database development
  - Simultaneous ML model initiation
  - Full stack basic implementation
- Front end unit testing
  - Low priority as the Client clarified that front end is not required.
  - Would be integrated with existing solution

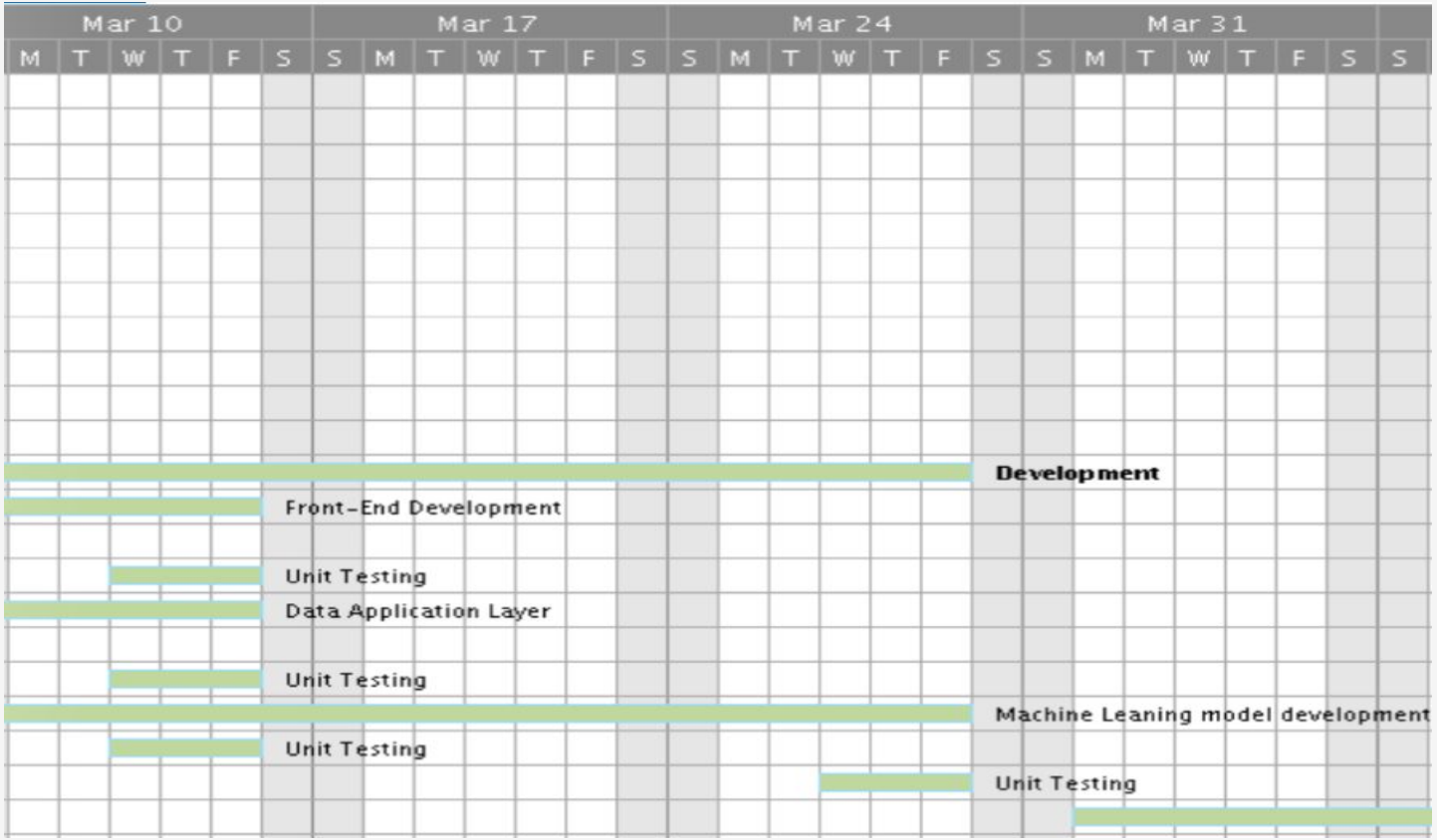
Next Steps - Testing

- Unit Testing
  - Front End Unit Testing every commit
  - Backend Unit Testing every commit
  - ML model will take shape after the basic foundation. No unit testing for next cycle.

Scalability - Future



Next Steps - Timeline



Questions?

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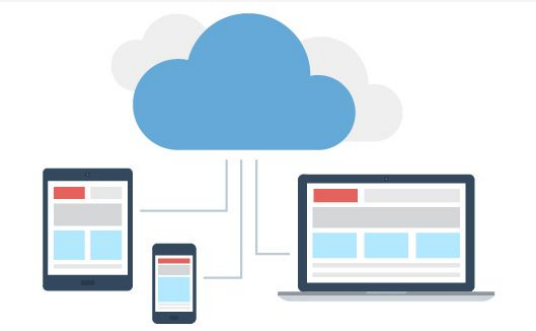
Thank You

Clients: Abhijnan Saha, Rajiv Kumar
Professor: William Y Arms
Teaching Assistant: Alison Cooper

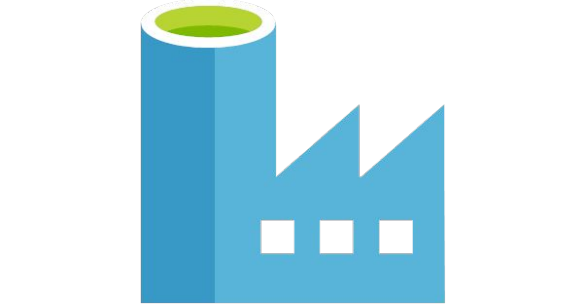
Why we made what we made

- Why Cloud?



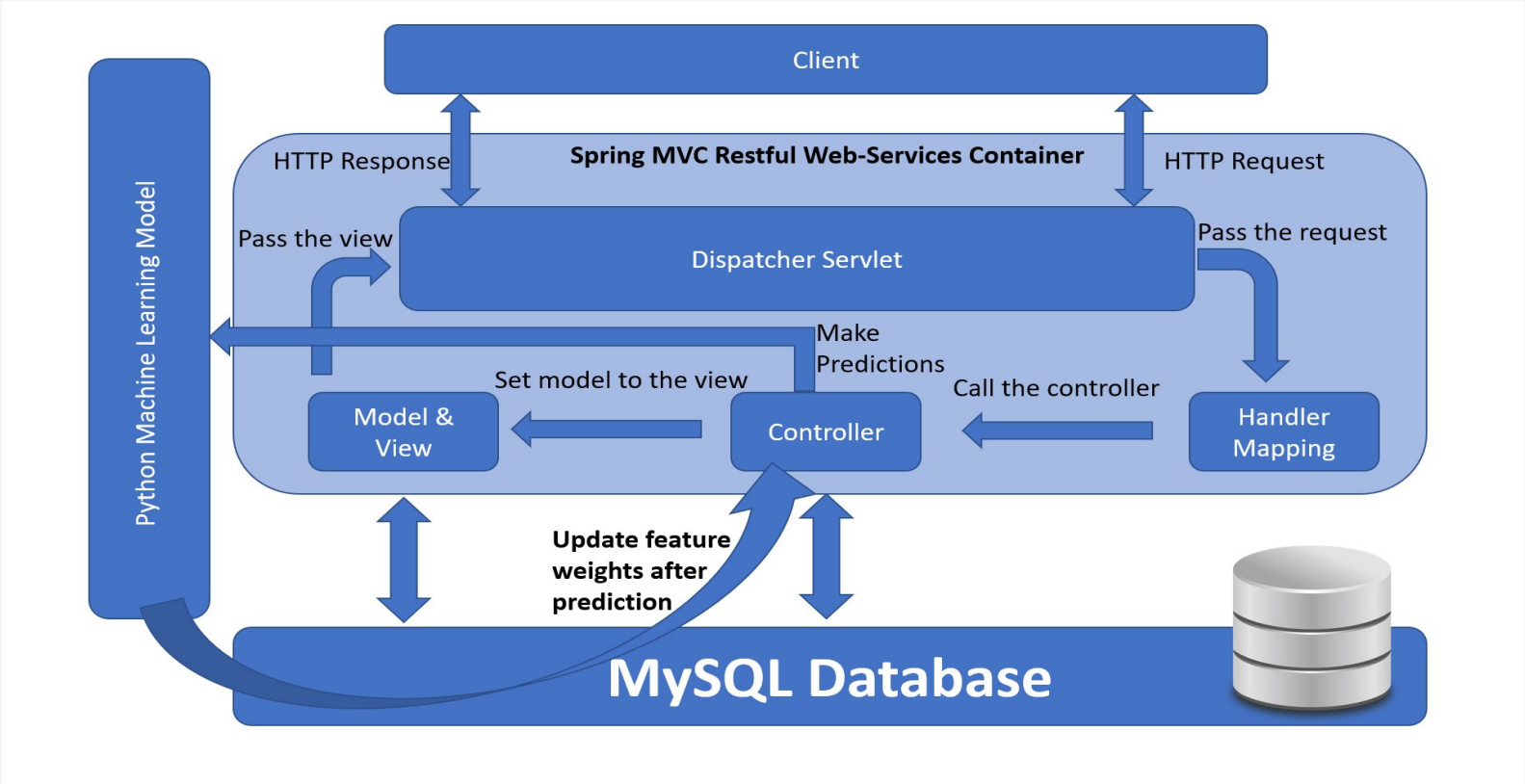
1. Cloud gifts us everything we have ever desired! Computing power, storage, scaling beyond boundaries…

- Has it not been done before?



2. It has been, but as a Proof of Concept and not full fledged Industry solution…

Overall Pipeline



Context

1. We want a critical foundation for the product processes by bringing the entire, complex product record — mechanical, electrical, software, and firmware — together in a single system.

2. Eliminate product and quality silos to improve quality management, requirements management, and issue resolution by connecting product processes directly to the product record.