Carnegie Mellon University

14-763/18-763
Systems and Toolchains for AI Engineers

FALL 2025

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Agenda

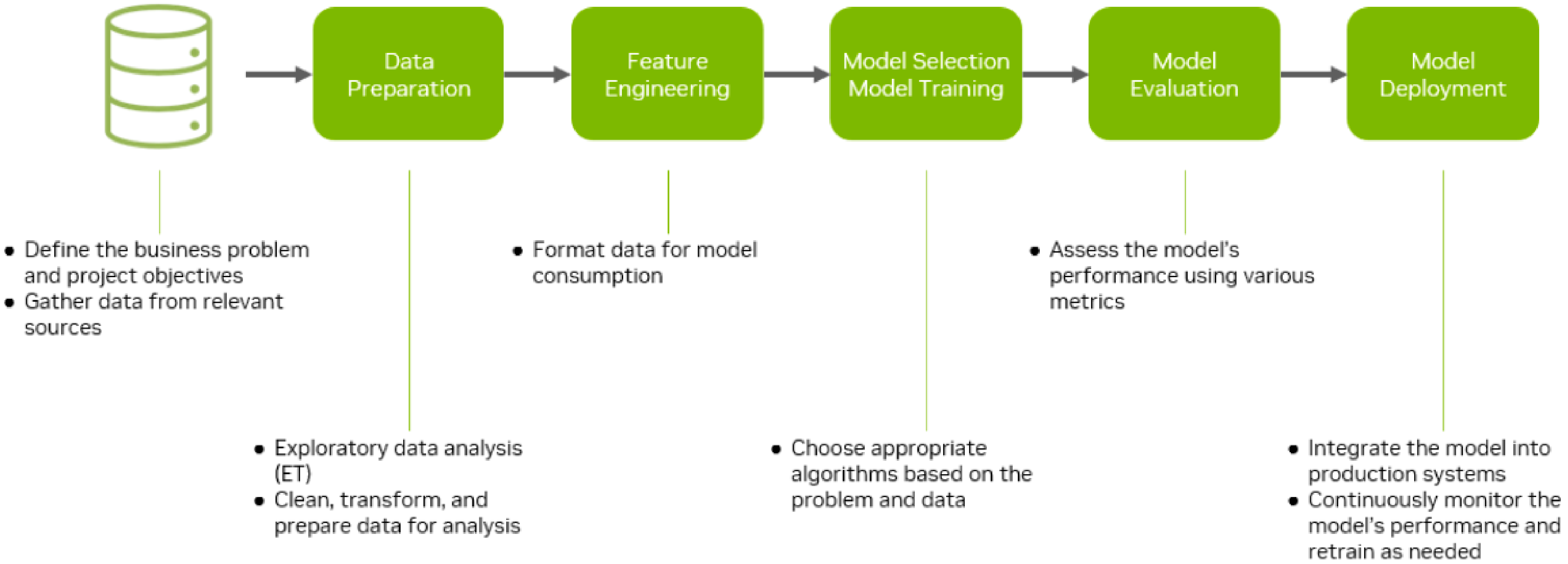
- Welcome and Introductions
- The Data Science Process
- Expectations for Incoming Students
- Teaching Team Introductions
- Course Syllabus & Schedule
- Course Dataset: NSL-KDD
- Next Steps

Why is this course Important?

- The Machine Learning market has a relentless pace of innovation, reflected by multiple trends such as democratization, augmentation, operationalization and composability. This innovation is reflected in growth opportunities and increase market size.
    - “By 2026, 30% of new applications will use AI to drive personalized adaptive user interfaces, up from under 5% today”, Gartner R&D.
    - “AI Market value of nearly 100 billion U.S. dollars is expected to grow twentyfold by 2030, up to nearly two trillion U.S. dollars.”, Statista Research.
- An ad hoc approach to AI isn’t sustainable and won’t fulfill the expected market growth & demand.
- The use of advanced AI tools, frameworks and practices will enable scaling and operationalizing AI, leading to sustainable AI that meets our market demand
- According to St. John’s University report, AI and Data analytics are the most important 2 skills in 2024.

The Machine Learning Modeling Workflow

Machine Learning requires a lot more than just training!



Data Preparation

Feature Engineering

Model Selection Model Training

Model Evaluation

Model Deployment

- Define the business problem and project objectives
- Gather data from relevant sources

- Exploratory data analysis (ET)
- Clean, transform, and prepare data for analysis

- Format data for model consumption

- Choose appropriate algorithms based on the problem and data

- Assess the model's performance using various metrics

- Integrate the model into production systems
- Continuously monitor the model's performance and retrain as needed

Figure 1.0 The Machine Learning Modeling Workflow

The Machine Learning Modeling Workflow – Cont’d

- Data may be sourced from from IoT devices, logs from webservers, data gathered from social media, census datasets, data streamed from online sources using APIs, etc.

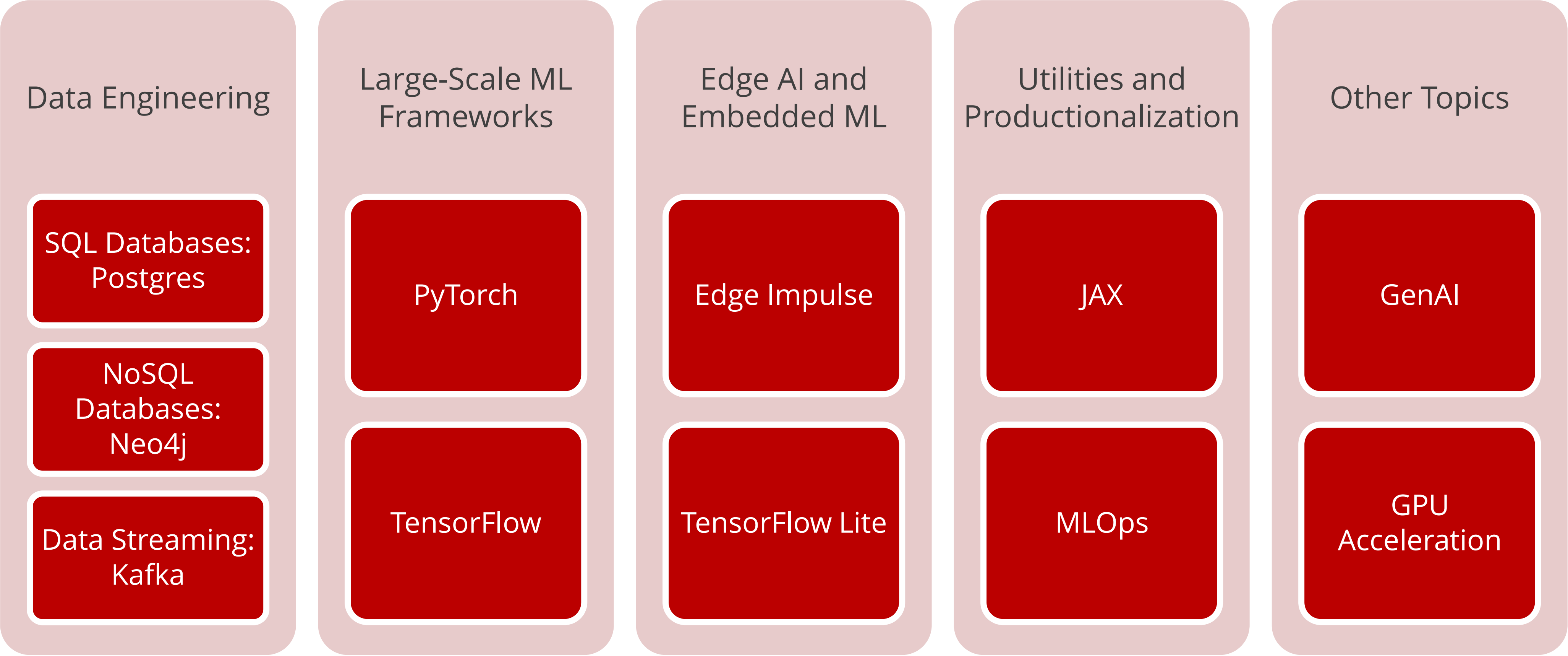
- Data preparation, or cleaning, is the process of collecting, choosing, modeling, and transforming data to answer an analytical question.

- Feature engineering is an iterative process that aims to transform raw data into AI-Ready format that is easier for algorithms to learn patterns.

- Model selection and training is the process of building the algorithms which learn to make predictions about unforeseen/future data.
    - The efficiency & accuracy of the machine learning model is then **evaluated** and fine-tuned to provide best possible performance.

- Model deployment refers to the application of a machine learning model on new data in a production environment. This process includes monitoring the model and communicating the model results to the users and data scientists

What is this course about?!



Data Engineering

- SQL Databases: Postgres
- NoSQL Databases: Neo4j
- Data Streaming: Kafka

Large-Scale ML Frameworks

- PyTorch
- TensorFlow

Edge AI and Embedded ML

- Edge Impulse
- TensorFlow Lite

Utilities and Productionalization

- JAX
- MLOps

Other Topics

- GenAI
- GPU Acceleration

Figure 2.0 Course Technologies

Course Knowledge Depth

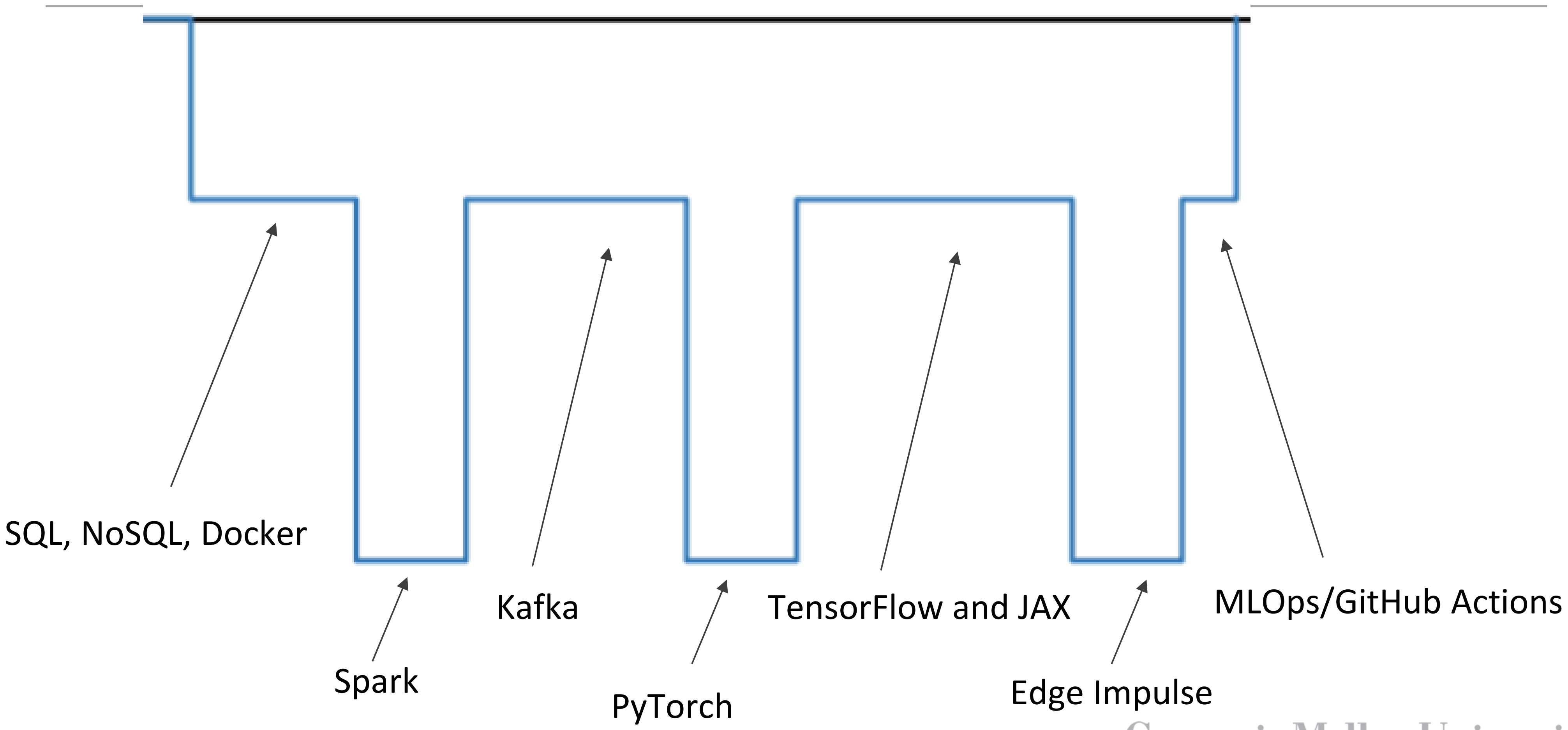


Figure 3.0 Course Knowledge Depth

Relevance of Course Topics to Today’s Market

Machine learning is not only about models.

ML Systems and Toolchains aim to productionalize models

AI Engineering, AI-Ready Data, Edge AI and Generative AI are areas of focus in this course

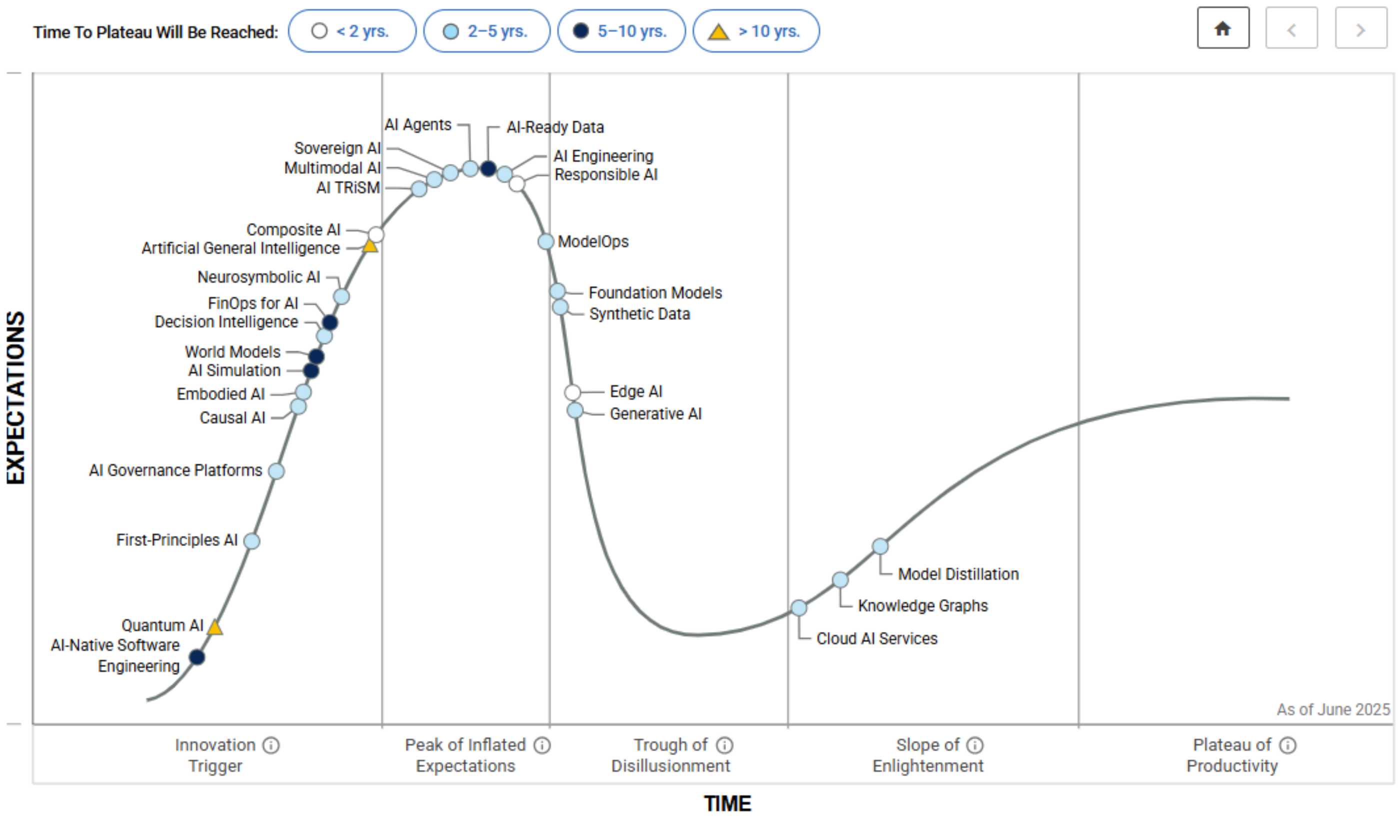


Figure 4.0 2025 Hype Cycle for Artificial Intelligence, by Gartner

What this course is and What is it not?

- This course will **help you get an introduction on different tools and technologies** that are needed to build machine learning models at large-scale or for embedded systems.

- This course will help you productionalize your models by running them on the cloud and as part of a larger pipeline using MLOps

- This course is **NOT a source of learning the internals of machine learning models!**

- Also, this course **doesn't offer a lot of depth on the theory behind the design of machine learning models**.

Expectations for Incoming Students

- ***You are expected to know Python or are willing to learn it.***
  - Watch the Python session recording if you need assistance!

- ***You are expected to have an introductory knowledge about machine learning models and a basic understanding of neural network theory.***

Instructor Introductions

MOHAMED FARAG

FARAG@CMU.EDU

GUANNAN QU

GQU@ANDREW.CMU.EDU

TA Introductions

- Anirudh Joshi - INI - ajoshi3@andrew.cmu.edu
- Hannah Manheimer - BME - hmanheim@andrew.cmu.edu
- Janbol Jangabyl - Civil - jjangaby@andrew.cmu.edu
- Jayant Sharma - BME - jayantsh@andrew.cmu.edu
- Jonathan He - MechE - jintongh@andrew.cmu.edu
- Manigandan Ramadasan - INI - mramadas@andrew.cmu.edu
- Yash Bobde - INI - ybobde@andrew.cmu.edu

Course Logistics

- Lectures recordings are made available after the lecture end time.

- You may ask questions interactively or via TopHat during the lecture.
  Sign up for a free TopHat account and join the course with the following code:
  226573

- Future lectures will be posted on Canvas as Jupyter Notebooks and PDF files.

- Students who have approved accommodation shall contact the course instructor to figure out how the instructor can meet their needs

Course Delivery Technology Stack

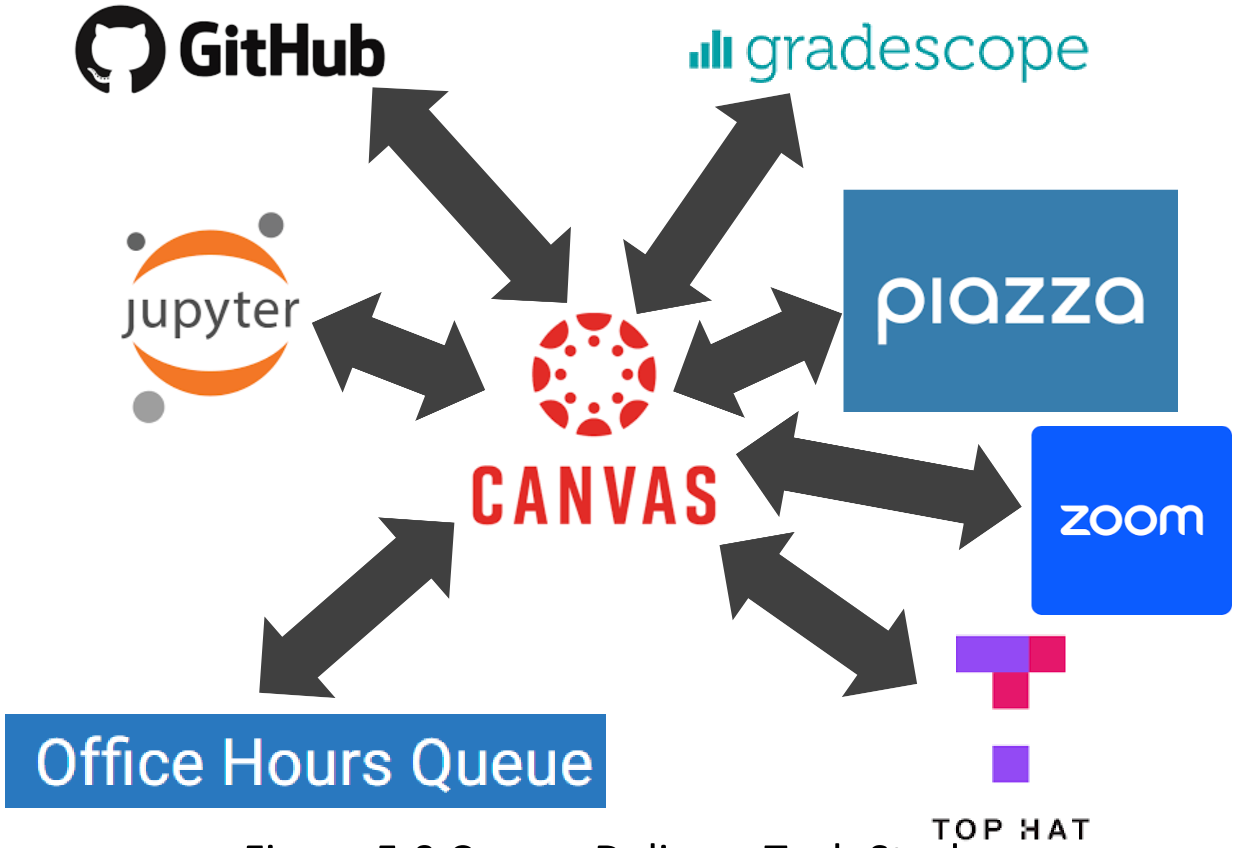
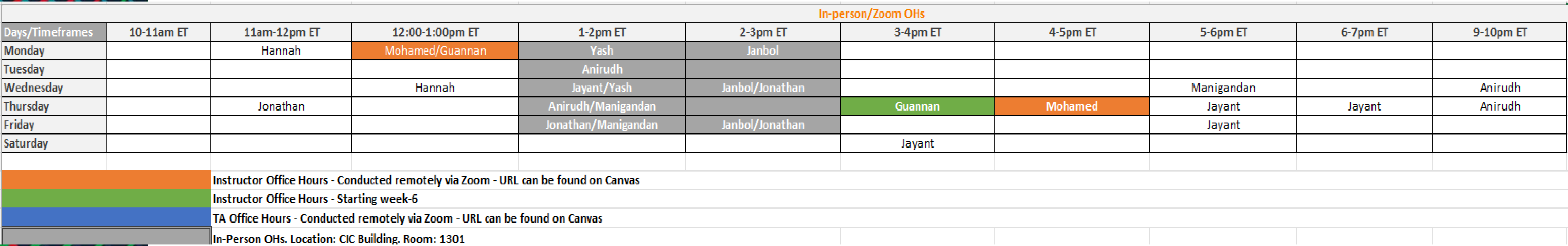


Figure 5.0 Course Delivery Tech Stack

Course Logistics – Cont’d - Office Hours



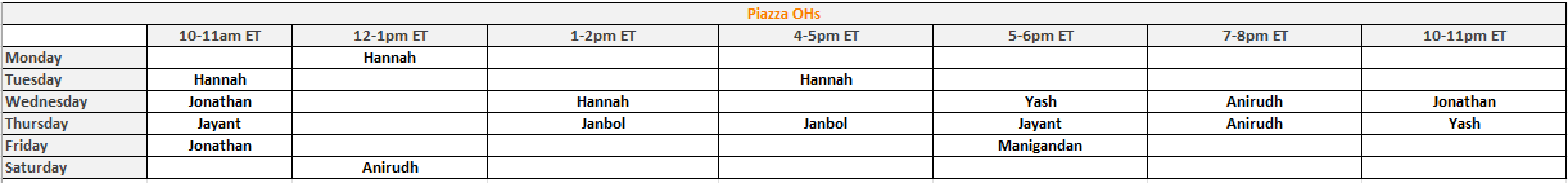
In-person/Zoom OHs

Days/Timeframes	10-11am ET	11am-12pm ET	12:00-1:00pm ET	1-2pm ET	2-3pm ET	3-4pm ET	4-5pm ET	5-6pm ET	6-7pm ET	9-10pm ET
Monday		Hannah	Mohamed/Guannan	Yash	Janbol					
Tuesday				Anirudh						
Wednesday			Hannah	Jayant/Yash	Janbol/Jonathan			Manigandan		Anirudh
Thursday		Jonathan		Anirudh/Manigandan		Guannan	Mohamed	Jayant	Jayant	Anirudh
Friday				Jonathan/Manigandan	Janbol/Jonathan			Jayant		
Saturday						Jayant				

🟧	Instructor Office Hours - Conducted remotely via Zoom - URL can be found on Canvas
🟩	Instructor Office Hours - Starting week-6
🟦	TA Office Hours - Conducted remotely via Zoom - URL can be found on Canvas
▨	In-Person OHs. Location: CIC Building. Room: 1301

- Instructor Office Hours will use this Zoom URL: https://cmu.zoom.us/j/92231657955?pwd=mNyb0fCSLo1EZwcajFcLugNwiV6dBc.1
- TA Office Hours will use this Zoom URL:
  - https://cmu.zoom.us/j/94562388908?pwd=i9HVsjiHwmZsy6VgsrZZ99ajjpGmxE.1
  - In-person OHs won't have Zoom.

Course Logistics – Piazza Hours



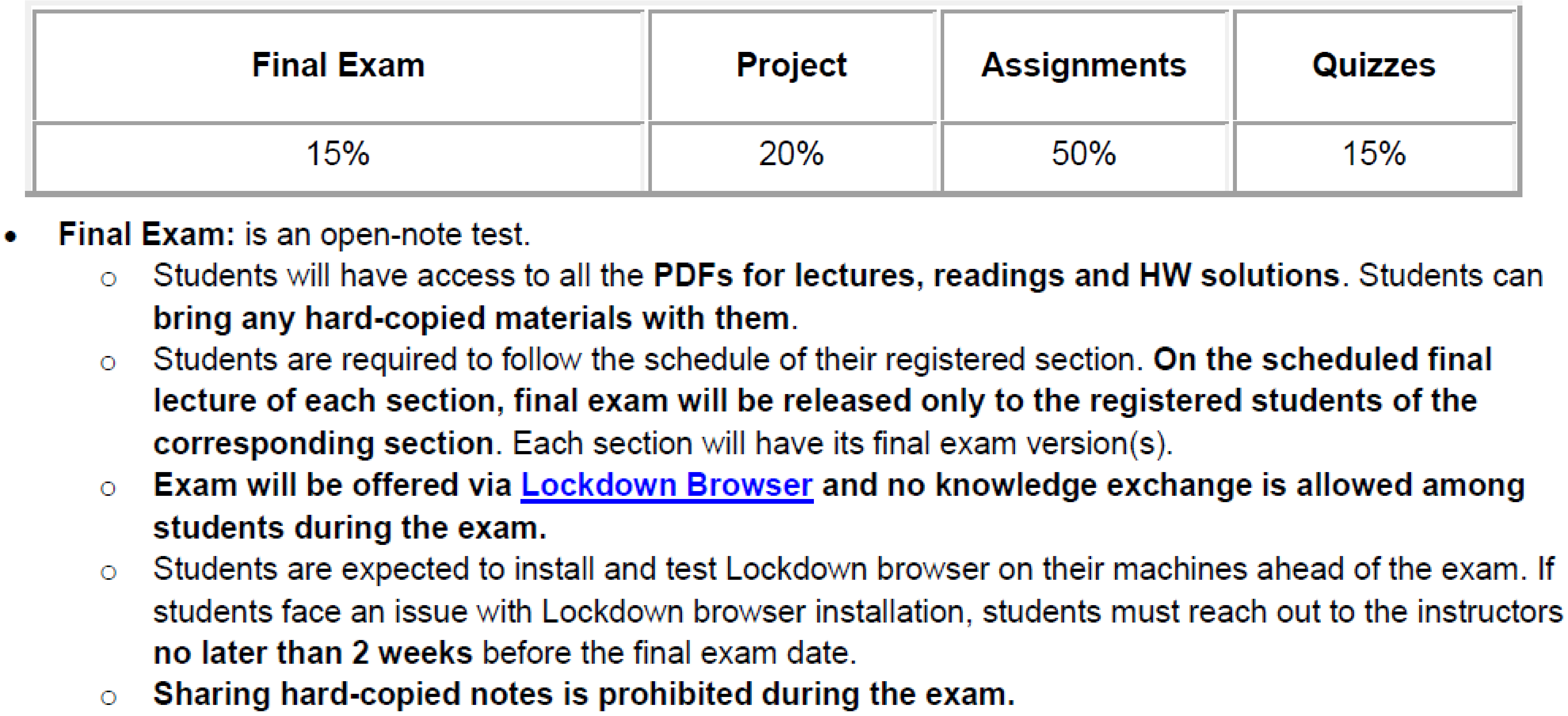
Piazza OHs							
	10-11am ET	12-1pm ET	1-2pm ET	4-5pm ET	5-6pm ET	7-8pm ET	10-11pm ET
Monday		Hannah					
Tuesday	Hannah			Hannah			
Wednesday	Jonathan		Hannah		Yash	Anirudh	Jonathan
Thursday	Jayant		Janbol	Janbol	Jayant	Anirudh	Yash
Friday	Jonathan				Manigandan		
Saturday		Anirudh					

- Please note that TAs will respond to inquiries/questions made ***before*** the Piazza OHs start time. Questions and inquiries that are made during the OHs time slot are not guaranteed to be answered during the same time slot.

Office Hours Etiquette Reminder

- Sign-up for a spot in the OH Queue: https://ohq.eberly.cmu.edu/#/courses and search for “14-863”
- Office Hours aim to help you find the path to maximize your learning experience.
- Getting the answers from the TA directly won't help you learn so **there won't be direct solutions provided during Office Hours**.
- The goal of the office hours is to **give you some ideas and pointers for you** to debug the issues.
- Please don't plan to spend **more than 15 minutes** in your conversation with the TA.
- Ask **good questions with due diligence**. Please research the issue and put an effort in implementing it before coming to Office hours.
    - **Example of a bad question:** I found this draft code online and I’m citing it but can’t get it to work. Can you help?
    - **Example of a good question:** I’m getting a bug in my deployment to the cloud, I researched the issue and found these 3 different references (share the URLs). I implemented the first one and it didn’t work. I’m trying the second one now and getting an error that I can’t find enough references to it online. What could be the root cause of it?

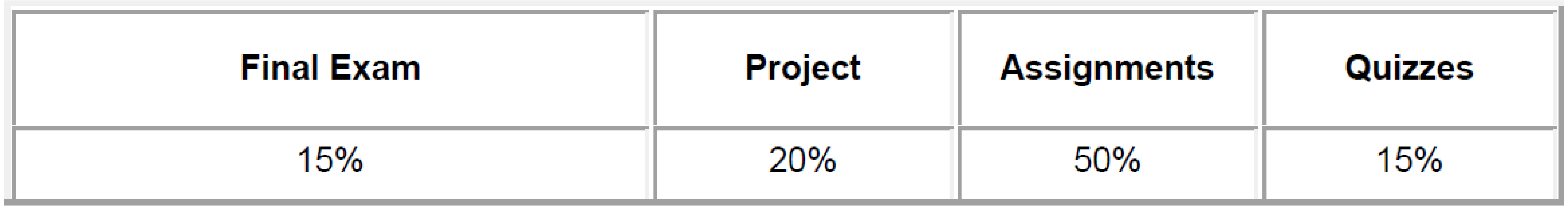
Course Assessment



Final Exam	Project	Assignments	Quizzes
15%	20%	50%	15%

- **Final Exam:** is an open-note test.
  - Students will have access to all the **PDFs for lectures, readings and HW solutions**. Students can **bring any hard-copied materials with them**.
  - Students are required to follow the schedule of their registered section. **On the scheduled final lecture of each section, final exam will be released only to the registered students of the corresponding section**. Each section will have its final exam version(s).
  - **Exam will be offered via Lockdown Browser and no knowledge exchange is allowed among students during the exam.**
  - Students are expected to install and test Lockdown browser on their machines ahead of the exam. If students face an issue with Lockdown browser installation, students must reach out to the instructors **no later than 2 weeks** before the final exam date.
  - **Sharing hard-copied notes is prohibited during the exam.**

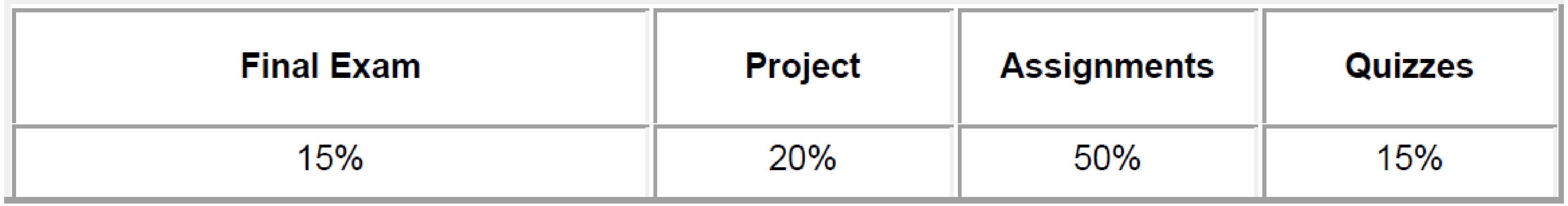
Course Assessment – Cont’d



Final Exam	Project	Assignments	Quizzes
15%	20%	50%	15%

- **Course Project:** Each student will have the option to team up with another student for the project and you will choose one of two project options to submit. This project leverages most of the topics and practices that are covered throughout the semester. Course details are released in Week-3. Project submission deadline is November 13th 11:59PM ET.
  - **Late submissions for the course project will receive no grade (0 points).**
- **Quizzes:** there will be 1 quiz published on Canvas during the lecture with a specific access code. The access code will be revealed during the lecture to the registered students of the corresponding section.
  - Quizzes will start from the second week of classes.
  - **Students will receive two excused absences for lectures (and their quizzes) for emergencies, sickness, etc.**
  - If you need to attend remotely for extended time period, please refer to the course homepage on Canvas.

Course Assessment – Cont'd



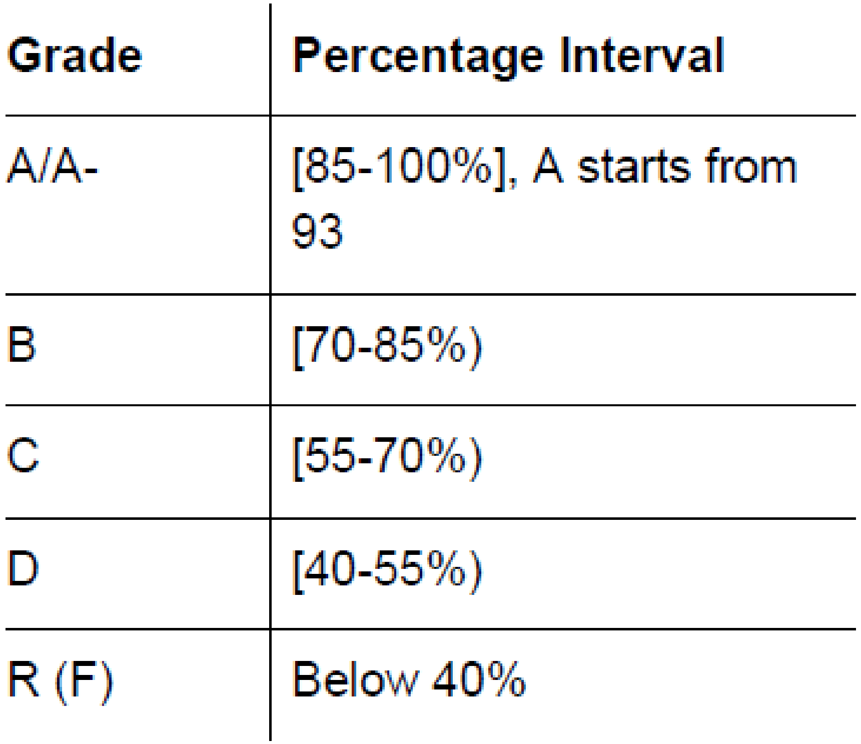
Final Exam	Project	Assignments	Quizzes
15%	20%	50%	15%

- **Homework Assignments:** there will be 8 homework assignments provided throughout the semester covering the practical aspects of the class. There will be good learning curve that students will have to take on their own.
- **Students will have 3 days to submit an assignment after the due date** and a late penalty will be applied. Late penalties are applied based on the timestamp of the last code commit on GitHub and it will follow this equation:
  - Total of 5 points for up to 24 hours delay
  - Total of 15 points for the next 24 hours delay
  - Total of 25 points for the next 24 hours delay
  - 100 points penalty (no grade) after this time.

After homework grades are released, **regrade requests can be made for 24 hours via Gradescope and CANNOT be submitted via email.**

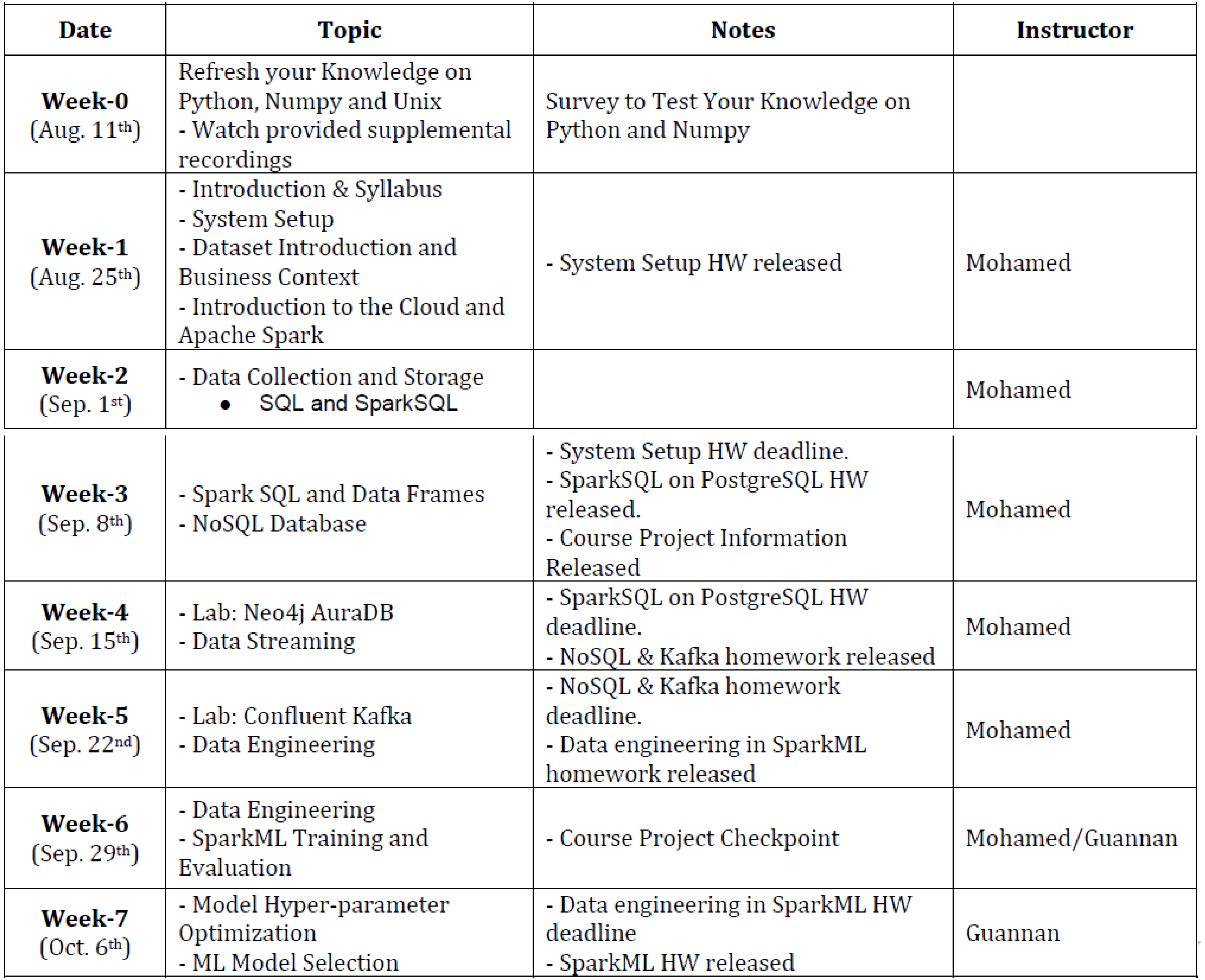
Course Grade Scheme

+/- are used to provide granularity



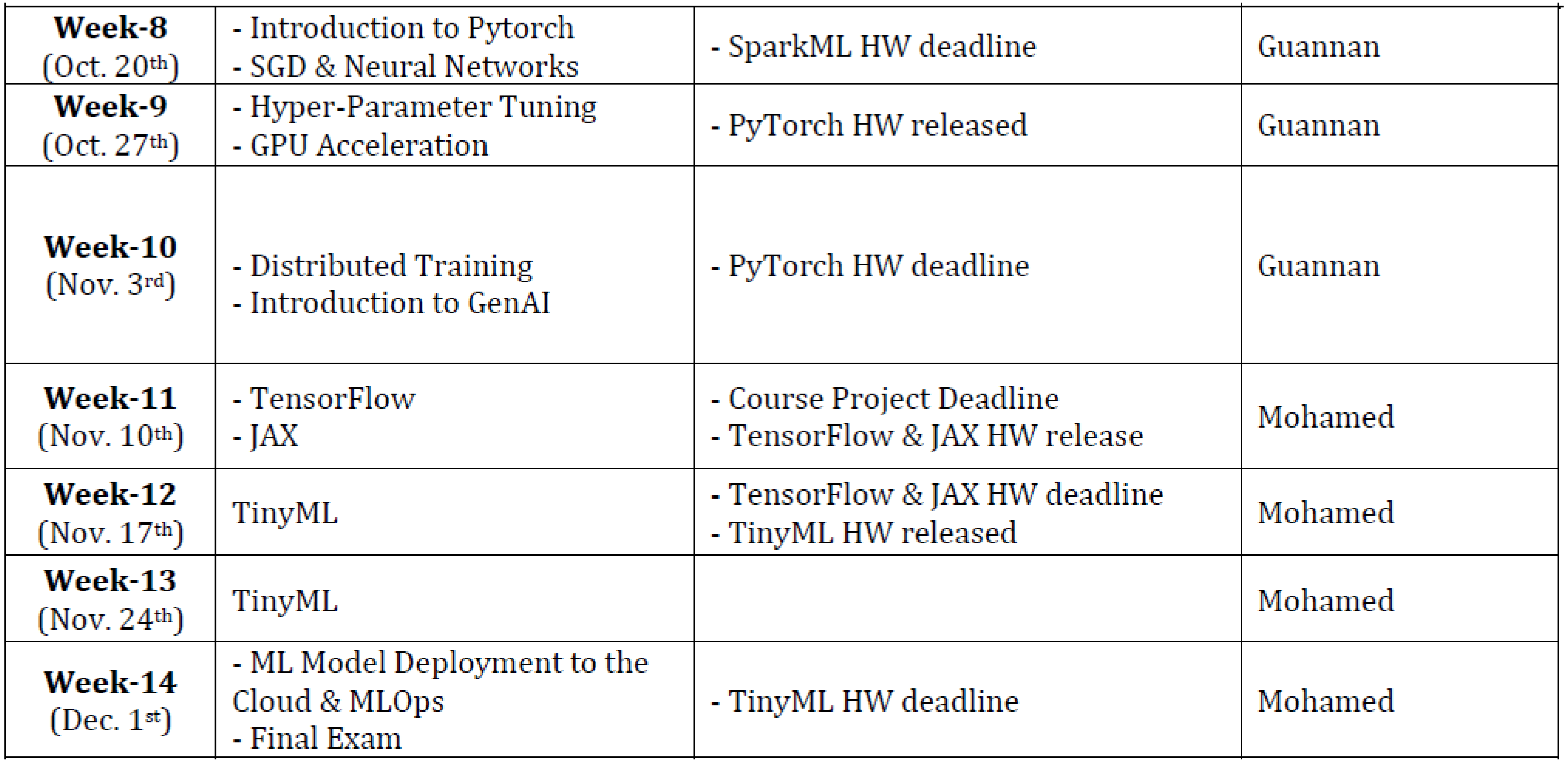
Grade	Percentage Interval
A/A-	[85-100%], A starts from 93
B	[70-85%)
C	[55-70%)
D	[40-55%)
R (F)	Below 40%

Course Schedule



Date	Topic	Notes	Instructor
Week-0 (Aug. 11th)	Refresh your Knowledge on Python, Numpy and Unix - Watch provided supplemental recordings	Survey to Test Your Knowledge on Python and Numpy	
Week-1 (Aug. 25th)	- Introduction & Syllabus - System Setup - Dataset Introduction and Business Context - Introduction to the Cloud and Apache Spark	- System Setup HW released	Mohamed
Week-2 (Sep. 1st)	- Data Collection and Storage ● SQL and SparkSQL		Mohamed
Week-3 (Sep. 8th)	- Spark SQL and Data Frames - NoSQL Database	- System Setup HW deadline. - SparkSQL on PostgreSQL HW released. - Course Project Information Released	Mohamed
Week-4 (Sep. 15th)	- Lab: Neo4j AuraDB - Data Streaming	- SparkSQL on PostgreSQL HW deadline. - NoSQL & Kafka homework released	Mohamed
Week-5 (Sep. 22nd)	- Lab: Confluent Kafka - Data Engineering	- NoSQL & Kafka homework deadline. - Data engineering in SparkML homework released	Mohamed
Week-6 (Sep. 29th)	- Data Engineering - SparkML Training and Evaluation	- Course Project Checkpoint	Mohamed/Guannan
Week-7 (Oct. 6th)	- Model Hyper-parameter Optimization - ML Model Selection	- Data engineering in SparkML HW deadline - SparkML HW released	Guannan

Course Schedule – Cont'd

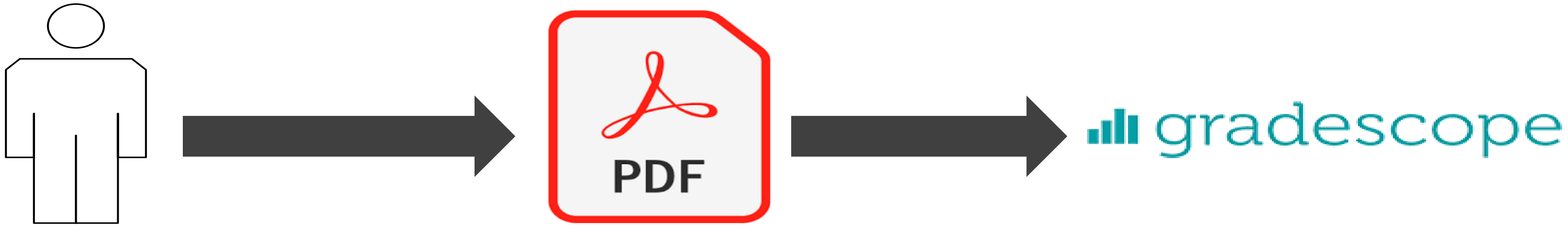


Week-8 (Oct. 20th)	- Introduction to Pytorch - SGD & Neural Networks	- SparkML HW deadline	Guannan
Week-9 (Oct. 27th)	- Hyper-Parameter Tuning - GPU Acceleration	- PyTorch HW released	Guannan
Week-10 (Nov. 3rd)	- Distributed Training - Introduction to GenAI	- PyTorch HW deadline	Guannan
Week-11 (Nov. 10th)	- TensorFlow - JAX	- Course Project Deadline - TensorFlow & JAX HW release	Mohamed
Week-12 (Nov. 17th)	TinyML	- TensorFlow & JAX HW deadline - TinyML HW released	Mohamed
Week-13 (Nov. 24th)	TinyML		Mohamed
Week-14 (Dec. 1st)	- ML Model Deployment to the Cloud & MLOps - Final Exam	- TinyML HW deadline	Mohamed

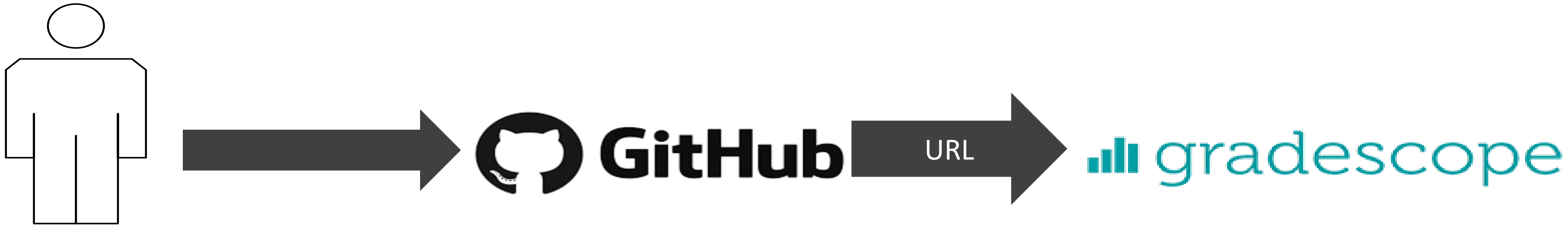
HW Submission Guidelines

- HW-1 focuses on Environment Setup and GitHub Skills. It’s released on Canvas, and you can submit it with no penalty until Thursday **<u>September 11th, 11:59PM ET</u>**.

- HW-1 submission:



- HW-2 and later assignment submissions:



Academic Integrity Violations (AIVs)

- AIVs are serious and can have direct impact on your course grade, your scholarship -if any-, your graduation timeline, and/or your continuation in your degree program.
- Simple rules to follow:
  - Cite all the references you are using. Use APA citation style.
  - Cite ChatGPT (or other AI tools) for any code/info used in your answers.
  - Don’t use more than 30% of your solution/answer from external sources.
  - Collaborate and share ideas with your peers.
  - Don’t share code with your peers (including in-class group exercises). Don’t use your peer’s code even after changing variable names or statement order.
  - Don’t share quiz access codes with your peers.

Other Syllabus Information

- **If you run out of Google Cloud credits, plan for 24-48-hour delay to get a new coupon.**
- Syllabus contains important information about student wellness, student academic success center, and food insecurity.
- The Syllabus can be found on Canvas under the Modules section

Waitlisted?

For enrollment questions and inquiries, please email

1) INI Academics at ini-academic@andrew.cmu.edu

OR

2) ECE Academics at

ece-academicaffairs@andrew.cmu.edu

Enrolled and Have Problems Accessing the Lecture Room?

Contact ini-help@andrew.cmu.edu

Bottom Line

- You are a graduate student at CMU, and we expect you to **pay close attention to the details** mentioned during lectures and in your homework assignments.
- Ask questions and **avoid making unreasonable assumptions**.
- Use your **intellectual abilities and problem-solving skills** to fill in any gaps beyond what the teaching team can share with you.
- We are **committed to your success** both inside and outside the classroom.
- Feel free to **reach out with any questions** related to research, internships, career advice, or related topics.

Course Dataset

Course Dataset

- In this course, we will use the NSL-KDD dataset.
- The NSL-KDD dataset is an enhanced dataset to help researchers compare different intrusion detection methods.
- The dataset contains 100k+ records which is suitable for our class purposes
- You may download this dataset from Canvas Modules’ section.

History of NSL-KDD Dataset

- Cybercrimes represent any criminal activity that involves a computer, a network, or a networked device. Cybercrimes may lead to physical damages or financial losses (in billions of dollars).

- It's critical to detect network intrusions before they occur. One way to identify intrusions is to look at previous potential intrusions and look for similarities/patterns. New intrusions are likely to share some aspects or features with previous intrusions. This field is called **Intrusion Detection**.

- In 1998, The **Defense Advanced Research Projects Agency (DARPA)** established the **Intrusion Detection Evaluation Program** to survey and evaluate research in intrusion detection. This program organized **The KDD cup** as an International Knowledge Discovery and Data Mining Tools Competition.

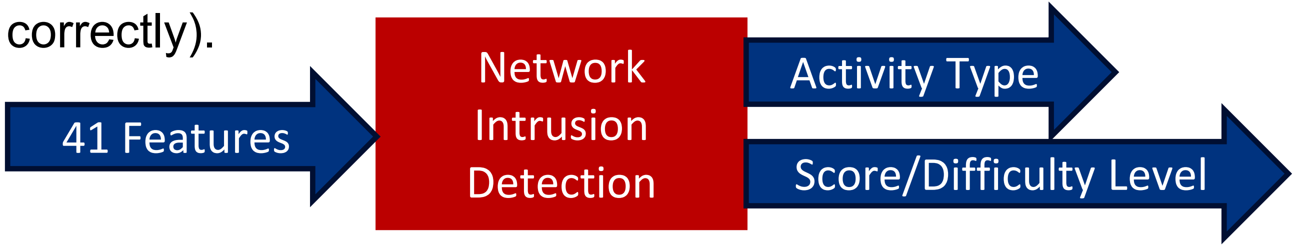
History of NSL-KDD Dataset – Cont’d

- In 1999, this competition was held with the goal of collecting traffic records. The competition task was to build a network intrusion detector, a predictive model capable of distinguishing between "bad" connections, called intrusions or attacks, and "good" normal connections. As a result of this competition, a mass amount of internet traffic records were collected and bundled into a data set called the **KDD'99**

- The **KDD'99 dataset** had several redundant records and issues with one column, so the **NSL-KDD dataset** was created as a newer version of it. We will use the NSL-KDD dataset in this course.

NSL-KDD Dataset

- The NSL-KDD dataset contains 43 features per record, with 41 of the features referring to the traffic input itself and the last two columns represent the **activity type** (whether it is normal or attack) and **Score/Difficulty level** (the classification difficulty score higher = harder to classify correctly).



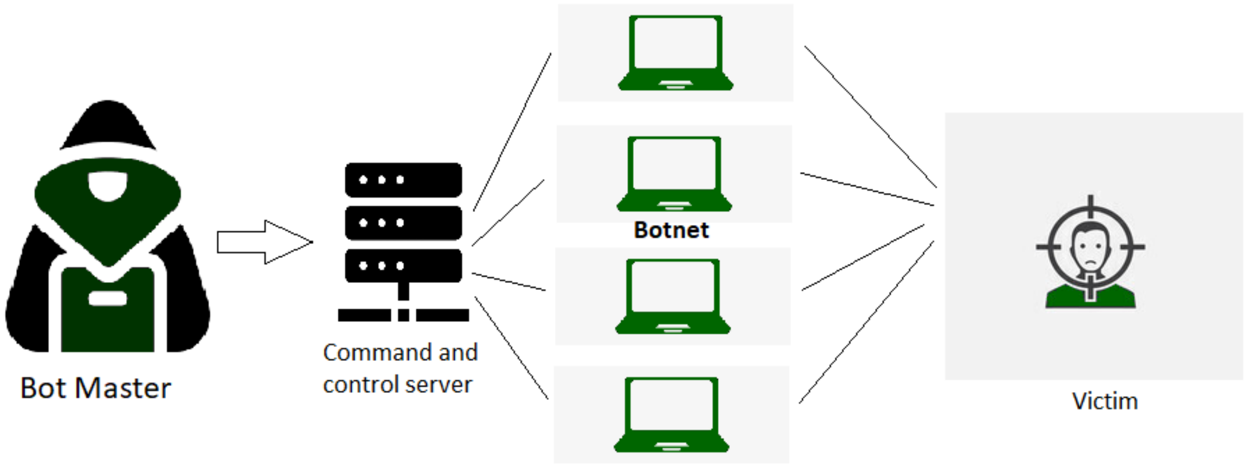
- Let’s start by exploring the output. The **score/difficulty level column** takes an integer value up to 21. On the other hand, the **activity type column** indicates either normal or type of the attack.

- In the dataset, there are 4 different classes of attacks:
  - Denial of Service (DoS)
  - Probe
  - User to Root (U2R)
  - Remote to Local (R2L)

NSL-KDD Dataset – DoS Attacks

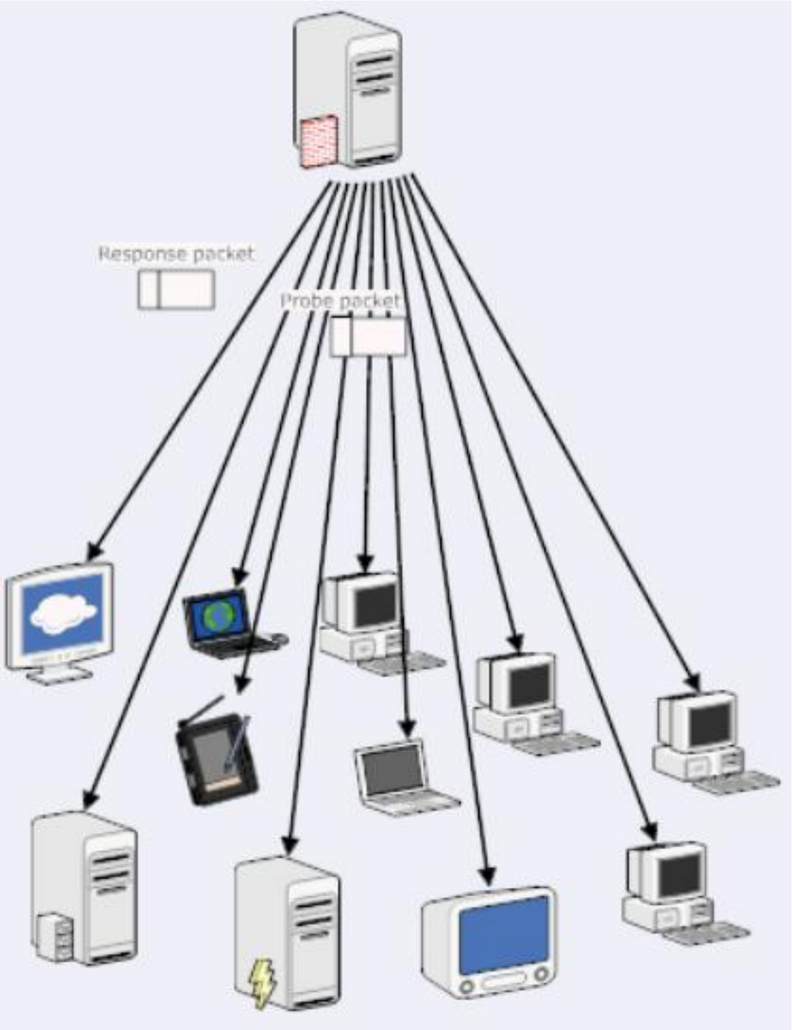
- DoS is an attack that tries to shut down the traffic flow to and from the target system. The Intrusion Detection System (IDS) is flooded with an abnormal amount of traffic, which the system can't handle, and shuts down to protect itself. This prevents normal traffic from visiting a network. An example of this could be an online retailer getting flooded with online orders on a day with a big sale, and because the network can't handle all the requests, it will shutdown and therefore, prevents paying customers from purchasing anything. This is the most common attack in the data set.

Most important attack



NSL-KDD Dataset – Probe Attacks

- Probe or surveillance is an attack that tries to get information from a network.
- The goal here is to act like a thief and steal important information, whether it be personal information about clients or banking information.



NSL-KDD Dataset – User 2 Root (U2R) Attacks

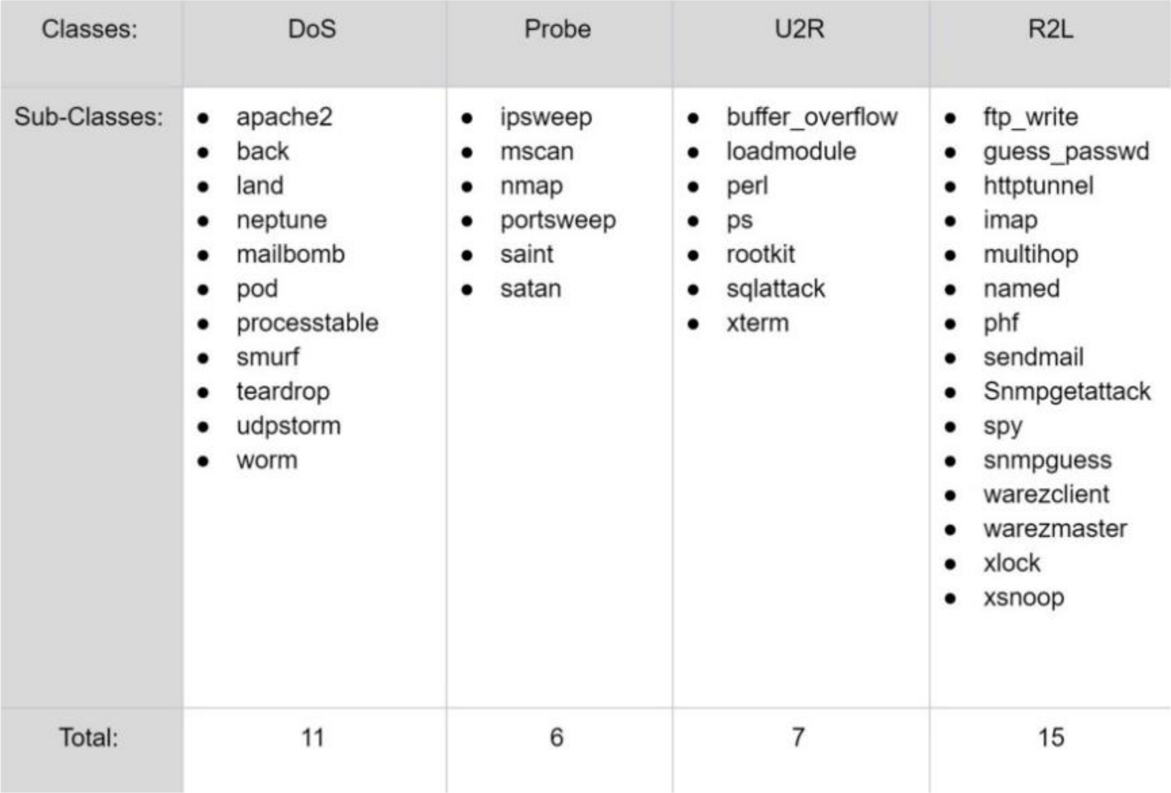
- U2R is an attack that starts off with a normal user account and tries to gain access to the system or network, as a super-user (root).
- The attacker attempts to exploit the vulnerabilities in a system to gain root privileges/access.
- Examples: Perl, Load Module and Eject attacks.

NSL-KDD Dataset – Remote 2 Local (R2L) Attacks

- R2L is an attack where intruders sends a set of packets to another computer or server over a network where they do not have permission to access as a local user.
- Examples of R2L include guessing passwords, ftp writes and IMAP.
- Notice the difference between U2R and R2L. **Can you explain?**

How are the attack categories listed on the dataset?

- In column number 42 in the dataset, the attack is represented by its sub-category (and not the parent category). So, you will find **neptune** in the activity type column instead of (DoS).



Classes:	DoS	Probe	U2R	R2L
Sub-Classes:	• apache2 • back • land • neptune • mailbomb • pod • processtable • smurf • teardrop • udpstorm • worm	• ipsweep • mscan • nmap • portsweep • saint • satan	• buffer_overflow • loadmodule • perl • ps • rootkit • sqlattack • xterm	• ftp_write • guess_passwd • httptunnel • imap • multihop • named • phf • sendmail • Snmpgetattack • spy • snmpguess • warezclient • warezmaster • xlock • xsnoop
Total:	11	6	7	15

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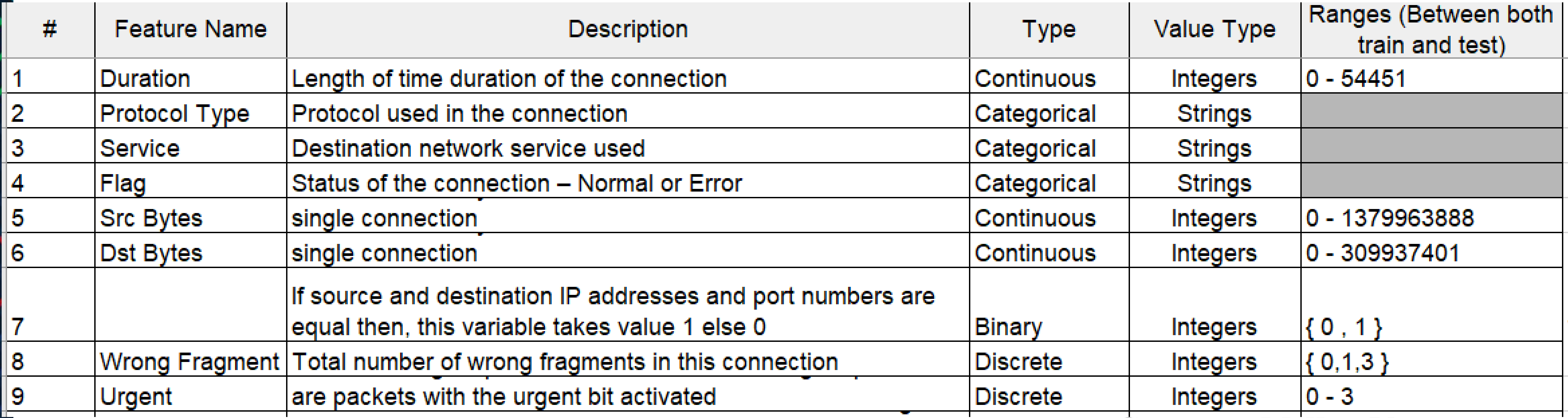
NSL-KDD Dataset – 41 Input Features

The 41 features in every traffic input can be broken down into four categories:

- Intrinsic features
- Content-based Features
- Time-based Features
- Host-based Features

NSL-KDD Dataset – 41 Input Features - Intrinsic

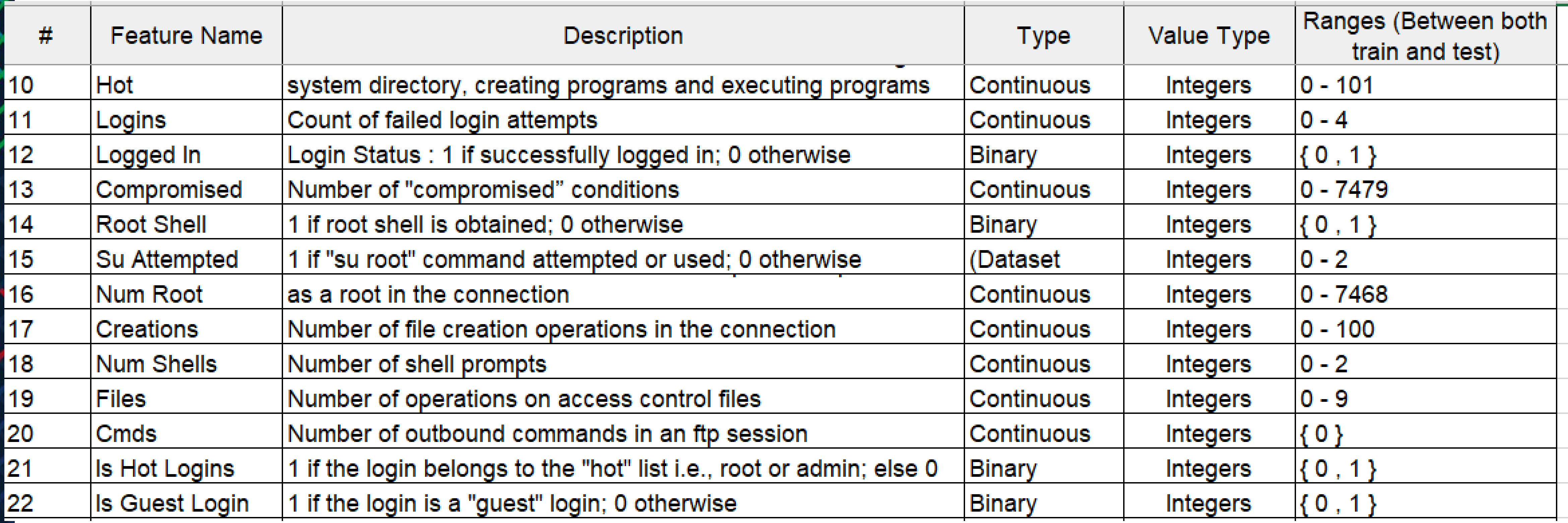
Intrinsic features can be derived from the header of the packet without looking into the payload itself, and hold the basic information about the packet. This category contains features 1–9.



#	Feature Name	Description	Type	Value Type	Ranges (Between both train and test)
1	Duration	Length of time duration of the connection	Continuous	Integers	0 - 54451
2	Protocol Type	Protocol used in the connection	Categorical	Strings	
3	Service	Destination network service used	Categorical	Strings	
4	Flag	Status of the connection – Normal or Error	Categorical	Strings	
5	Src Bytes	single connection	Continuous	Integers	0 - 1379963888
6	Dst Bytes	single connection	Continuous	Integers	0 - 309937401
7		If source and destination IP addresses and port numbers are equal then, this variable takes value 1 else 0	Binary	Integers	{ 0 , 1 }
8	Wrong Fragment	Total number of wrong fragments in this connection	Discrete	Integers	{ 0,1,3 }
9	Urgent	are packets with the urgent bit activated	Discrete	Integers	0 - 3

NSL-KDD Dataset – 41 Input Features - Content

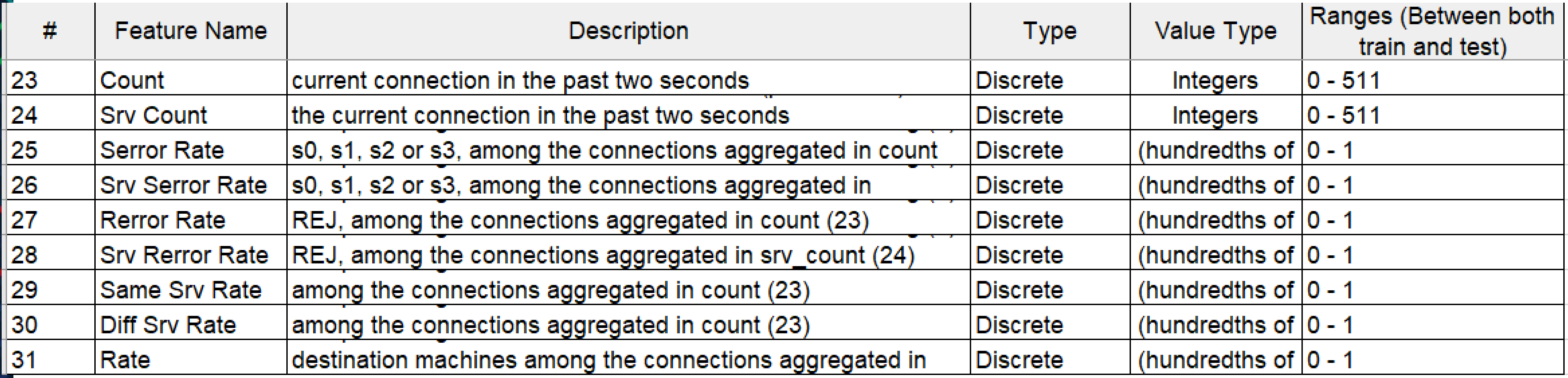
Content features hold information about the original packets, as they are sent in multiple pieces rather than one. With this information, the system can access the payload. This category contains features 10–22.



#	Feature Name	Description	Type	Value Type	Ranges (Between both train and test)
10	Hot	system directory, creating programs and executing programs	Continuous	Integers	0 - 101
11	Logins	Count of failed login attempts	Continuous	Integers	0 - 4
12	Logged In	Login Status : 1 if successfully logged in; 0 otherwise	Binary	Integers	{ 0 , 1 }
13	Compromised	Number of "compromised" conditions	Continuous	Integers	0 - 7479
14	Root Shell	1 if root shell is obtained; 0 otherwise	Binary	Integers	{ 0 , 1 }
15	Su Attempted	1 if "su root" command attempted or used; 0 otherwise	(Dataset	Integers	0 - 2
16	Num Root	as a root in the connection	Continuous	Integers	0 - 7468
17	Creations	Number of file creation operations in the connection	Continuous	Integers	0 - 100
18	Num Shells	Number of shell prompts	Continuous	Integers	0 - 2
19	Files	Number of operations on access control files	Continuous	Integers	0 - 9
20	Cmds	Number of outbound commands in an ftp session	Continuous	Integers	{ 0 }
21	Is Hot Logins	1 if the login belongs to the "hot" list i.e., root or admin; else 0	Binary	Integers	{ 0 , 1 }
22	Is Guest Login	1 if the login is a "guest" login; 0 otherwise	Binary	Integers	{ 0 , 1 }

NSL-KDD Dataset – 41 Input Features – Time-based

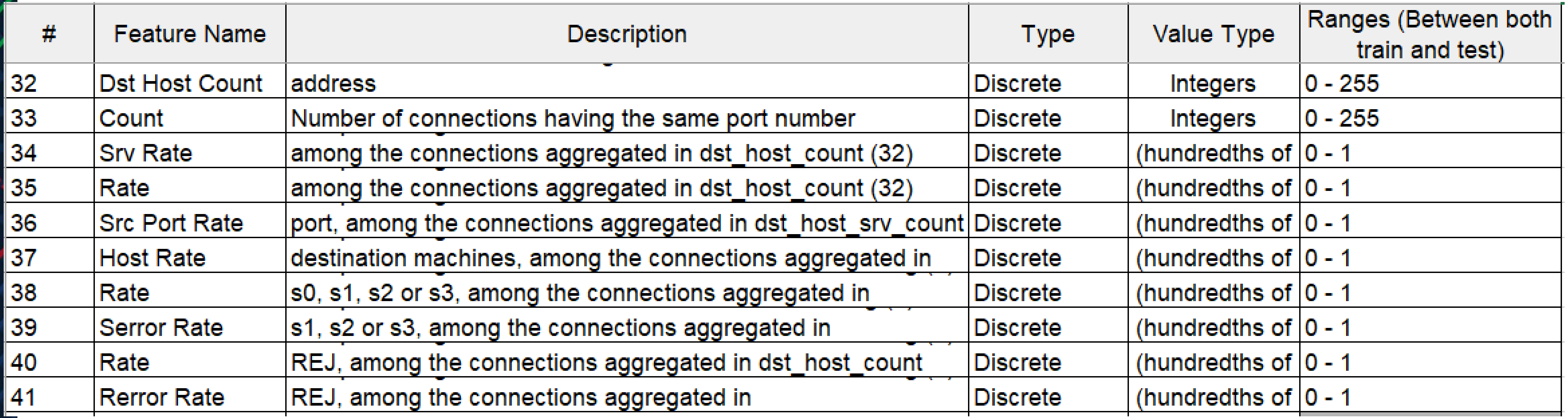
Time-based features hold the analysis of the traffic input over a two-second window and contains information like how many connections it attempted to make to the same host. These features are mostly counts and rates rather than information about the content of the traffic input. This category contains features 23–31.



#	Feature Name	Description	Type	Value Type	Ranges (Between both train and test)
23	Count	current connection in the past two seconds	Discrete	Integers	0 - 511
24	Srv Count	the current connection in the past two seconds	Discrete	Integers	0 - 511
25	Serror Rate	s0, s1, s2 or s3, among the connections aggregated in count	Discrete	(hundredths of	0 - 1
26	Srv Serror Rate	s0, s1, s2 or s3, among the connections aggregated in	Discrete	(hundredths of	0 - 1
27	Rerror Rate	REJ, among the connections aggregated in count (23)	Discrete	(hundredths of	0 - 1
28	Srv Rerror Rate	REJ, among the connections aggregated in srv_count (24)	Discrete	(hundredths of	0 - 1
29	Same Srv Rate	among the connections aggregated in count (23)	Discrete	(hundredths of	0 - 1
30	Diff Srv Rate	among the connections aggregated in count (23)	Discrete	(hundredths of	0 - 1
31	Rate	destination machines among the connections aggregated in	Discrete	(hundredths of	0 - 1

NSL-KDD Dataset – 41 Input Features – Host-based

Host-based features are similar to Time-based features, except instead of analyzing over a 2-second window, it analyzes over a series of connections made (how many requests made to the same host over x-number of connections). These features are designed to access attacks, which span longer than a two-second window time-span. This category contains features 32–41.



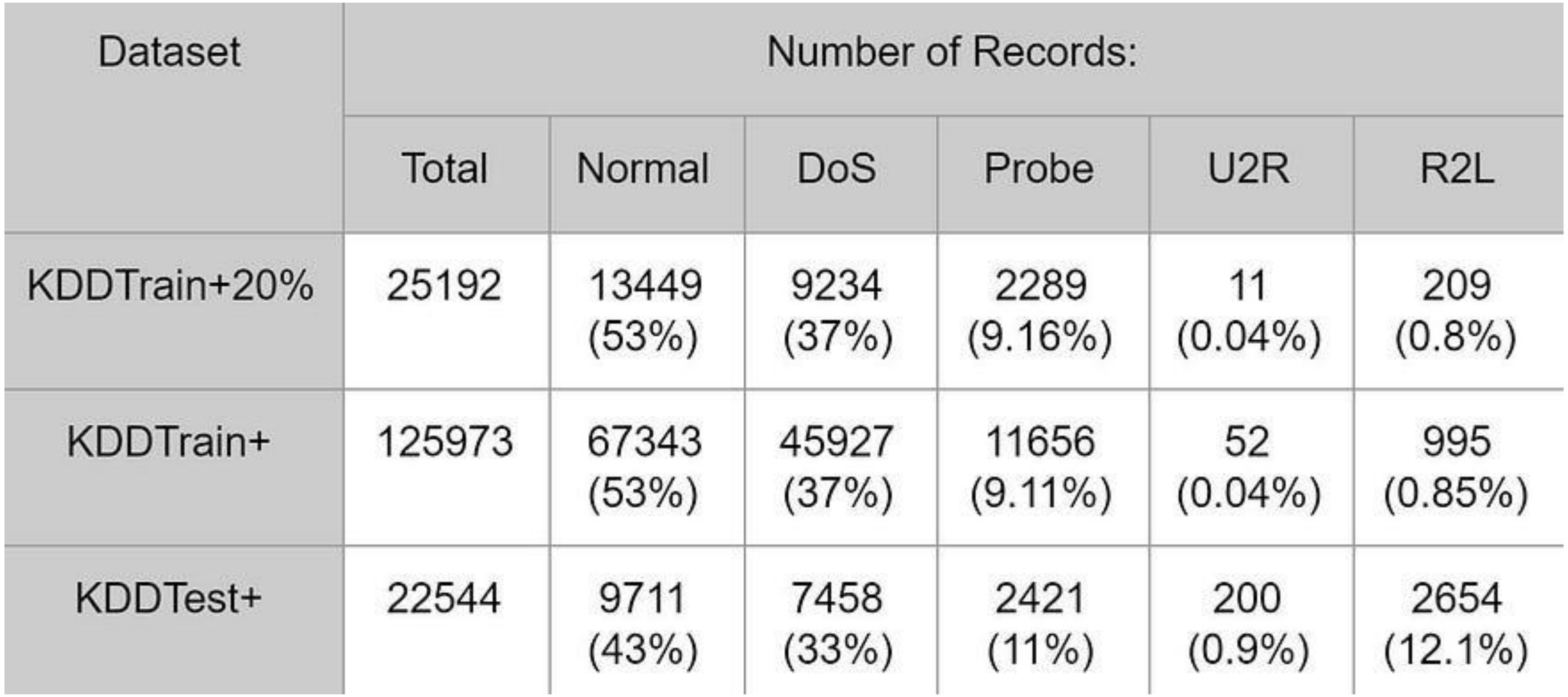
#	Feature Name	Description	Type	Value Type	Ranges (Between both train and test)
32	Dst Host Count	address	Discrete	Integers	0 - 255
33	Count	Number of connections having the same port number	Discrete	Integers	0 - 255
34	Srv Rate	among the connections aggregated in dst_host_count (32)	Discrete	(hundredths of	0 - 1
35	Rate	among the connections aggregated in dst_host_count (32)	Discrete	(hundredths of	0 - 1
36	Src Port Rate	port, among the connections aggregated in dst_host_srv_count	Discrete	(hundredths of	0 - 1
37	Host Rate	destination machines, among the connections aggregated in	Discrete	(hundredths of	0 - 1
38	Rate	s0, s1, s2 or s3, among the connections aggregated in	Discrete	(hundredths of	0 - 1
39	Serror Rate	s1, s2 or s3, among the connections aggregated in	Discrete	(hundredths of	0 - 1
40	Rate	REJ, among the connections aggregated in dst_host_count	Discrete	(hundredths of	0 - 1
41	Rerror Rate	REJ, among the connections aggregated in	Discrete	(hundredths of	0 - 1

NSL-KDD Dataset – File Explanation

- **KDDTrain+.ARFF**: The full NSL-KDD train set with binary labels in ARFF format
- **KDDTrain+.TXT**: The full NSL-KDD train set including attack-type labels and difficulty level in CSV format
- **KDDTrain+_20Percent.ARFF**: A 20% subset of the KDDTrain+.arff file
- **KDDTrain+_20Percent.TXT**: A 20% subset of the KDDTrain+.txt file
- **KDDTest+.ARFF**: The full NSL-KDD test set with binary labels in ARFF format
- **KDDTest+.TXT**: The full NSL-KDD test set including attack-type labels and difficulty level in CSV format
- **KDDTest-21.ARFF**: A subset of the KDDTest+.arff file which does not include records with difficulty level of 21 out of 21
- **KDDTest-21.TXT**: A subset of the KDDTest+.txt file which does not include records with difficulty level of 21 out of 21

Try this at home!

Open the **KDDTrain text file** using Excel (or a Spreadsheet viewer) and validate these statistics



Dataset	Number of Records:					
	Total	Normal	DoS	Probe	U2R	R2L
KDDTrain+20%	25192	13449 (53%)	9234 (37%)	2289 (9.16%)	11 (0.04%)	209 (0.8%)
KDDTrain+	125973	67343 (53%)	45927 (37%)	11656 (9.11%)	52 (0.04%)	995 (0.85%)
KDDTest+	22544	9711 (43%)	7458 (33%)	2421 (11%)	200 (0.9%)	2654 (12.1%)

Next Steps

- Complete the Python survey if you haven’t done so.
- Read “**A Detailed Analysis of the KDD CUP 99 Data Set.pdf”** published on Canvas.
- Prepare Juypter Notebooks (or JupyterLab) to view future lectures and run code snippets.
- Sign-up for the course on TopHat.
- Join the course Piazza.
- Join the student Slack workspace.
- Check Homework-1 PDF.
- Familiarize yourself with the in-person locations of TA Ohs.

Waitlisted Students