CS 398 ACC
Streaming

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MP3

How’s it going?

Final Autograder run:

- Tonight ~9pm
- Tomorrow ~3pm

- Due tomorrow at 11:59 pm.
- Latest Commit to the repo at the time will be graded.
- Last Office Hours today after the lecture until 7pm.

Outline

- Streaming Overview
- Spark Streaming
- Spark Streaming Programming
- Final Project Announcement

Outline

- **Streaming Overview**
- Spark Streaming
- Spark Streaming Programming
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Streaming

- Why streaming?
  - Lots of data is not fixed, in practice
  - We have new data coming in all the time; it makes sense to respond in real time

- What is streaming?
  - Clients push “events” in real time to an interface with our streaming system
  - The streaming system distributes input across the cluster (like batch processing)
  - Some resultant data is generated, which can be saved or streamed out of the system

Batch Processing vs Stream Processing

	Batch Processing	Stream Processing
Data Size	Large batches of data; Most data in a data set	“An event”; Micro-batches of records
Nominal Latency	Minutes to Hours	In the order of milliseconds
Analysis	Complex Algorithm/Analytics	Simple functions, aggregation, rolling metrics

Application of Streaming Data

- Real-Time Machine Learning
  - e.g. Twitter's "trending" topics, disaster monitoring, etc.

- Tracking changes in the finance markets in real-time

- Processing sensor data in large industrial settings
  - (Also scientific settings)

Stream Sources

- File System
- Internet of Things
- Network Traffic
- Embedded devices on a radio frequency

Apache Storm - A pure streaming system

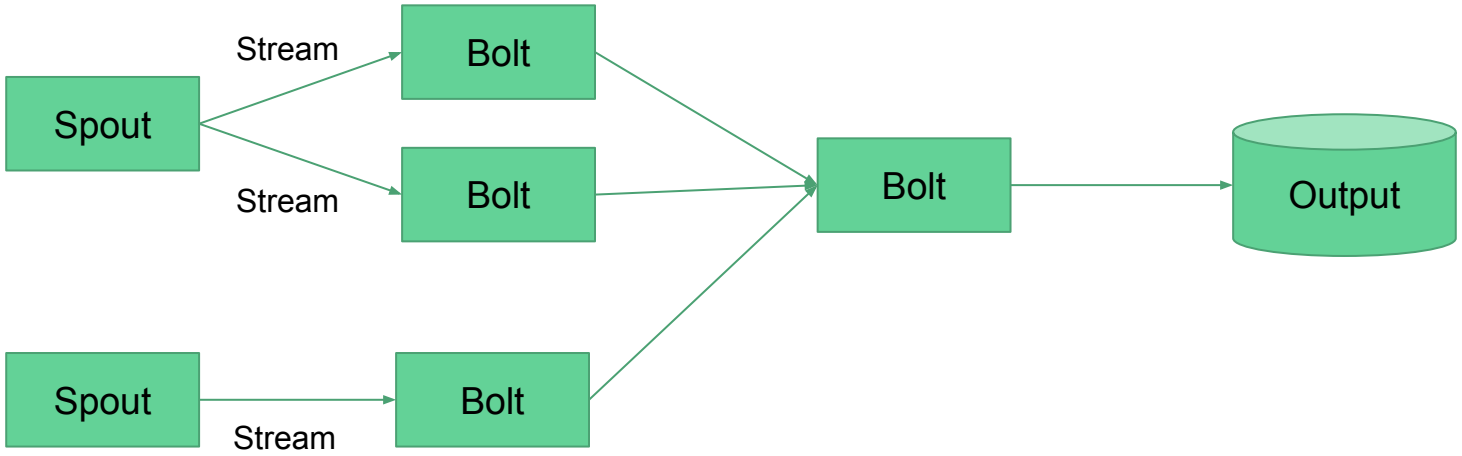
- Purpose-built for real-time stream computation

- Three main concepts:
  - “Stream”: An unbounded sequence of tuples (like an infinite RDD)
  - “Spout”: A source of tuples
  - “Bolt”: A transformation operation on a stream

APACHE STORM™

Apache Storm - A pure streaming system

- Spouts, Bolts, and Streams define a “Topology”



APACHE STORM™

Apache Storm

- Powerful language-agnostic tool/framework
- Open-sourced by Twitter
  - Used to power Twitter's real-time tweet analytics
  - Now Twitter uses Heron
- Handles fault tolerance
  - Keeps track of which tuples have been fully processed
  - If a "Bolt" fails, unprocessed / partially processed tuples are reprocessed

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- Streaming Overview
- **Spark Streaming**
- Spark Streaming Programming
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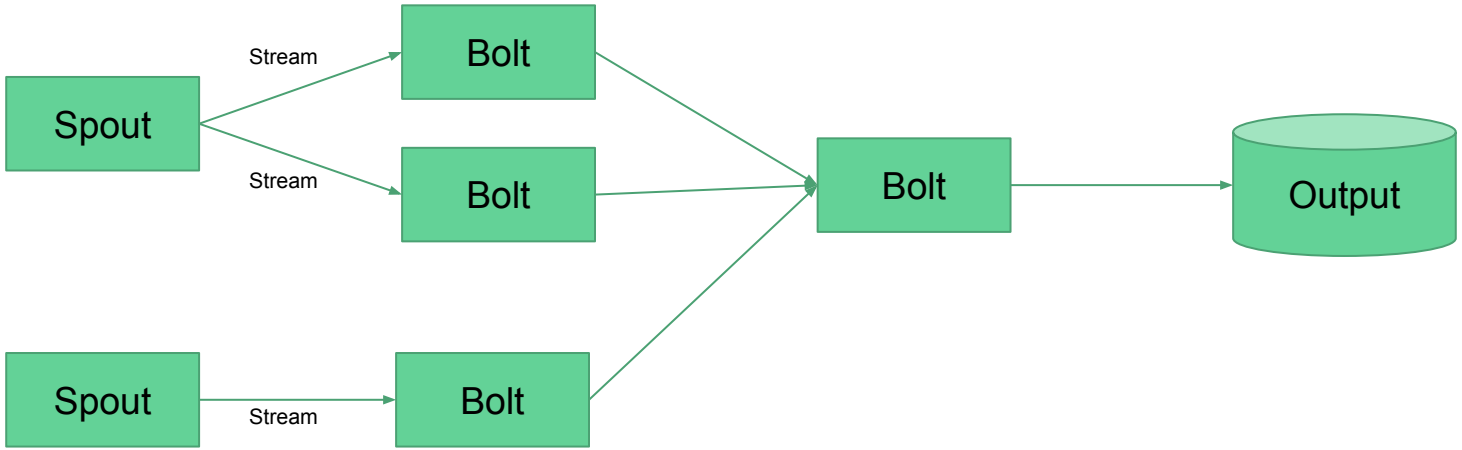
Spark Streaming

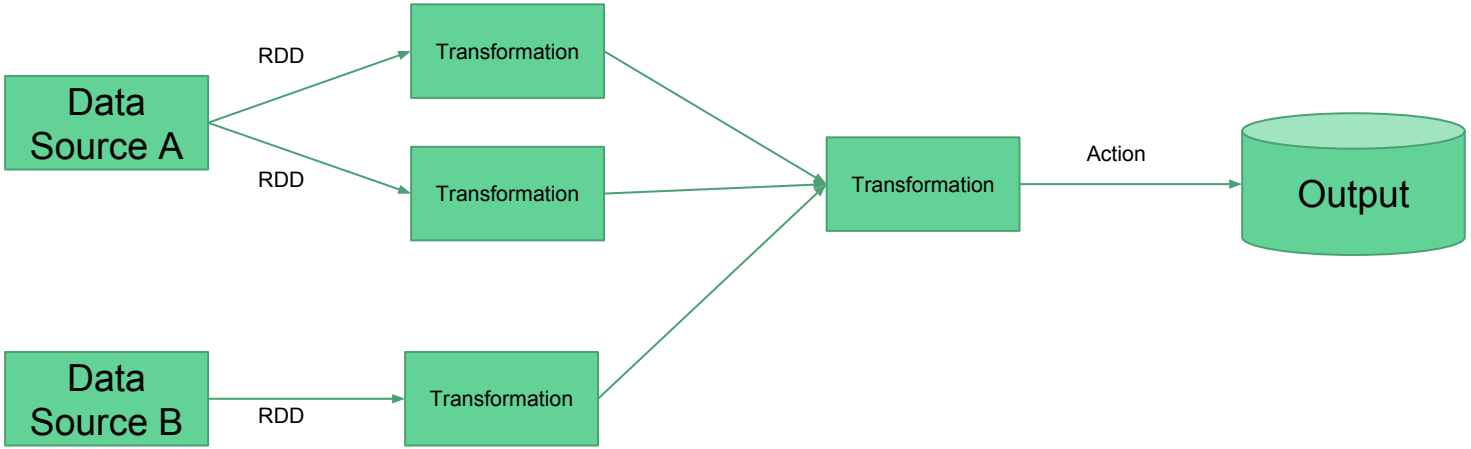
Spark Looks a lot like Apache Storm...

Apache Storm



Spark Looks a lot like Apache Storm...

Spark Streaming

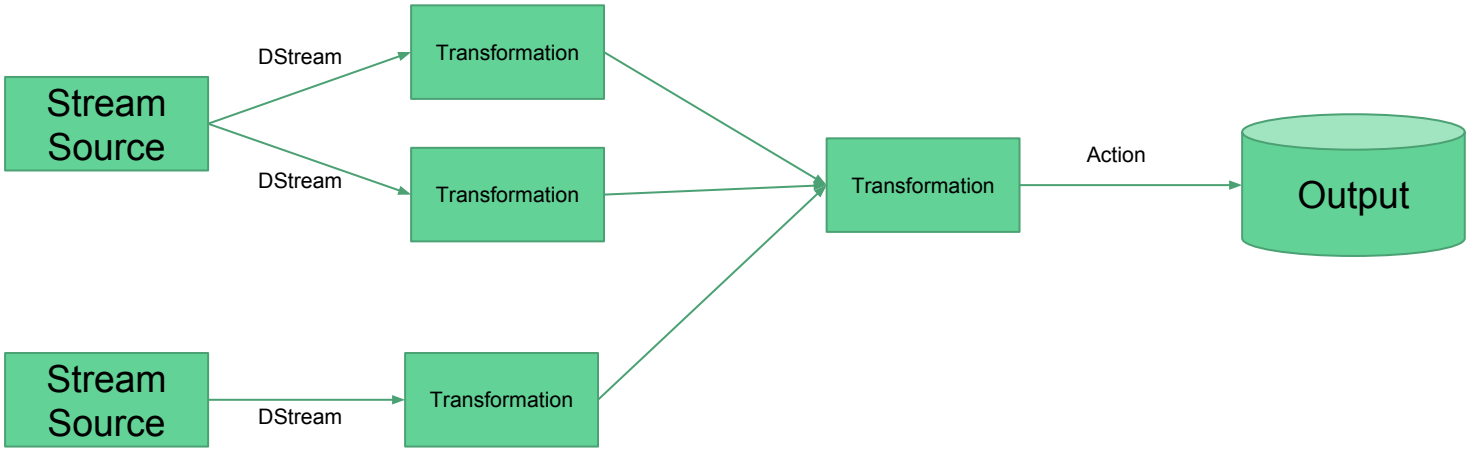


How Spark Handles Streaming

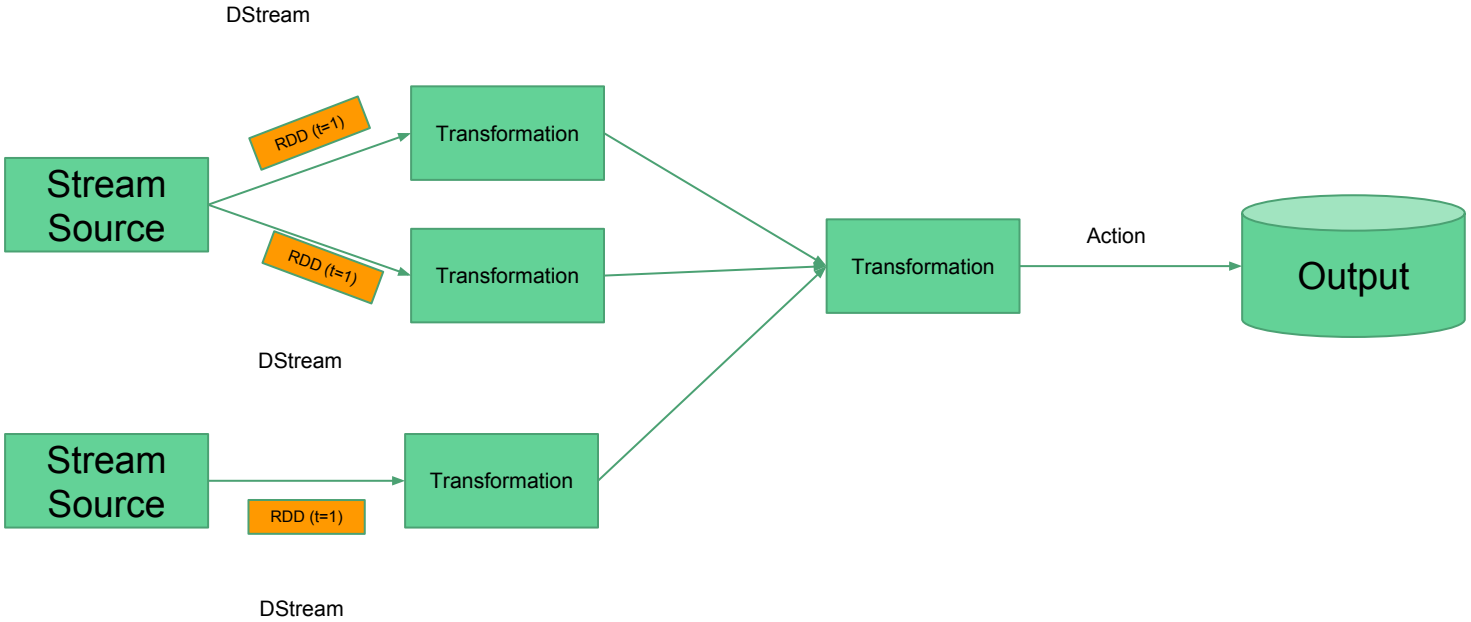
- Spark Core has a robust way for creating computation graphs on batch data
- How can we extend this to streaming data?

How Spark Handles Streaming

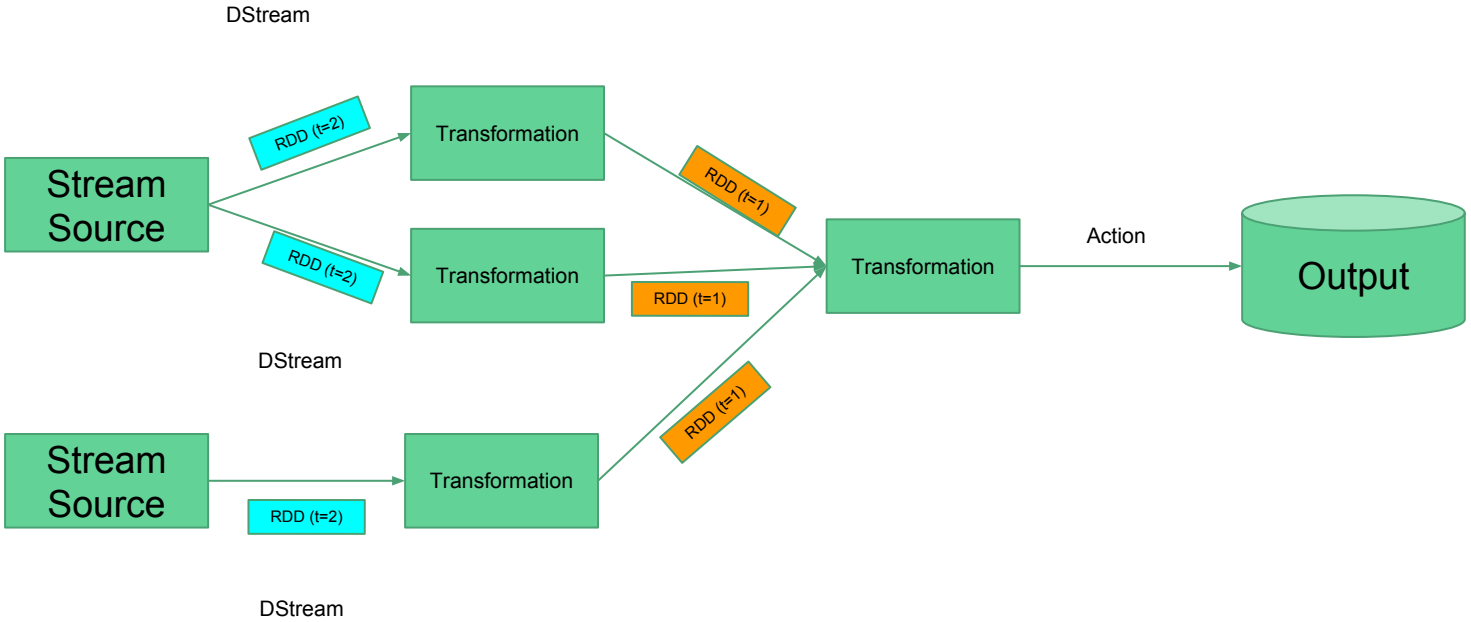
How Spark Handles Streaming



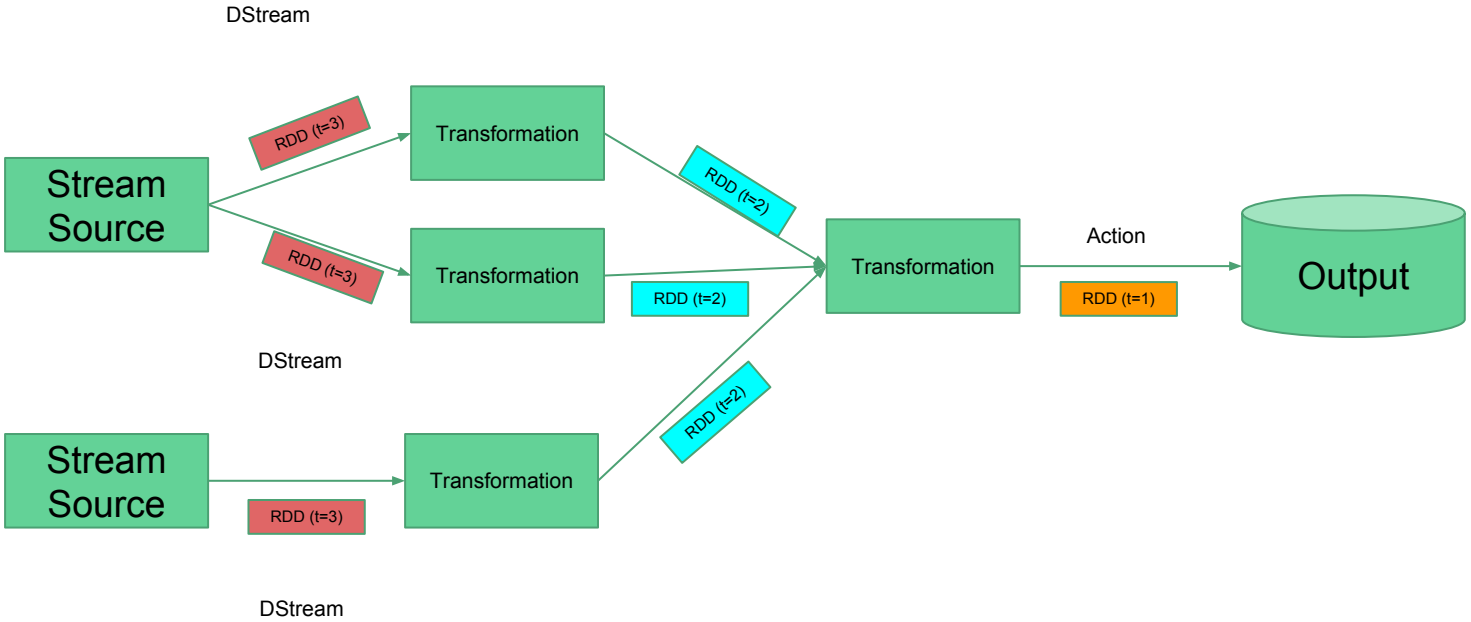
How Spark Handles Streaming



How Spark Handles Streaming



How Spark Handles Streaming



How Spark Handles Streaming

- DStream
  - “Discretized Stream” which represents an infinite stream of data
  - In actuality, it’s a (endless) sequence of RDDs
- Spark Streaming Context
  - Similar to the Spark Context, except it handles DStreams
  - Has a user-defined batch interval
    - Defines the window size for RDDs
- Job Processing
  - Executed in multiples of the batch interval

Spark Stream Sources

- Built-in Data Sources
  - File Stream - Load new files in a given directory
  - Socket Stream - Listen on a TCP connection for new data

- Additional Supported Stream Sources
  - Kafka (Apache)
  - Flume (Apache, in the Hadoop ecosystem)
  - Kinesis (AWS)

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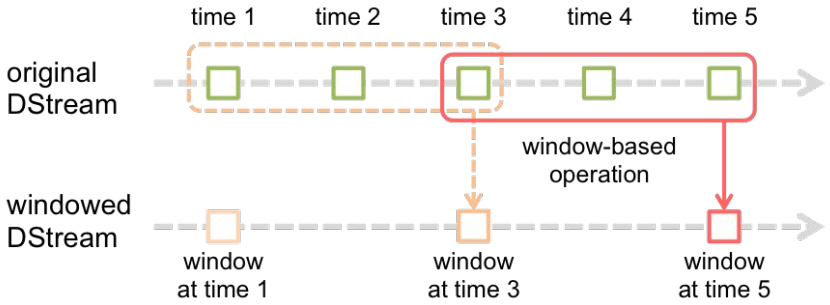
Spark Streaming Programming

- Transformations
  - Operations on DStreams (mostly) identical to RDDs
  - Functions: Map, Filter, Join, etc.

- Windowed Operations
  - Applied transformation on a time-based window of data
  - Functions: CountByWindow, ReduceByWindow, etc.



Spark Streaming Programming

- Stateful Operations
  - So far, we're limited to "seeing" data within our current window
  - What if we need arbitrary state?
  - Functions: "UpdateStateByKey"
    - Uses an RDD to keep a persistent state

- The "Transform" Function
  - Allows you get access to the underlying DStream RDD
  - Used for "combining" DStream data with arbitrary RDDs
    - i.e. Join streamed data on precomputed data

Spark Streaming Programming Example

```
from pyspark import SparkContext
from pyspark.streaming import StreamingContext


# local streaming context with two threads
sc = SparkContext("local[2]", "NetworkWordCount")
ssc = StreamingContext(sc, 1)  # batch interval of 1 second

# DStream that pulls from localhost:8888
lines = ssc.socketTextStream("localhost", 8888)
```

Spark Streaming Programming Example

```
# We can use the lines DStream almost like a normal RDD
filtered = lines.filter(lambda l: 'cloud' in l).flatMap(lambda x: x.split()
key_on_word = filtered.map(lambda w: (w, 1))

# Count in window lengths of 30 seconds, evaluated every 10 seconds
windowed = key_on_word.countByValueAndWindow(30, 10)

# We can call an action on DStreams like RDDs
windowed.pprint()

# Start stream processing
ssc.start()
```

MP4 - Spark Streaming

- Will be released Tonight.
- Due next Tuesday at 11:59pm (as normal)

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CS398 Final Project

- **Goal:** Perform exploratory analysis on a large dataset using cloud technologies
- **High Level Overview:**
  - Choose a dataset; Perform some type of novel analysis; Document and present your findings
- **Components**:
  - Group Selection
  - Project Proposal
  - Project Presentation
  - Project Report
  - Peer Evaluation

CS398 Final Project

- **Group Selection**
  - Project groups must have 3-4 students
  - You may select your own groups
    - We will also open the Piazza group selection forum
  - Group selection will be “locked in” by submitting a form on **March 10th at 11:59pm**
    - **March 9th - Drop Deadline**

CS398 Final Project

- **Dataset Selection**
  - **Groups are free to pick datasets given:**
    - Dataset size is between 3GB - 500GB
    - You have the rights to use it for educational purposes
  - **Groups will be given cluster or S3 space to place their dataset**
    - Groups are responsible for loading the dataset into S3 / the cluster
  - **Final Project page lists many example datasets**
    - i.e. Government data, AWS public data, etc.
  - **Due in your Project Proposal**

CS398 Final Project

- **Project Proposal**
  - Addresses:
    - What dataset you'll be using
    - What technologies / frameworks you'll be using
    - Hypotheses about the data that you plan to test
    - Briefly defend the utility / novelty of your planned work
  - Should be detailed enough to have an idea of what you'll be working on
  - You may deviate from your proposal as you work
  - **Due March 16th at 11:59pm**

CS398 Final Project

- **Project Work**
  - **All work on projects will be independent of the class**
    - MPs will continue to be released
  - **Groups are encouraged to use the course cluster**
  - **Groups may request additional software / resources**
    - Requests will be evaluated by course staff

CS398 Final Project

- **Project Report**
  - The “final product” of your work
  - Should address:
    - What datasets / frameworks you ultimately used
    - What results / insights / knowledge you recovered from the data
    - What issues did you encounter during the project; how did you resolve them
  - All application code must be submitted
  - Should include a brief performance report
  - **Due May 2nd at 11:59pm** (Day before Reading Day)

CS398 Final Project

- **Project Report Grading**
  - **Usage of Cloud Computing (40%)**
    - Did your project make adequate use of the CC technologies discussed in class?
  - **Treatment of Dataset (20%)**
    - Did your project make logical use of the dataset you chose?
  - **Application Novelty (20%)**
    - Did your group attempt to do something new and interesting? (Not WordCount™ 2.0)
  - **Formatting (10%)**
    - Is your report coherent? Does it contain all components?
  - **Code Submission (10%)**
    - Did you submit all the code necessary to replicate your results?

CS398 Final Project

- **Project Presentation**
  - Conducted during the last 2 weeks of lecture
    - **April 23, April 25, April 30**
  - Present high-level findings of your project in 8-10 minutes
    - What dataset did you use?
    - What technologies did you use?
    - What were your results? What applications do your findings have?

CS398 Final Project

- **Peer Evaluation**
  - Evaluation of Group Members
    - You will evaluate the contributions of your group members
    - You will be graded (in part) by the evaluations of your group members
  - Evaluation of Other Groups
    - You must attend *at least* 2 of the 3 project presentation days
    - You will evaluate the presentations of the other groups that present on those days
    - You will be graded (in part) by the evaluations of your peers

CS398 Final Project

- **Grading Overview**:
  - Group Selection: **5%**
  - Project Proposal: **10%**
  - Project Report: **45%**
  - Project Presentation: **20%**
  - Peer Evaluation: **10% + 10%**

CS398 Final Project

- **Deadline Overview**:
  - **Group Selection:** March 10th (Week 8)
  - **Project Proposal:** March 16th (Week 9, Right before Spring Break)
  - **Project Report:** May 2nd (Week 16, Right before Reading Day)
  - **Project Presentation:** During scheduled lecture times, Weeks 15-16
  - **Peer Evaluation**
    - Evaluation of peers: During scheduled lecture times, Weeks 15-16
    - Group member evaluation: Due right before Reading Day