

Individual HW: 02

CS51510-001, fall 2025

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Abstract

Design and implement a memory database using singly Linked List data structure, that is able to read the student data from the CSV file, adopt to any changes done in the CSV file and write it a output CSV file.

Introduction

This document is part of Algorithms course (51510-001), individual homework-2. The goal of the document is to create a memory database using Linked list, that can store student details from a CSV file, Adapt to changes that are done to the CSV file, and write the output in a new CSV file.

We first download the student dataset from the given website

<https://www.kaggle.com/datasets/kellygakii/student-data-csv>. The implementation of this memory database has been done in two programming languages JAVA and PYTHON

The below document explains the Student class- which defines the attributes of a student (from CSV), Then it explains the singly Linked List class and its functionalities, leading us to the implementation of the memory database with the given constraints, finally we end the document with the results screenshot and sample test cases to prove the working of the memory database.

User Story

I want a lightweight **in-memory** database to store **variable** number of student records, I should be able to read and store the student records from a **CSV file** and the database to adopt to any insertions or deletion in the CSV file **automatically** and finally I should be able to **export** the database to a CSV file.

1.1 Acceptance criteria

- **Recursively** read the *student-data.csv* file to the memory database
- Adapt to any changes in the CSV file
- Export the in-memory database to a CSV file
- Should be able to run in **Ubuntu** environment
- Need the solution in **Java** and **Python**
- Provide output Screen shots to prove the working

1. Software Design

We are given with five constraints to follow while building the memory database and there are as follows,

- Use a **Singly linked List** for the in-memory database as the size of the dataset can scale in real-time
- Follow **Recursive** functions since the user specified it
- Use **file watcher** service to observe if there is any file modification change and reload the database
- Reload **only** the changes not the entire database
- Provide **Object-oriented** solution using Java and Python

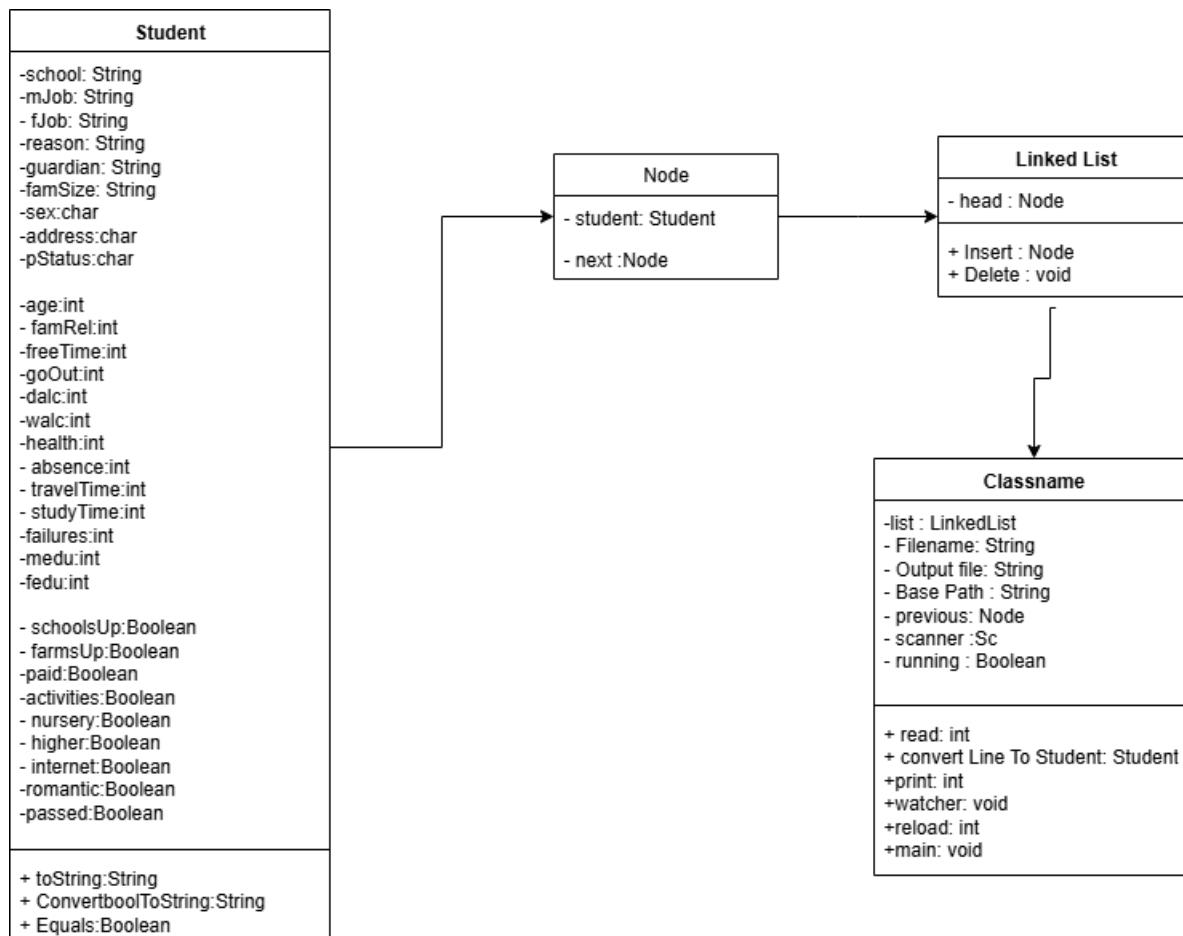


Figure 1-Class diagram

2. Student Class

this is the blueprint of the student details that are supposed to be read and stored in the Linked List. From the given CSV file we can see there are 31 features to a student which included school, age, sex and paid.

```

Class Student{
    String school;
    .
    .
    Character sex;
    .
    .
    Integer age;
    .
    .
    Boolean paid;
    .
    .
    Boolean Equals(student2)
    String toString(student)
}

```

The class also contains a constructor method to convert the read CSV row (CSV reader returns a comma separated String line) to Student object. Two student attributes/methods one to convert the Student object to comma separated String, which can be written back to the CSV file and an equals methods that checks the equality of two student objects.(See Appendix section for the full Student class implementation)

Note not all the attributes of the Student class are String objects, some are of primitive data types like char, Int and Boolean. This allocation of different data types is to improve the program efficiency by reducing the memory required by String data type.

1.1 Equals()/_eq_()

It is an overwritten method of the equals() method provided by the Object class. By default it compares two object's memory location if same return equal (shallow comparison). We over write the method to compare the member variables of the two objects and say they are equal or not (deep comparison)

```

String toString(student){
    Return school +","+sex+","+", "+age+"," +address+....."
}

```

1.2 `toString()/_str_`

It is a overwritten method of the `toString()` methods provided by the `Object` class. By default it converts the object to string so that it can be used to print/debug/ We overwrite the method to return the Object in a specific string format (Comma separated values)

```
Boolean equals(obj){  
    Return school == obj.school && age == obj.age && sex =obj.sex ..... ;  
}
```

Note we don't need to specify the keyword `this` to specify to point to the class variable, since it is a member method

1.3 Convert Boolean to string

The user understands only the way that is specified in the input, we can convert the value and store in the memory but it is important to speak the same language of the user. The user document contains "yes" "no" instead of True/False, so the output should also be in the same language.

2. Linked List class

This class defined a singly linked list, with a static inner class which is used to define a Node.

The inner class `Node` define how a Linked list node should be like, Since it is a singly Node, it contains the student data and a pointer to the next Node. It also has a constructor which initializes the `Node` object with the student data and always the next Node address is set to null by default. Refer Appendix for the implementation

```
Static inner class Node{  
    Student student;  
    Node next;  
    Node(student){  
        This.student=student  
        This.next=null  
    }  
}
```

The outer class defined the structure of the Linked list on whole, initially the Linked list only contains the head Node and we can chain in any number of Nodes as and when needed. So the class only contains a head of type `Node`, Along with the function like insertion of a new node at the end of `LinkedList`. Refer Appendix for the implementation

```

Class LinkedList{

    Node head;

    Static inner class Node{...}

    Node insert(currentNode , student, nextNode) {}

    Node delete(prevNode,nextNode) {}

}

```

2.1. Insert Method

This class method is used to insert a node as the head Node if List is empty or at the back of an existing Linked List; this accepts current last nod, the Student details object and the next Node (If there is no next Node it is null). It returns the updated last node, i.e. the current node.

```

Node insert(currentNode, student, nextNode){

    newStudent = Node(student)

    newStudent.next = nextNode

    if head==null

        head=newStudent

    else

        currentNode.next=newStudent

    return newStudent

}

```

2.2 Delete Method

This class method is used to delete the Node. We mean delete is we unlink the node from the linked list so that the garbage collector can remove the hanging Node. This method accepts the previous node and the next node, so that the pointer of the previous node can be set to the next node, making the current node hanging.

```

Delete (previousNode, nextNode){

If previousNode = null //delete the head node

    Head = nextNode

Else

    previousNode.next = nextNode

}

```

3. Memory Database

This is the class that is responsible for creating and maintaining the memory database using the linkedList class. It has 4 member variables, LinkedList, inputFile, output file, a condition variable and a scanner object. It also has a constructor to instantiate the member variables (We use constructor based dependency injection) along with the following methods.

```
Class MemoryDatabase{  
    LinkedList() list  
  
    String inputFile  
  
    String outputFile  
  
    Scanner sc  
  
    Boolean condition  
  
    MemoryDatabase(LinkedList list, inputFile, outputFile, Scanner sc){  
  
        This.list =list  
  
        This.inputFile = inputFile;  
  
        This.outputFile= outputFile  
  
        This.sc =sc  
  
        This.condition = true  
  
    }  
  
<Following methods>  
}
```

3.1. Read the CSV file

Firstly we convert the CSV file to a built-in Reader object, to facilitate successful reading of the file.

```
BufferedReader br = new BufferedReader(new FileReader(<Input.csv>)
```

We can now invoke the readLine() method of the Reader class to read the row one by one. This method reads one row at a time and moves the pointer to the next line internally, so that we invoke the method again the next line of the file is read returning the entire comma separated row as a String.

```
Br.readLine()
```

We skip the header row/ Capture the header separately to use it while printing the output CSV.

We can have a dedicated method to recursively read the CSV file and add the student details at the end of the Linked List.

3.2. Read method

This method recursively calling `readLine()` method to read the Reader object until the end of file is reached and calls the `linkedList.insert()` method to insert a new node. Accepts the Reader object and the last node of the Linked List (Initially, Reader and head node) It return status code 0 as a completion reading the file to EOF.

The `readLine()` method return a comma separated String which is first split into a string array using regular exp `,` before being converted into student class object. We again convert some String into int,char and Boolean to match with the student class data types.

Once we have the student, we call the `LinkedList.insert()` list to insert in the linked list, which return the last node of the Linked list.

We recursively call the `read()` method with the Reader object (read pointer is managed by the object itself) and the updated last nod of the Linked List.

```
Int read(Reader,lastNode){  
    String row = reader.readLine()  
    If row == null    //If EOF  
        Return 0;  
    String[] line = row.split(",")  
    Student student = convertStringToStudent(line)  
    Node node = LinkedList.insert(lastNode,student)  
    Return read(Reader,node)  
}
```

3.3. File Watcher

A separate thread that is responsible to notify if there is any modifications in the given CSV file. This monitors the file continuously until there is a keyboard interrupts to stop the watching process. When there is any change in the file it triggers a utility method to detect what and where the change happened in the CSV file and make changes to the Linked list accordingly. Accepts and return void.

3.4. Reload Method

This utility method recursively checks the File using the file Reader object for any changes, the check happens by comparing the file lines with the Node of the Linked list, The check can be of three type,

3.4.1. Both file and the Linked list has not reached the end

If there is any mismatch is the row and the corresponding Node of the linked list, then there is a flag of something is changed, The key idea to find if something is inserted or deleted is if something need to be deleted from the linked list then the next node of the linked list will be equal to the current row of the linked list or null else it is insertion operation.

If current.next is not null and reader is not null

If currentRow is not currentNode.student

If currentRow is equal to nextNode.student

Delete current note

Else

Insert current row in the Linked list

3.4.2 File has reached the end and not the Linked List

If there are extra node in the Linked list and not the file then those node needs to be deleted from the linked list

If current.next is not null and reader is null

Delete current node

3.4.3 Linked list has reached the end and not the File

If there are extra rows in the File and not the linked list then those rows needs to be added at the end of the linked list.

If current.next is null and reader is not null

Insert current row in the Linked list

3.4.4 Both file and Linked list has reached the end

Both the linked list and the File is in Sync and we can safely return back to the calling function

3.5. Prepare for printing

Open the Output csv file in writer mode using the in build writer object.

```
PrintWriter printWriter = new PrintWriter(new FileWriter(<Output.csv>));
```

We can now use the `println()` method which is part of `printWriter` to write our content in the newline.

Also write the header line which was read and stored separately during the read step

```
printWriter.println(header);
```

Now we can call the dedicated method that traverses the Linked List and print the student details in the CSV recursively.

Note `print()` method writes in the same line and `println()` write in a new line, and the printer writer class keep track of the last line written and points to the next available line.

3.6. Print Linked List

This method is used to traverse and print the linked list node by node recursively in the output CSV file. This method accepts the Writer object and the current Node (Initially passing the head node). And returns the completion status when reached the last node of the Linked list.

Get the student object from the current node and convert it to comma separated String. Also use the `println()` method of the Writer object to write the comma separated string in the CSV file. Finally check if this is the last node of the Lisnked List if yes return the completion status else recursively call the `print()` method with the updated `currentNode.next` and the writer object.

```
print(writer,currentNode){  
    Row = currentNode.student.toString()  
    Writer.println(row)  
    If currentNode.next == Null  
        Return 0  
    Return print(writer,currentNode.next)  
}
```

3.7. Prepare to execute/ main()

Get the input csv file and the output file location from the user as input parameters

1. Instantiate the memory Database class by passing the input filename, output file name and the Linked list class object as constructor parameters
2. Open the input file using the Reader object and the output file using Writer object.
3. Read the header line before calling the `read()` method to recursively read the rest of file

4. Create a new thread watcherService() and load it with the watcher method
5. Start the watcher thread, which pause the current/main thread
6. Wait until the watcher thread completes and joins with the main thread
7. Print the header into the output CSV file before calling the print() to recursively print all the node of linked list to the output.csv recursively.

Step 2 to Step 7 might throw different exception including file not found, so enclose all in a try block and handle all the exception collectively using the catch block.

4. Executing the Program

Make sure all the source program and the required data have been downloaded and in place. The folder structure is given as follows,

Downloads

```
|  
AlgoIndHw2-main  
|  
IndHw2  
|  
---- Java  
|  
----LinkedList.java  
----Student.java  
----MemoryDatabase.java  
-----Python  
|  
----LinkedList.java  
----Student.java  
----MemoryDatabase.java  
-----Data
```

|
----student-data.csv

Also make sure to change the student-data.csv file after starting the executions of the program, to verify the adoption of Linked List with any changes respect to the CSV file, you can **refer to one of the sample test cases below.**

1. Using Java

To execute,

Open terminal where we have the python programs **Downloads>AlgoIndHw2->main>IndHw2>Java**

“javac *.java” – this compiles the all the java files in the current directory to the .class file

“java *MemoryDatabase*” – this executes the *MemoryDatabase.class* file which has the main method and that is used for executing a java program, The rest two classes are dependents so those are executed when the program initializes them internally.

Note the class file name is the same as the java class name given in “*MemoryDatabase.java*”. We can also run the java file in one command “java *MemoryDatabase.java*” but it is not recommended for large scale applications. Also it is worthy to mention running the java *MemoryDatabase* only triggers the main main even the *Memory database* class and it methods needs to be initialized inside the main method (Static and not static methods)

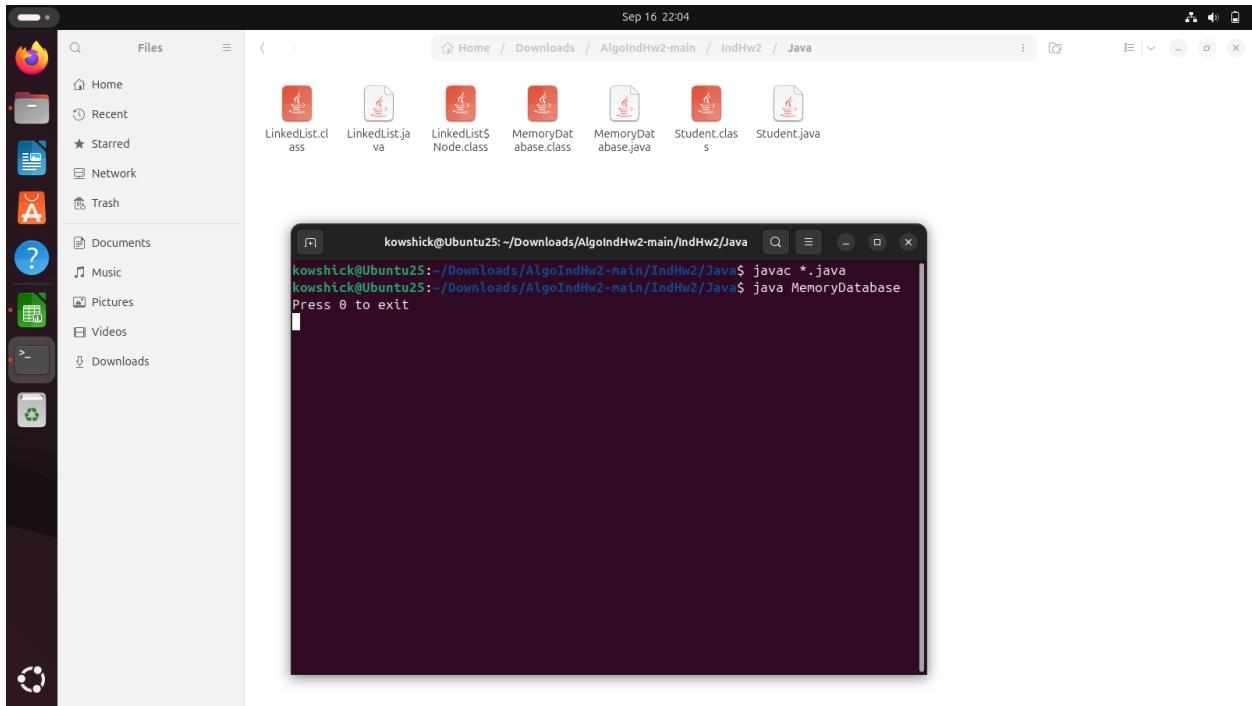


Figure 2- Compile and run the Java program

The screenshot shows a LibreOffice Calc interface with a terminal window overlaid. The terminal window displays Java code execution and file monitoring logs.

Terminal Output:

```
kowshick@Ubuntu25:~/Downloads/AlgoIndHw2-main/IndHw2/Java$ javac *.java
kowshick@Ubuntu25:~/Downloads/AlgoIndHw2-main/IndHw2/Java$ java MemoryDatabase
Press 0 to exit
student-data.csv has changed!
0
Stopping watcher...
kowshick@Ubuntu25:~/Downloads/AlgoIndHw2-main/IndHw2/Java$
```

LibreOffice Calc Worksheet:

student-data.csv — LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

Cells A4:XFD4

Formulas f, Σ = GP

	A	B	C	D	E	F
1	school	sex	age	address	famsize	Pstatus
2	GP	F	18U	GT3	A	T
3	GP	F	17U	GT3	T	T
4	GP	F	17U	GT3	T	T
5	GP	F	15U	LE3	T	T
6	GP	F	15U	GT3	T	T
7	GP	F	16U	GT3	T	T
8	GP	M	16U	LE3	T	T
9	GP	M	16U	LE3	T	T
10	GP	F	17U	GT3	A	T
11	GP	M	15U	LE3	A	T
12	GP	M	15U	GT3	T	T
13	GP	F	15U	GT3	T	T
14	GP	F	15U	GT3	T	T
15	GP	M	15U	LE3	T	T
16	GP	M	15U	GT3	T	T
17	GP	M	15U	GT3	A	T
18	GP	F	16U	GT3	T	T
19	GP	F	16U	GT3	T	T
20	GP	F	16U	GT3	T	T
21	GP	M	17U	GT3	T	T
22	GP	M	16U	LE3	T	T
23	GP	M	15U	GT3	T	T
24	GP	M	15U	GT3	T	T
25	GP	M	16U	LE3	T	T
26	GP	M	16U	LE3	T	T
27	GP	F	15R	GT3	T	T
28	GP	F	16U	GT3	T	T
29	GP	M	15U	GT3	T	T
30	GP	M	15U	GT3	T	T

student-data

Sheet 1 of 1 Selected: 1 row, 16,384 columns Default English (USA) Average: 3.23076923076923; Sum: 42

Figure 3- Do changes to CSV when program is running

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet	romantic
2	GP	F	18	U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	true	false	false	true	true	false	fe	
3	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	false	true	false	false	true	true	fe	
4	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	false	true	false	false	true	true	fe	
5	GP	F	15	U	LE3	T	1	1	at_home	other	other	mother	1	2	3	true	false	true	false	true	true	fe	
6	GP	F	15	U	GT3	T	4	2	health	services	home	mother	1	3	0	false	true	true	true	true	true	tr	
7	GP	F	16	U	GT3	T	3	3	other	other	home	father	1	2	0	false	true	false	true	true	false	fe	
8	GP	M	16	U	LE3	T	4	3	services	other	reputation	mother	1	2	0	false	true	true	true	true	true	fe	
9	GP	M	16	U	LE3	T	2	2	other	other	home	mother	1	2	0	false	false	false	true	true	true	fe	
10	GP	F	17	U	GT3	A	4	4	other	teacher	home	mother	2	2	0	true	true	false	false	true	true	fe	
11	GP	M	15	U	LE3	A	3	2	services	other	home	mother	1	2	0	false	true	true	false	true	false	fe	
12	GP	M	15	U	GT3	T	3	4	other	other	home	mother	1	2	0	false	true	true	true	true	true	fe	
13	GP	F	15	U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	false	true	true	false	true	true	fe	
14	GP	F	15	U	GT3	T	2	1	services	other	reputation	father	3	3	0	false	true	false	true	true	true	fe	
15	GP	M	15	U	LE3	T	4	4	health	services	course	father	1	1	0	false	true	true	true	true	true	fe	
16	GP	M	15	U	GT3	T	4	3	teacher	other	course	mother	2	2	0	false	true	false	true	true	true	fe	
17	GP	M	15	U	GT3	A	2	2	other	other	home	other	1	3	0	false	true	false	true	true	tr		
18	GP	F	16	U	GT3	T	4	4	health	other	home	mother	1	1	0	false	true	true	false	true	true	fe	
19	GP	F	16	U	GT3	T	4	4	services	services	reputation	mother	1	3	0	false	true	true	true	true	true	fe	
20	GP	F	16	U	GT3	T	3	3	other	other	reputation	mother	3	2	0	true	true	false	true	true	false	fe	
21	GP	M	17	U	GT3	T	3	2	services	services	course	mother	1	1	3	false	true	false	true	true	true	fe	
22	GP	M	16	U	LE3	T	4	3	health	other	home	father	1	1	0	false	false	true	true	true	true	fe	
23	GP	M	15	U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	false	false	false	true	true	true	fe	
24	GP	M	15	U	GT3	T	4	4	health	health	other	father	1	1	0	false	true	true	false	true	true	fe	
25	GP	M	16	U	LE3	T	4	2	teacher	other	course	mother	1	2	0	false	false	true	true	true	true	fe	
26	GP	M	16	U	LE3	T	2	2	other	other	reputation	mother	2	2	0	false	true	false	true	true	true	fe	
27	GP	F	15	R	GT3	T	2	4	services	health	course	mother	1	3	0	true	true	true	true	true	true	fe	
28	GP	F	16	U	GT3	T	2	2	services	services	home	mother	1	1	2	false	true	true	false	false	true	fe	
29	GP	M	15	U	GT3	T	2	2	other	other	home	mother	1	1	0	false	true	true	true	true	true	fe	
30	GP	M	15	U	GT3	T	4	2	health	services	other	mother	1	1	0	false	true	false	true	true	true	fe	

Figure 4- Updated output CSV

2. Using Python

To execute

Open terminal where we have the python programs **Downloads>AlgolIndHw2-main>IndHw2>Python**

“*python3 MemoryDatabase.py*” – command interprets and executes the code.

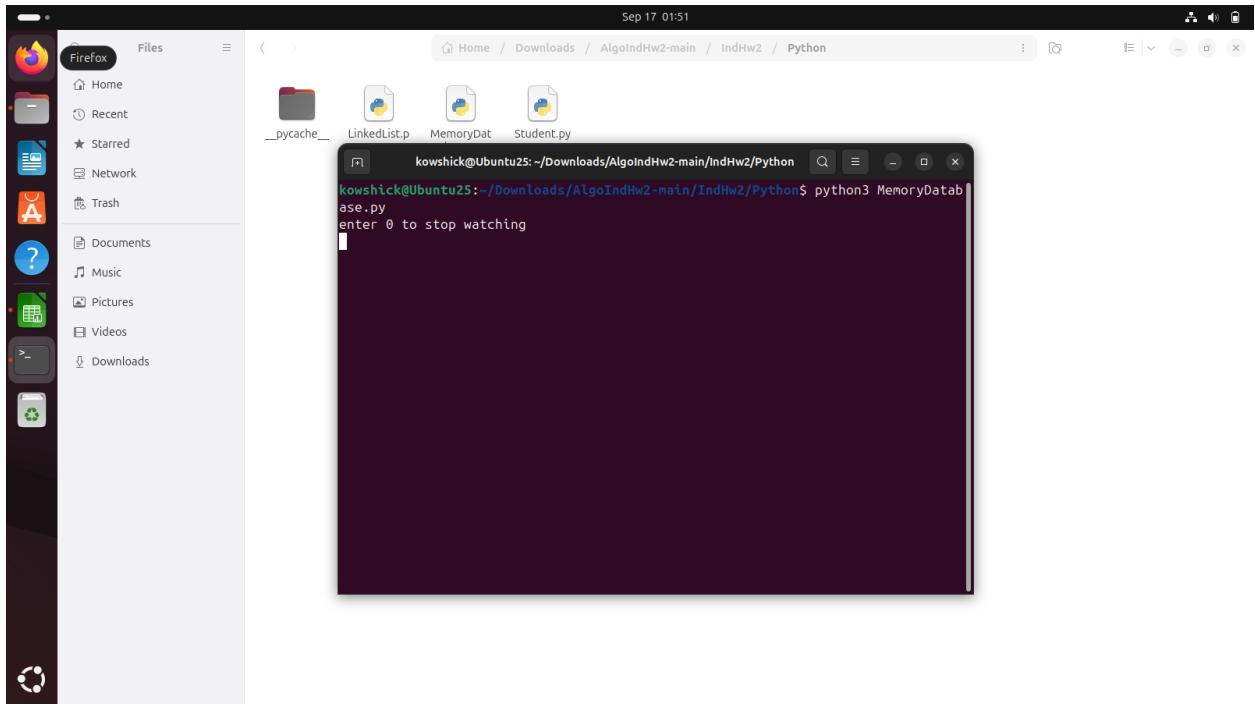


Figure 5- Run the python program

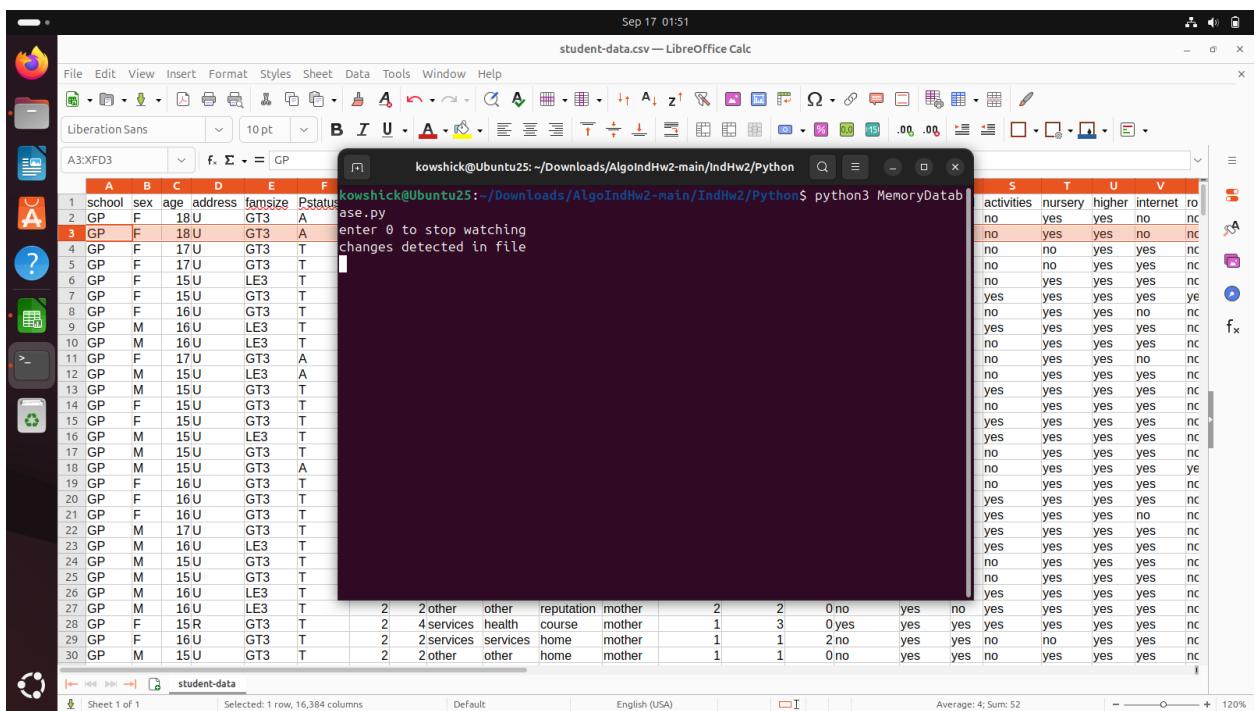


Figure 6- Do changes in CSV and detected by program

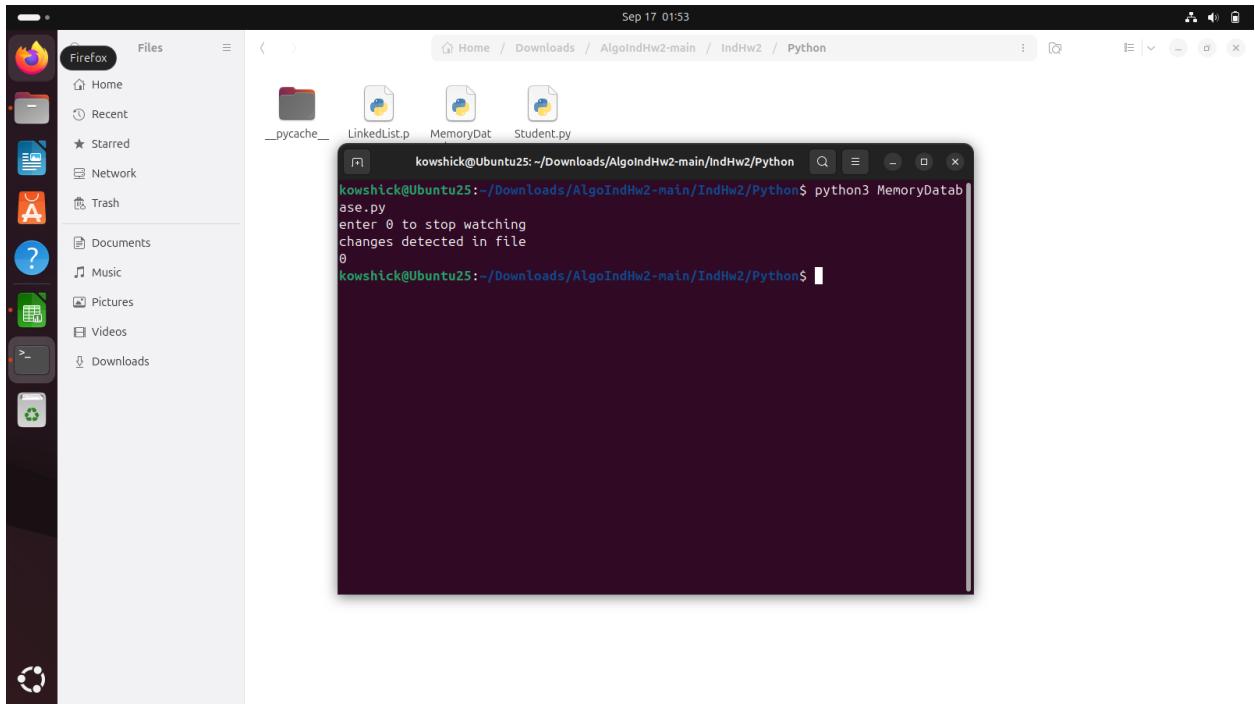


Figure 7- Stop the watcher

student-op-data.csv — LibreOffice Calc																																																
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	school	sex	age	address	famsize	Pstatus	Medu	Feu	Mjob	Fjob	reason	guardian	traveltime	studystime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet	r
1	GP	F	18	U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
2	GP	F	18	U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
3	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	False	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
4	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	False	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
5	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	False	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
6	GP	F	15	U	GT3	T	4	2	health	services	home	mother	1	3	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
7	GP	F	15	U	GT3	T	4	2	health	services	home	mother	1	3	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
8	GP	M	16	U	LE3	T	4	3	services	other	reputation	mother	1	2	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
9	GP	M	16	U	LE3	T	4	3	services	other	reputation	mother	1	2	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
10	GP	F	17	U	GT3	A	4	4	other	teacher	home	mother	2	2	0	True	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
11	GP	F	17	U	GT3	A	4	4	other	teacher	home	mother	2	2	0	True	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
12	GP	M	15	U	GT3	T	3	4	other	other	home	mother	1	2	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
13	GP	M	15	U	GT3	T	3	4	other	other	home	mother	1	2	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True													
14	GP	F	15	U	GT3	T	2	1	services	other	reputation	father	3	3	0	False	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
15	GP	F	15	U	GT3	T	2	1	services	other	reputation	father	3	3	0	False	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
16	GP	M	15	U	GT3	T	4	3	teacher	other	course	mother	2	2	0	False	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
17	GP	M	15	U	GT3	T	4	3	teacher	other	course	mother	2	2	0	False	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
18	GP	F	16	U	GT3	T	4	4	health	other	home	mother	1	1	0	False	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
19	GP	F	16	U	GT3	T	4	4	health	other	home	mother	1	1	0	False	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True												
20	GP	F	16	U	GT3	T	3	3	other	other	reputation	mother	3	2	0	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
21	GP	F	16	U	GT3	T	3	3	other	other	reputation	mother	3	2	0	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
22	GP	M	16	U	LE3	T	4	3	health	other	home	father	1	1	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
23	GP	M	16	U	LE3	T	4	3	health	other	home	father	1	1	0	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
24	GP	M	15	U	GT3	T	4	4	health	other	other	father	1	1	0	False	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
25	GP	M	15	U	GT3	T	4	4	health	other	other	father	1	1	0	False	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
26	GP	M	16	U	LE3	T	2	2	other	other	reputation	mother	2	2	0	False	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
27	GP	M	16	U	LE3	T	2	2	other	other	reputation	mother	2	2	0	False	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False												
28	GP	F	16	U	GT3	T	2	2	services	services	home	mother	1	1	2	False	True	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False											
29	GP	F	16	U	GT3	T	2	2	services	services	home	mother	1	1	2	False	True	True	False	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False											
30	GP	M	15	U	GT3	T	4	2	health	services	other	mother	1	1	0	False	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False											

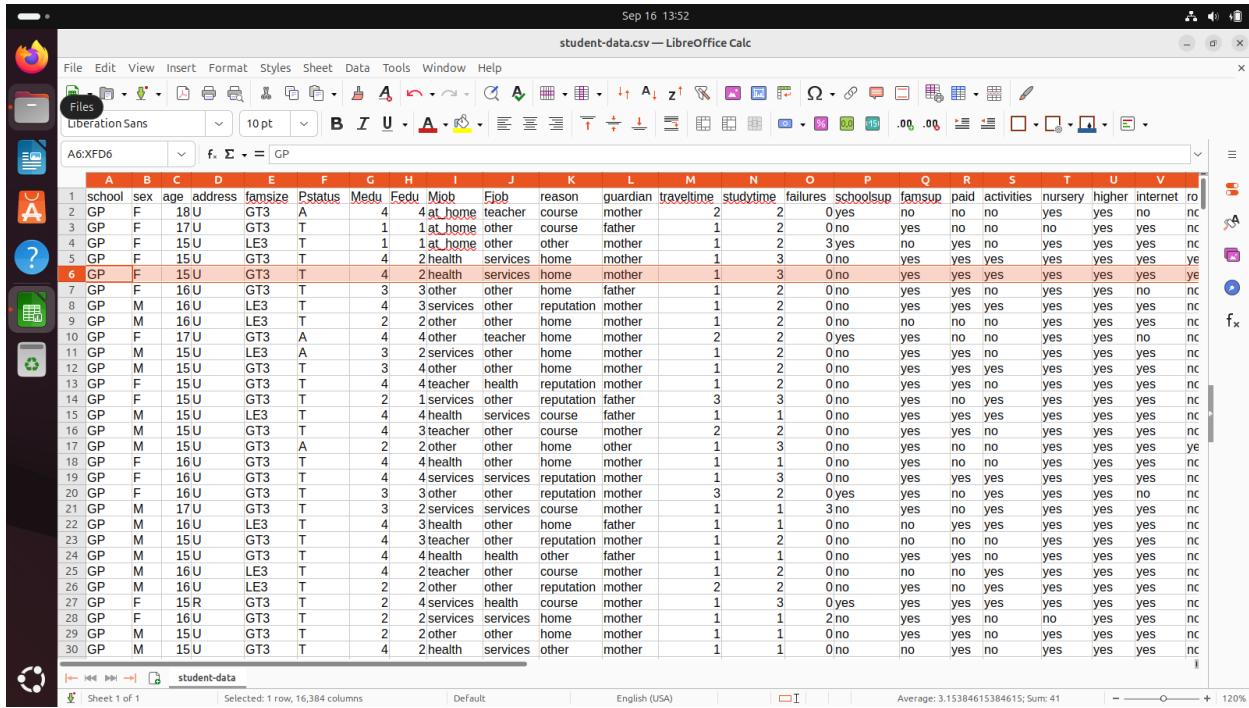
Figure 8- Output reflecting the changes

5. Sample Test Cases

5.1. Base cases

5.1.1 Insert at middle

Insert a student record somewhere in the middle of the existing CSV as shown



The screenshot shows a LibreOffice Calc spreadsheet titled "student-data.csv". The spreadsheet contains 30 rows of student data. A new row has been inserted at row 6, which is highlighted with a red background. The new row contains the following values:

school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet	romantic
GP	F	18U	GT3	A	4	4	4	at_home	teacher	course	mother	2	2	0	yes	no	no	yes	yes	no	nc	
GP	F	17U	GT3	T	1	1	1	at_home	other	course	father	1	2	0	no	yes	no	no	yes	yes	nc	
GP	F	15U	LE3	T	1	1	1	at_home	other	other	mother	1	2	3	yes	no	yes	yes	yes	yes	nc	
GP	F	15U	GT3	T	4	4	2	health	services	home	mother	1	3	0	no	yes	yes	yes	yes	yes	ye	
6	GP	F	15U	GT3	T	4	2	health	services	home	mother	1	3	0	no	yes	yes	yes	yes	yes	ye	
7	GP	F	16U	GT3	T	3	3	other	other	home	father	1	2	0	no	yes	yes	no	yes	yes	no	
8	GP	M	16U	LE3	T	4	3	services	other	reputation	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
9	GP	M	16U	LE3	T	2	2	other	other	home	mother	1	2	0	no	no	no	yes	yes	yes	nc	
10	GP	F	17U	GT3	A	4	4	other	teacher	home	mother	2	2	0	yes	yes	no	yes	yes	no	nc	
11	GP	M	15U	LE3	A	3	3	2	services	other	home	mother	1	2	0	no	yes	yes	yes	yes	nc	
12	GP	M	15U	GT3	T	3	3	other	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
13	GP	F	15U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	no	yes	yes	no	yes	yes	nc	
14	GP	F	15U	GT3	T	2	1	services	other	reputation	father	3	3	0	no	yes	no	yes	yes	yes	nc	
15	GP	M	15U	LE3	T	4	4	health	services	course	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
16	GP	M	15U	GT3	T	4	3	teacher	other	course	mother	2	2	0	no	yes	yes	no	yes	yes	yes	
17	GP	M	15U	GT3	A	2	2	other	other	home	other	1	3	0	no	yes	no	no	yes	yes	ye	
18	GP	F	16U	GT3	T	4	4	health	other	home	mother	1	1	0	no	yes	no	no	yes	yes	nc	
19	GP	F	16U	GT3	T	4	4	services	services	reputation	mother	1	3	0	no	yes	yes	yes	yes	yes	nc	
20	GP	F	16U	GT3	T	3	3	other	other	reputation	mother	3	2	0	yes	yes	no	yes	yes	no	nc	
21	GP	M	17U	GT3	T	3	2	2	services	services	course	mother	1	1	3	no	yes	no	yes	yes	nc	
22	GP	M	16U	LE3	T	4	3	health	other	home	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
23	GP	M	15U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	no	no	no	no	yes	yes	nc	
24	GP	M	15U	GT3	T	4	4	health	health	other	father	1	1	0	no	yes	no	yes	yes	yes	nc	
25	GP	M	16U	LE3	T	4	2	teacher	other	course	mother	1	2	0	no	no	no	yes	yes	yes	nc	
26	GP	M	16U	LE3	T	2	2	other	other	reputation	mother	2	2	0	no	yes	no	yes	yes	yes	nc	
27	GP	F	15R	GT3	T	2	2	4	services	health	course	mother	1	3	0	yes	yes	yes	yes	yes	yes	nc
28	GP	F	16U	GT3	T	2	2	2	services	services	home	mother	1	1	2	no	yes	yes	no	yes	yes	nc
29	GP	M	15U	GT3	T	2	2	other	other	home	mother	1	1	0	no	yes	yes	no	yes	yes	nc	
30	GP	M	15U	GT3	T	4	2	health	services	other	mother	1	1	0	no	no	yes	no	yes	yes	nc	

Figure 9- Insert at middle

Sep 16 14:08 student-op-data.csv — LibreOffice Calc

The screenshot shows a LibreOffice Calc spreadsheet titled "student-op-data.csv". The data consists of 30 rows of student information across 21 columns. A new row has been inserted at row 6, which contains the following values:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Edu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsups	famsup	paid	activities	nursery	higher	internet
2	GP	F	18U	GT3	A	4	4at_home	teacher	course	mother		2	2	0true	false	false	true	true	false	true	fe	nc
3	GP	F	17U	GT3	T	1	1at_home	other	course	father		1	2	0false	true	false	false	true	true	true	fe	nc
4	GP	F	15U	LE3	T	1	1at_home	other	other	mother		1	2	3true	true	false	true	true	true	true	fe	nc
5	GP	F	15U	GT3	T	4	2health	services	home	mother		1	3	0false	true	true	true	true	true	true	tr	nc
6	GP	F	15U	GT3	T	4	2health	services	home	mother		1	3	0false	true	true	true	true	true	true	tr	nc
7	GP	F	16U	GT3	T	3	3other	other	home	father		1	2	0false	true	true	false	true	true	true	fe	nc
8	GP	M	16U	LE3	T	4	3services	other	reputation	mother		1	2	0false	true	true	true	true	true	true	fe	nc
9	GP	M	16U	LE3	T	2	2other	other	home	mother		1	2	0false	false	false	true	true	true	true	fe	nc
10	GP	F	17U	GT3	A	4	4other	teacher	home	mother		2	2	0true	true	false	false	true	true	true	fe	nc
11	GP	M	15U	LE3	A	3	2services	other	home	mother		1	2	0false	true	true	false	true	true	true	fe	nc
12	GP	M	15U	GT3	T	3	4other	other	home	mother		1	2	0false	true	true	false	true	true	true	fe	nc
13	GP	M	15U	GT3	T	4	4other	other	home	mother		1	2	0false	true	true	false	true	true	true	fe	nc
14	GP	F	15U	GT3	T	2	1services	other	reputation	father		3	3	0false	true	false	true	true	true	true	fe	nc
15	GP	M	15U	LE3	T	4	4health	services	course	father		1	1	0false	true	true	true	true	true	true	fe	nc
16	GP	M	15U	GT3	T	4	3teacher	other	reputation	mother		2	2	0false	true	false	true	true	true	true	fe	nc
17	GP	M	15U	GT3	A	2	2other	other	course	mother		1	3	0false	true	false	false	true	true	true	fe	nc
18	GP	F	16U	GT3	T	4	4health	other	home	mother		1	1	0false	true	false	false	true	true	true	fe	nc
19	GP	F	16U	GT3	T	2	2other	other	home	mother		1	1	0false	true	true	false	true	true	true	fe	nc
20	GP	M	15U	GT3	T	4	2health	services	other	mother		1	1	0false	false	true	true	true	true	true	fe	nc
21	GP	F	16U	GT3	T	4	4services	other	reputation	mother		1	3	0false	true	true	true	true	true	true	fe	nc
22	GP	M	16U	LE3	T	4	3health	other	home	father		1	1	0false	false	true	true	true	true	true	fe	nc
23	GP	M	15U	GT3	T	4	3teacher	other	reputation	mother		1	2	0false	false	false	true	true	true	true	fe	nc
24	GP	M	16U	LE3	T	4	2teacher	other	course	mother		1	1	0false	true	false	true	true	true	true	fe	nc
25	GP	M	16U	LE3	T	2	2other	other	reputation	mother		2	2	0false	true	false	true	true	true	true	fe	nc
26	GP	F	15R	GT3	T	2	4services	health	course	mother		1	3	0true	true	true	true	true	true	true	fe	nc
27	GP	F	16U	GT3	T	2	2services	services	home	mother		1	1	2false	true	true	false	false	true	true	fe	nc
28	GP	M	15U	GT3	T	2	2other	other	home	mother		1	1	0false	true	true	false	true	true	true	fe	nc
29	GP	M	15U	GT3	T	4	2health	services	other	mother		1	1	0false	false	true	true	true	true	true	fe	nc
30	GP	M	16U	GT3	T	4	4services	other	home	mother		1	1	0false	true	false	true	true	true	true	fe	nc

Figure 10- Output reflecting insertion in middle

5.1.2 Delete from middle

Delete a student record somewhere from the middle of the existing CSV as shown

Sep 16 13:53 student-data.csv — LibreOffice Calc

The screenshot shows a LibreOffice Calc spreadsheet titled "student-data.csv". The data consists of 30 rows of student information across 21 columns. A row has been deleted from the middle of the dataset, specifically row 6. The row that was deleted contained the following values:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V		
1	school	sex	age	address	famsize	Pstatus	Medu	Edu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsups	famsup	paid	activities	nursery	higher	internet	
2	GP	F	18U	GT3	A	4	4at_home	teacher	course	mother		2	2	0yes	no	no	yes	yes	no	no	nc	nc	
3	GP	F	17U	GT3	T	1	1at_home	other	course	father		1	2	0no	yes	no	yes	yes	yes	yes	nc	nc	
4	GP	F	15U	LE3	T	1	1at_home	other	other	mother		1	2	3yes	no	yes	yes	yes	yes	yes	nc	nc	
5	GP	F	15U	GT3	T	4	2health	services	home	mother		1	3	0no	yes	yes	yes	yes	yes	yes	ye	ye	
6	GP	F	16U	GT3	T	3	3other	other	home	father		1	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
7	GP	M	16U	LE3	T	4	3services	other	reputation	mother		1	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
8	GP	M	16U	LE3	T	2	2other	other	home	mother		1	2	0no	no	no	yes	yes	yes	yes	nc	nc	
9	GP	F	17U	GT3	A	4	4other	teacher	home	mother		2	2	0yes	yes	no	yes	yes	yes	yes	nc	nc	
10	GP	M	15U	LE3	A	3	2services	other	home	mother		1	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
11	GP	M	15U	GT3	T	3	4other	other	home	mother		1	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
12	GP	F	15U	GT3	T	4	4teacher	health	reputation	mother		1	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
13	GP	F	15U	GT3	T	2	1services	other	reputation	father		3	3	0no	yes	no	yes	yes	yes	yes	nc	nc	
14	GP	M	15U	LE3	T	4	4health	services	course	father		1	1	0no	yes	yes	yes	yes	yes	yes	nc	nc	
15	GP	M	15U	GT3	T	4	3teacher	other	course	mother		2	2	0no	yes	yes	yes	yes	yes	yes	nc	nc	
16	GP	M	15U	GT3	A	2	2other	other	home	other		1	3	0no	yes	no	yes	yes	yes	yes	ye	ye	
17	GP	F	16U	GT3	T	4	4health	other	home	mother		1	1	0no	yes	no	yes	yes	yes	yes	nc	nc	
18	GP	F	16U	GT3	T	4	4services	services	reputation	mother		1	3	0no	yes	yes	yes	yes	yes	yes	nc	nc	
19	GP	F	16U	GT3	T	3	3other	other	reputation	mother		3	2	0yes	yes	no	yes	yes	no	nc	nc		
20	GP	M	17U	GT3	T	3	2services	services	course	mother		1	1	3no	yes	no	yes	yes	yes	yes	nc	nc	
21	GP	M	16U	LE3	T	4	3health	other	home	father		1	1	0no	no	yes	yes	yes	yes	yes	nc	nc	
22	GP	M	15U	GT3	T	4	3teacher	other	reputation	mother		1	2	0no	no	no	yes	yes	yes	yes	nc	nc	
23	GP	M	15U	GT3	T	4	4health	other	other	father		1	1	0no	yes	yes	no	yes	yes	yes	nc	nc	
24	GP	M	16U	LE3	T	4	2teacher	other	course	mother		1	2	0no	no	no	yes	yes	yes	yes	nc	nc	
25	GP	M	16U	LE3	T	2	2other	other	reputation	mother		2	2	0no	yes	no	yes	yes	yes	yes	nc	nc	
26	GP	F	15R	GT3	T	2	4services	health	course	mother		1	3	0yes	yes	yes	yes	yes	yes	yes	nc	nc	
27	GP	F	16U	GT3	T	2	2services	services	home	mother		1	1	2no	yes	yes	no	no	yes	yes	yes	nc	nc
28	GP	M	15U	GT3	T	2	2other	other	home	mother		1	1	0no	yes	yes	no	yes	yes	yes	nc	nc	
29	GP	M	15U	GT3	T	4	2health	services	other	mother		1	1	0no	no	yes	yes	yes	yes	yes	nc	nc	
30	GP	M	16U	LE3	A	3	4services	other	home	mother		1	2	0yes	yes	no	yes	yes	yes	yes	nc	nc	

Figure 11- Delete from middle

Sep 16 14:10 student-op-data.csv — LibreOffice Calc

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	school	sex	age	address	famsize	Pstatus	Medu	Medu	4at_home	teacher	course	mother	2	2	0true	false	false	true	true	false	fe
2	GP	F	18U	GT3	A	4	4at_home	teacher	course	father	1	2	0false	true	false	false	false	true	true	true	fe
3	GP	F	17U	GT3	T	1	1at_home	other	course	mother	1	2	3true	false	true	true	true	true	true	true	fe
4	GP	F	15U	LE3	T	1	1at_home	other	other	mother	1	2	0false	true	true	true	true	true	true	true	fe
5	GP	F	16U	GT3	T	3	3other	other	home	father	1	2	0false	true	true	false	true	true	true	false	fe
6	GP	M	16U	LE3	T	4	3services	other	reputation	mother	1	2	0false	true	true	false	false	true	true	true	fe
7	GP	M	16U	LE3	T	2	2other	other	home	mother	1	2	0false	false	false	false	false	true	true	true	fe
8	GP	F	17U	GT3	A	4	4other	teacher	home	mother	2	2	0true	true	false	false	false	true	true	false	fe
9	GP	M	15U	LE3	A	3	2services	other	home	mother	1	2	0false	true	true	true	false	true	true	true	fe
10	GP	M	15U	GT3	T	3	4other	other	home	mother	1	2	0false	true	true	true	true	true	true	true	fe
11	GP	F	15U	GT3	T	4	4teacher	health	reputation	mother	1	2	0false	true	true	false	true	true	true	true	fe
12	GP	F	15U	GT3	T	2	1services	other	reputation	father	3	3	0false	true	false	true	true	true	true	true	fe
13	GP	M	15U	LE3	T	4	4health	services	course	father	1	1	0false	true	true	true	true	true	true	true	fe
14	GP	M	15U	GT3	T	4	3teacher	other	course	mother	2	2	0false	true	true	false	true	true	true	true	fe
15	GP	M	15U	GT3	A	2	2other	other	home	other	1	3	0false	true	false	false	true	true	true	tr	fe
16	GP	F	16U	GT3	T	4	4health	other	home	mother	1	1	0false	false	false	true	true	true	true	true	fe
17	GP	F	16U	GT3	T	4	4services	services	reputation	mother	1	3	0false	true	true	true	true	true	true	true	fe
18	GP	F	16U	GT3	T	3	3other	other	reputation	mother	3	2	0true	true	false	true	true	true	false	fe	
19	GP	M	17U	GT3	T	3	2services	services	course	mother	1	1	3false	true	false	true	true	true	true	true	fe
20	GP	M	16U	LE3	T	4	3health	other	home	father	1	1	0false	false	true	true	true	true	true	fe	
21	GP	M	15U	GT3	T	4	3teacher	other	reputation	mother	1	2	0false	false	false	false	true	true	true	fe	
22	GP	M	15U	GT3	T	4	4health	health	other	father	1	1	0false	true	true	false	true	true	true	fe	
23	GP	M	16U	LE3	T	4	2teacher	other	course	mother	1	2	0false	false	false	true	true	true	true	fe	
24	GP	M	16U	LE3	T	2	2other	other	reputation	mother	2	2	0false	true	false	true	true	true	true	fe	
25	GP	F	15R	GT3	T	2	4services	health	course	mother	1	3	0true	true	true	true	true	true	true	fe	
26	GP	F	16U	GT3	T	2	2services	services	home	mother	1	1	2false	true	true	false	false	true	true	fe	
27	GP	M	15U	GT3	T	2	2other	other	home	mother	1	1	0false	true	true	false	true	true	true	fe	
28	GP	M	15U	GT3	T	4	2health	services	other	mother	1	1	0false	false	false	true	true	true	true	fe	
29	GP	M	16U	LE3	A	3	4services	other	home	mother	1	2	0true	true	false	true	true	true	true	fe	
30	GP	M	16U	GT3	T	4	4teacher	teacher	home	mother	1	2	0false	true	true	true	true	true	true	tr	

Figure 12-Output reflection deletion from middle

5.1.3 Insert at end

Insert a student record at the end of the existing CSV as shown

Sep 16 13:55 student-data.csv — LibreOffice Calc

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
385	MS	M	19R	GT3	T	1	1other	services	other	mother	2	1	1no	no	no	yes	yes	no	nc		
386	MS	M	18R	GT3	T	4	2other	other	home	father	2	1	1no	yes	no	yes	yes	no	nc		
387	MS	F	18R	GT3	T	2	2at_home	other	other	mother	2	3	0no	no	yes	yes	yes	no	nc		
388	MS	F	18R	GT3	T	4	4teacher	at_home	reputation	mother	3	1	0no	yes	yes	yes	yes	yes	ye		
389	MS	F	19R	GT3	T	2	3services	other	course	mother	1	3	1no	no	yes	no	yes	yes	yes	nc	
390	MS	F	18U	LE3	T	3	1teacher	services	course	mother	1	2	0no	yes	yes	no	yes	yes	yes	nc	
391	MS	F	18U	GT3	T	1	1other	other	course	mother	2	2	1no	no	yes	yes	yes	no	nc		
392	MS	M	20U	LE3	A	2	2services	services	course	other	1	2	2no	yes	yes	yes	yes	no	nc		
393	MS	M	17U	LE3	T	3	1services	services	course	mother	2	1	0no	no	no	no	yes	yes	yes	nc	
394	MS	M	21R	GT3	T	1	1other	other	course	other	1	1	3no	no	no	no	yes	no	nc		
395	MS	M	18R	LE3	T	3	2services	other	course	mother	3	1	0no	no	no	no	no	yes	yes	nc	
396	MS	M	19U	LE3	T	1	1other	at_home	course	father	1	1	0no	no	no	no	yes	yes	yes	nc	
397	MS	M	19U	LE3	T	1	1other	at_home	course	father	1	1	0no	no	no	yes	yes	yes	yes	nc	
398																					
399																					
400																					
401																					
402																					
403																					
404																					
405																					
406																					
407																					
408																					
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410																					
411																					
412																					
413																					
414																					

Figure 13- Insertion at the end

Sep 16 14:12 student-op-data.csv — LibreOffice Calc

A397:XFD397 f. Σ = MS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
373	MS	M	18R	LE3	T	1	2	at_home	services	other	father	3	1	0	false	true	true	true	true	false	true
374	MS	F	17U	GT3	T	2	2	other	at_home	home	mother	1	3	0	false	false	true	true	true	false	tr
375	MS	F	17R	GT3	T	1	2	other	other	course	mother	1	1	0	false	false	false	true	true	true	fe
376	MS	F	18R	LE3	T	4	4	other	other	reputation	mother	2	3	0	false	false	false	true	true	true	fe
377	MS	F	18R	GT3	T	1	1	other	other	home	mother	4	3	0	false	false	false	true	true	true	fe
378	MS	F	20U	GT3	T	4	2	health	other	course	other	2	3	2	false	true	true	false	true	true	tr
379	MS	F	18R	LE3	T	4	4	teacher	services	course	mother	1	2	0	false	false	true	true	true	true	fe
380	MS	F	18U	GT3	T	3	3	other	other	home	mother	1	2	0	false	false	true	false	true	true	tr
381	MS	F	17R	GT3	T	3	1	at_home	other	reputation	mother	1	2	0	false	true	true	false	true	true	fe
382	MS	M	18U	GT3	T	4	4	teacher	teacher	home	father	1	2	0	false	false	true	false	true	true	fe
383	MS	M	18R	GT3	T	2	1	other	other	mother	2	1	0	false	false	false	false	true	true	tr	
384	MS	M	17U	GT3	T	2	3	other	services	home	father	2	2	0	false	false	false	true	true	true	fe
385	MS	M	19R	GT3	T	1	1	other	services	other	mother	2	1	1	false	false	false	true	true	false	fe
386	MS	M	18R	GT3	T	4	2	other	other	home	father	2	1	1	false	false	true	false	true	false	fe
387	MS	F	18R	GT3	T	2	2	at_home	other	other	mother	2	3	0	false	false	true	false	true	false	fe
388	MS	F	18R	GT3	T	4	4	teacher	at_home	reputation	mother	3	1	0	false	true	true	true	true	tr	
389	MS	F	19R	GT3	T	2	3	services	other	course	mother	1	3	1	false	false	true	false	true	true	fe
390	MS	F	18U	LE3	T	3	1	teacher	services	course	mother	1	2	0	false	true	false	true	true	fe	
391	MS	F	18U	GT3	T	1	1	other	course	mother	2	2	1	false	false	false	true	true	false	fe	
392	MS	M	20U	LE3	A	2	2	services	services	course	other	1	2	2	false	true	true	false	true	false	fe
393	MS	M	17U	LE3	T	3	1	services	services	course	mother	2	1	0	false	false	false	false	true	true	fe
394	MS	M	21R	GT3	T	1	1	other	other	course	other	1	1	3	false	false	false	false	true	false	fe
395	MS	M	18R	LE3	T	3	2	services	other	course	mother	3	1	0	false	false	false	false	true	true	fe
396	MS	M	19U	LE3	T	1	1	other	at_home	course	father	1	1	0	false	false	false	true	true	true	fe
397	MS	M	19U	LE3	T	1	1	other	at_home	course	father	1	1	0	false	false	false	true	true	true	fe
398																					
399																					
400																					
401																					
402																					

student-data.csv

Sheet 1 of 1 Selected: 1 row, 16,384 columns Default English (USA) Average: 3.61538461538462; Sum: 47 120% 120%

Figure 14- Output reflection insertion at the end

5.1.4 Delete at top

Delete a student record at the top of the existing CSV as shown

Sep 16 13:54 student-data.csv — LibreOffice Calc

A2:XFD2 f. Σ = GP

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet
2	GP	F	18U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	yes	no	no	no	yes	yes	no	nc
3	GP	F	17U	GT3	T	1	1	at_home	other	course	father	1	2	0	no	yes	no	no	yes	yes	yes	nc
4	GP	F	15U	LE3	T	4	2	health	services	home	mother	1	3	0	no	yes	yes	yes	yes	yes	yes	ye
5	GP	F	15U	GT3	T	4	3	other	other	home	father	1	2	0	no	yes	yes	no	yes	yes	no	nc
6	GP	M	16U	GT3	T	2	2	other	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	yes	nc
7	GP	M	16U	LE3	T	4	3	services	other	reputation	mother	1	2	0	no	yes	yes	yes	yes	yes	yes	nc
8	GP	M	16U	LE3	T	2	2	other	other	home	mother	1	2	0	no	no	no	no	yes	yes	yes	nc
9	GP	F	17U	GT3	A	4	4	other	teacher	home	mother	2	2	0	yes	yes	no	no	yes	yes	no	nc
10	GP	M	15U	LE3	A	3	2	services	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	yes	nc
11	GP	M	15U	GT3	T	3	4	other	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	yes	nc
12	GP	F	15U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	no	yes	yes	yes	yes	yes	yes	nc
13	GP	F	15U	GT3	T	2	1	services	other	reputation	father	3	3	0	no	yes	no	yes	yes	yes	yes	nc
14	GP	M	15U	LE3	T	4	4	health	services	course	father	1	1	0	no	yes	yes	yes	yes	yes	yes	nc
15	GP	M	15U	GT3	T	4	3	teacher	other	course	mother	2	2	0	no	yes	yes	no	yes	yes	yes	nc
16	GP	M	15U	GT3	A	2	2	other	other	home	other	1	3	0	no	yes	no	no	yes	yes	yes	ye
17	GP	F	16U	GT3	T	4	4	health	other	home	mother	1	1	0	no	yes	no	no	yes	yes	yes	nc
18	GP	F	16U	GT3	T	4	4	services	services	reputation	mother	1	3	0	no	yes	yes	yes	yes	yes	yes	nc
19	GP	F	16U	GT3	T	3	3	other	other	reputation	mother	3	2	0	yes	yes	no	yes	yes	no	nc	
20	GP	M	17U	GT3	T	3	2	services	services	course	mother	1	1	3	no	yes	no	yes	yes	yes	yes	nc
21	GP	M	16U	LE3	T	4	3	health	other	home	father	1	1	0	no	yes	yes	yes	yes	yes	yes	nc
22	GP	M	15U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	no	no	no	yes	yes	yes	yes	nc
23	GP	M	15U	GT3	T	4	4	health	health	other	father	1	1	0	no	yes	yes	no	yes	yes	yes	nc
24	GP	M	16U	LE3	T	4	2	teacher	other	course	mother	1	2	0	no	no	no	yes	yes	yes	yes	nc
25	GP	M	16U	LE3	T	2	2	other	other	reputation	mother	2	2	0	no	yes	no	yes	yes	yes	yes	nc
26	GP	F	15R	GT3	T	2	2	4	services	health	course	mother	1	3	0	yes	yes	yes	yes	yes	yes	nc
27	GP	F	16U	GT3	T	2	2	services	services	home	mother	1	1	2	no	yes	yes	no	yes	yes	yes	nc
28	GP	M	15U	GT3	T	2	2	other	other	home	mother	1	1	0	no	yes	yes	no	yes	yes	yes	nc
29	GP	M	15U	GT3	T	4	2	health	services	other	mother	1	1	0	no	yes	no	yes	yes	yes	yes	nc
30	GP	M	16U	LE3	A	3	4	services	other	home	mother	1	2	0	yes	yes	no	yes	yes	yes	yes	nc

student-data.csv

Sheet 1 of 1 Selected: 1 row, 16,384 columns Default English (USA) Average: 4; Sum: 52 120% 120%

Figure 15- Delete the head

Sep 16 14:10

student-op-data.csv — LibreOffice Calc

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsups	famsup	paid	activities	nursery	higher	internet
2	GP	F	17U	GT3	T	1	1	at_home	other	course	father	1	2	0	false	true	false	false	false	true	true	fe
3	GP	F	15U	LE3	T	1	1	at_home	other	other	mother	1	2	3	true	false	true	false	true	true	true	fe
4	GP	F	15U	GT3	T	4	2	health	services	home	mother	1	3	0	false	true	true	true	true	true	true	tr
5	GP	F	16U	GT3	T	3	3	other	other	home	father	1	2	0	false	true	true	false	true	true	false	fe
6	GP	M	16U	LE3	T	4	3	services	other	reputation	mother	1	2	0	false	true	true	true	true	true	true	fe
7	GP	M	16U	LE3	T	2	2	other	other	home	mother	1	2	0	false	false	false	false	true	true	true	fe
8	GP	F	17U	GT3	A	4	4	other	teacher	home	mother	2	2	0	true	true	false	false	true	true	false	fe
9	GP	M	15U	LE3	A	3	2	services	other	home	mother	1	2	0	false	true	true	false	true	true	true	fe
10	GP	M	15U	GT3	T	3	4	other	other	home	mother	1	2	0	false	true	true	true	true	true	true	fe
11	GP	F	15U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	false	true	true	false	true	true	true	fe
12	GP	F	15U	GT3	T	2	1	2	services	other	reputation	father	3	3	0	false	true	true	false	true	true	fe
13	GP	M	15U	LE3	T	4	4	health	services	course	father	1	1	0	false	true	true	true	true	true	true	fe
14	GP	M	15U	GT3	T	4	3	teacher	other	course	mother	2	2	0	false	true	true	false	true	true	true	fe
15	GP	M	15U	GT3	A	2	2	other	other	home	other	1	3	0	false	true	false	false	true	true	tr	
16	GP	F	16U	GT3	T	4	4	health	other	home	mother	1	1	0	false	false	false	false	true	true	true	fe
17	GP	F	16U	GT3	T	4	4	services	services	reputation	mother	1	3	0	false	true	true	true	true	true	true	fe
18	GP	F	16U	GT3	T	3	3	other	other	reputation	mother	3	2	0	true	true	true	true	true	true	false	fe
19	GP	M	17U	GT3	T	3	2	services	services	course	mother	1	1	3	false	true	true	true	true	true	true	fe
20	GP	M	16U	LE3	T	4	2	services	other	course	mother	1	1	0	false	true	true	true	true	true	true	fe
21	GP	M	15U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	false	false	false	false	true	true	true	fe
22	GP	M	15U	GT3	T	4	4	health	other	other	father	1	1	0	false	true	true	false	true	true	true	fe
23	GP	M	16U	LE3	T	4	2	other	other	home	other	1	2	0	false	true	true	true	true	true	true	fe
24	GP	M	16U	GT3	T	2	2	other	other	reputation	mother	2	2	0	false	true	true	false	true	true	true	fe
25	GP	M	16U	LE3	T	4	2	teacher	other	course	mother	1	2	0	false	false	false	false	true	true	true	nc
26	GP	M	16U	LE3	T	2	2	other	other	reputation	mother	2	2	0	false	true	false	false	true	true	true	nc
27	GP	F	15R	GT3	T	2	2	4	services	health	course	mother	1	3	0	true	true	true	true	true	true	fe
28	GP	F	16U	GT3	T	2	2	2	services	services	home	mother	1	1	2	false	true	false	true	true	true	fe
29	GP	M	15U	LE3	A	3	3	4	services	other	home	mother	1	2	0	true	true	false	true	true	true	fe
30	GP	M	16U	GT3	T	4	4	teacher	teacher	home	mother	1	2	0	false	true	true	true	true	true	tr	

Figure 16- Output reflecting deletion of head

5.2 Edge cases

5.2.1 Insert at top

Insert a student record at the top of the existing CSV as shown

Sep 16 13:54

student-data.csv — LibreOffice Calc

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	4	4	at_home	teacher	course	mother	2	2	0	yes	no	no	no	yes	
2	GP	F	18U	GT3	A	4	4	at_home	teacher	course	mother	1	2	0	no	yes	no	no	no	yes	nc	
3	GP	F	17U	GT3	T	1	1	at_home	other	course	father	1	2	3	yes	no	yes	no	yes	yes	nc	
4	GP	F	15U	LE3	T	1	1	at_home	other	other	mother	1	2	0	no	yes	yes	yes	yes	yes	ye	
5	GP	F	15U	GT3	T	4	2	health	services	home	mother	1	3	0	no	yes	yes	yes	yes	yes	nc	
6	GP	F	16U	GT3	T	3	3	other	other	home	father	1	2	0	no	yes	yes	no	yes	yes	nc	
7	GP	F	16U	GT3	T	4	3	services	other	reputation	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
8	GP	M	16U	LE3	T	4	3	services	other	reputation	mother	2	2	0	no	yes	yes	yes	yes	yes	nc	
9	GP	M	16U	LE3	T	2	2	other	other	home	mother	1	2	0	no	no	no	no	yes	yes	nc	
10	GP	F	17U	GT3	A	4	4	other	teacher	home	mother	2	2	0	yes	yes	no	no	yes	yes	nc	
11	GP	M	15U	LE3	A	3	2	services	other	home	mother	1	2	0	no	yes	yes	no	yes	yes	nc	
12	GP	M	15U	GT3	T	3	3	other	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
13	GP	F	15U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	no	yes	yes	no	yes	yes	nc	
14	GP	F	15U	GT3	T	2	1	2	services	other	reputation	father	3	3	0	no	yes	no	yes	yes	nc	
15	GP	M	15U	LE3	T	4	4	health	services	course	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
16	GP	M	15U	GT3	T	4	3	teacher	other	course	mother	2	2	0	no	yes	yes	yes	yes	yes	nc	
17	GP	M	15U	GT3	A	2	2	other	other	home	other	1	3	0	no	yes	no	no	yes	yes	ye	
18	GP	F	16U	GT3	T	4	4	health	other	home	mother	1	1	0	no	yes	no	no	yes	yes	nc	
19	GP	F	16U	GT3	T	4	4	services	services	reputation	mother	1	3	0	no	yes	yes	yes	yes	yes	nc	
20	GP	F	16U	GT3	T	3	3	other	other	reputation	mother	3	2	0	yes	yes	no	yes	yes	yes	nc	
21	GP	M	17U	GT3	T	3	2	2	services	services	course	mother	1	1	3	no	yes	no	yes	yes	yes	nc
22	GP	M	16U	LE3	T	4	3	health	other	home	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
23	GP	M	15U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	no	no	no	yes	yes	yes	nc	
24	GP	M	15U	GT3	T	4	4	health	health	other	father	1	1	0	no	yes	no	yes	yes	yes	nc	
25	GP	M	16U	LE3	T	4	2	teacher	other	course	mother	1	2	0	no	no	yes	yes	yes	yes	nc	
26	GP	M	16U	LE3	T	2	2	other	other	reputation	mother	2	2	0	no	yes	no	yes	yes	yes	nc	
27	GP	F	15R	GT3	T	2	2	4	services	health	course	mother	1	3	0	yes	yes	yes	yes	yes	nc	
28	GP	F	16U	GT3	T	2	2	2	services	services	home	mother	1	1	2	no	yes	yes	no	yes	yes	nc
29	GP	M	15U	GT3	T	2	2	other	other	home	mother	1	1	0	no	yes	yes	no	yes	yes	nc	
30	GP	M	15U	GT3	T	4	2	health	services	other	mother	1	1	0	no	yes	no	yes	yes	yes	nc	

Figure 17- Insert a new head

Sep 16 14:11

student-op-data.csv — LibreOffice Calc

A B C D E F G H I J K L M N O P Q R S T U V

1 school sex age address famsize Pstatus Medu Fedu Mjob Fjob reason guardian traveltime studytime failures schoolsup famsup paid activities nursery higher internet

2 GP F 18 U GT3 A 4 4 at_home teacher course mother 2 2 0 true false false false true true false fe

3 GP F 18 U GT3 A 4 4 at_home teacher course mother 2 2 0 true false false false true true false fe

4 GP F 17 U GT3 T 1 1 at_home other course father 1 2 0 false true false false true true false fe

5 GP F 15 U LE3 T 1 1 at_home other other mother 1 2 3 true false true false true true true fe

6 GP F 15 U GT3 T 4 2 health services home mother 1 3 0 false true true true true true true tr

7 GP F 16 U GT3 T 3 3 other other home father 1 2 0 false true true false true true true fe

8 GP M 16 U LE3 T 4 3 services other reputation mother 1 2 0 false true true true true true fe

9 GP M 16 U LE3 T 2 2 other other home mother 1 2 0 false false false true true true fe

10 GP F 17 U GT3 A 4 4 other teacher home mother 2 2 0 true true false false true true false fe

11 GP M 15 U LE3 A 3 2 services other home mother 1 2 0 false true true false true true true fe

12 GP M 15 U GT3 T 3 4 other other home mother 1 2 0 false true true true true true fe

13 GP F 15 U GT3 T 4 4 teacher health reputation mother 1 2 0 false true true false true true fe

14 GP F 15 U GT3 T 2 1 services other reputation father 3 3 0 false true false true true true fe

15 GP M 15 U LE3 T 4 4 health services course father 1 1 0 false true true true true true fe

16 GP M 15 U GT3 T 4 3 teacher other course mother 2 2 0 false true false true true true fe

17 GP M 15 U GT3 A 2 2 other other home other 1 3 0 false true false false true true true fe

18 GP F 16 U GT3 T 4 4 health other home mother 1 1 0 false true true false true true fe

19 GP F 16 U GT3 T 4 4 services services reputation mother 1 3 0 false true true true true fe

20 GP F 16 U GT3 T 3 3 other other reputation mother 3 2 0 true true false true true false fe

21 GP M 17 U GT3 T 3 2 services services course mother 1 1 3 false true false true true true fe

22 GP M 16 U LE3 T 4 3 health other home father 1 1 0 false false true true true true fe

23 GP M 15 U GT3 T 4 3 teacher other reputation mother 1 2 0 false false false true true true fe

24 GP M 15 U GT3 T 4 4 health health other father 1 1 0 false true true false true true fe

25 GP M 16 U LE3 T 4 2 teacher other course mother 1 2 0 false false false true true true fe

26 GP M 16 U LE3 T 2 2 other other reputation mother 2 2 0 false true false true true true fe

27 GP F 15 R GT3 T 2 4 services health course mother 1 3 0 true true true true true true fe

28 GP F 16 U GT3 T 2 2 services services home mother 1 1 2 false true true false false true true fe

29 GP M 15 U GT3 T 2 2 other other home mother 1 1 0 false true true false true true true fe

30 GP M 15 U GT3 T 4 2 health services other mother 1 1 0 false false true true true true fe

student-op-data

Sheet 1 of 1 Selected: 1 row, 16,384 columns Default English (USA) Average: 4; Sum: 52 120%

Figure 18- Output reflecting insertion of new head

5.2.2 Delete at end

Delete a student record at the bottom of the existing CSV as shown

Sep 16 14:13

student-op-data.csv — LibreOffice Calc

A B C D E F G H I J K L M N O P Q R S T U V

373 MS M 18 R LE3 T 1 2 at_home services other father 3 1 0 false true true true false true tr

374 MS F 17 U GT3 T 2 2 other at_home home mother 1 3 0 false false false true true false fe

375 MS F 17 R GT3 T 1 2 other other course mother 1 1 0 false false false true true true fe

376 MS F 18 R LE3 T 4 4 other other reputation mother 2 3 0 false false false true true true fe

377 MS F 18 R GT3 T 1 1 other other home mother 4 3 0 false false false true true true fe

378 MS F 20 U GT3 T 4 2 health other course other 2 3 2 false true true false false true tr

379 MS F 18 R LE3 T 4 4 teacher services course mother 1 2 0 false false true true true fe

380 MS F 18 U GT3 T 3 3 other other home mother 1 2 0 false false true true true fe

381 MS F 17 R GT3 T 3 1 at_home other reputation mother 1 2 0 false true true false true fe

382 MS M 18 U GT3 T 4 4 teacher teacher home father 1 2 0 false false false true true fe

383 MS M 18 R GT3 T 2 1 other other other mother 2 1 0 false false false true false true fe

384 MS M 17 U GT3 T 2 3 other services home father 2 2 0 false false false true true true fe

385 MS M 19 R GT3 T 1 1 other services other mother 2 1 1 false false false true true false fe

386 MS M 18 R GT3 T 4 2 other other home father 2 1 1 false false true false true true fe

387 MS F 18 R GT3 T 2 2 at_home other other mother 2 3 0 false false true false true false fe

388 MS F 18 R GT3 T 4 4 teacher at_home reputation mother 3 1 0 false true true true true fe

389 MS F 19 R GT3 T 2 3 services other course mother 1 3 1 false false false true true fe

390 MS F 18 U LE3 T 3 1 teacher services course mother 1 2 0 false true true false true fe

391 MS F 18 U GT3 T 1 1 other other course mother 2 2 1 false false false true true fe

392 MS M 20 U LE3 A 2 2 services services course other 1 2 2 false true true false true fe

393 MS M 17 U LE3 T 3 1 services services course mother 2 1 0 false false false false true true fe

394 MS M 21 R GT3 T 1 1 other other course other 1 1 3 false false false false false true fe

395 MS M 18 R LE3 T 3 2 services other course mother 3 1 0 false false false false false true fe

398

399

400

401

402

403

404

student-op-data

Sheet 1 of 1 Default English (USA) Average: ; Sum: 0 120%

Figure 19- Delete the last node

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
385	MS	M	19R	GT3	T	1	1	other	services	other	mother	2	1	1	no	no	no	yes	yes	no	nc
386	MS	M	18R	GT3	T	4	2	other	other	home	father	2	1	1	no	yes	no	yes	yes	no	nc
387	MS	F	18R	GT3	T	2	2	at_home	other	other	mother	2	3	0	no	yes	no	yes	yes	no	nc
388	MS	F	18R	GT3	T	4	4	teacher	at_home	reputation	mother	3	1	0	no	yes	yes	yes	yes	yes	ye
389	MS	F	19R	GT3	T	2	3	services	other	course	mother	1	3	1	no	no	yes	no	yes	yes	nc
390	MS	F	18U	LE3	T	3	1	teacher	services	course	mother	1	2	0	no	yes	no	yes	yes	yes	nc
391	MS	F	18U	GT3	T	1	1	other	other	course	mother	2	2	1	no	no	yes	yes	yes	no	nc
392	MS	M	20U	LE3	A	2	2	services	services	course	other	1	2	2	no	yes	no	yes	yes	no	nc
393	MS	M	17U	LE3	T	3	1	services	services	course	mother	2	1	0	no	no	no	no	yes	yes	nc
394	MS	M	21R	GT3	T	1	1	other	other	course	other	1	1	3	no	no	no	no	yes	no	nc
395	MS	M	18R	LE3	T	3	2	services	other	course	mother	3	1	0	no	no	no	no	yes	yes	nc
396	MS	M	19U	LE3	T	1	1	other	at_home	course	father	1	1	0	no	no	no	yes	yes	yes	nc
397																					
398																					
399																					
400																					
401																					
402																					
403																					
404																					
405																					
406																					
407																					
408																					
409																					
410																					
411																					
412																					
413																					
414																					

Figure 20- Output reflecting deletion of last node

5.2.3 No Insertion or deletion

It is not specified in the requirement document that there will always be insertions or deletion

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet
2	GP	F	18U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	true	false	false	false	true	true	false	fe
3	GP	F	17U	GT3	T	1	1	at_home	other	course	father	1	2	0	false	true	false	false	false	true	true	fe
4	GP	F	15U	LE3	T	1	1	at_home	other	other	mother	1	2	3	true	false	true	false	true	true	true	fe
5	GP	F	15U	GT3	T	4	2	health	services	home	mother	1	3	0	false	true	true	true	true	true	true	tr
6	GP	F	16U	GT3	T	3	3	other	other	home	father	1	2	0	false	true	true	false	true	true	true	fe
7	GP	M	16U	LE3	T	4	3	services	other	reputation	mother	1	2	2	false	true	true	true	true	true	true	fe
8	GP	M	16U	LE3	T	2	2	other	other	home	mother	1	2	0	false	true	true	true	true	true	true	fe
9	GP	F	17U	GT3	A	4	4	other	teacher	home	mother	2	2	0	true	false	false	false	true	true	true	fe
10	GP	M	15U	LE3	A	3	2	services	other	home	mother	1	2	0	false	true	true	false	true	true	true	fe
11	GP	M	15U	GT3	T	3	4	other	other	home	mother	1	2	0	false	true	true	true	true	true	true	fe
12	GP	F	15U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	false	true	true	false	true	true	true	fe
13	GP	F	15U	GT3	T	2	1	services	other	reputation	father	3	3	0	false	true	true	true	true	true	true	fe
14	GP	M	15U	LE3	T	4	4	health	services	course	father	1	1	0	false	true	true	true	true	true	true	fe
15	GP	M	15U	GT3	T	4	3	teacher	other	course	mother	2	2	0	false	true	true	false	true	true	true	fe
16	GP	M	15U	GT3	A	2	2	other	other	home	other	1	3	0	false	true	false	false	true	true	tr	
17	GP	F	16U	GT3	T	4	4	health	other	home	mother	1	1	0	false	true	false	false	true	true	true	fe
18	GP	F	16U	GT3	T	4	4	services	services	reputation	mother	1	3	0	false	true	true	true	true	true	true	fe
19	GP	F	16U	GT3	T	3	3	other	other	reputation	mother	3	2	0	true	true	false	true	true	true	false	fe
20	GP	M	17U	GT3	T	3	2	services	services	course	mother	1	1	3	false	true	false	true	true	true	true	fe
21	GP	M	16U	LE3	T	4	3	health	other	home	father	1	1	0	false	true	true	true	true	true	true	fe
22	GP	M	15U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	false	false	false	false	true	true	true	fe
23	GP	M	15U	GT3	T	4	4	health	health	other	father	1	1	0	false	true	true	false	true	true	true	fe
24	GP	M	16U	LE3	T	4	2	teacher	other	course	mother	1	2	0	false	false	false	true	true	true	true	fe
25	GP	M	16U	LE3	T	2	2	other	other	reputation	mother	2	2	0	false	true	false	true	true	true	true	fe
26	GP	F	15R	GT3	T	2	4	services	health	course	mother	1	3	0	true	true	true	true	true	true	true	fe
27	GP	F	16U	GT3	T	2	2	services	services	home	mother	1	1	2	false	true	true	false	true	true	true	fe
28	GP	M	15U	GT3	T	2	2	other	other	home	mother	1	1	0	false	true	true	false	true	true	true	fe
29	GP	M	15U	GT3	T	4	2	health	services	other	mother	1	1	0	false	true	false	true	true	true	true	fe
30	GP	M	16U	LE3	A	3	4	services	other	home	mother	1	2	0	true	true	false	true	true	true	true	fe

Figure 21- Unchanged input

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	school	sex	age	address	famsize	Pstatus	Medu	Fedu	Mjob	Fjob	reason	guardian	traveltime	studytime	failures	schoolsup	famsup	paid	activities	nursery	higher	internet	ro
2	GP	F	18	U	GT3	A	4	4	at_home	teacher	course	mother	2	2	0	yes	no	no	yes	yes	no	nc	
3	GP	F	17	U	GT3	T	1	1	at_home	other	course	father	1	2	0	no	yes	no	no	yes	yes	nc	
4	GP	F	15	U	LE3	T	1	1	at_home	other	other	mother	1	2	3	yes	no	yes	yes	yes	yes	nc	
5	GP	F	15	U	GT3	T	4	2	health	services	home	mother	1	3	0	no	yes	yes	yes	yes	yes	ye	
6	GP	F	16	U	GT3	T	3	3	other	other	home	father	1	2	0	no	yes	yes	no	yes	yes	nc	
7	GP	M	16	U	LE3	T	4	3	services	other	reputation	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
8	GP	M	16	U	LE3	T	2	2	other	other	home	mother	1	2	0	no	no	no	yes	yes	yes	nc	
9	GP	F	17	U	GT3	A	4	4	other	teacher	home	mother	2	2	0	yes	yes	no	yes	yes	no	nc	
10	GP	M	15	U	LE3	A	3	2	services	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
11	GP	M	15	U	GT3	T	3	4	other	other	home	mother	1	2	0	no	yes	yes	yes	yes	yes	nc	
12	GP	F	15	U	GT3	T	4	4	teacher	health	reputation	mother	1	2	0	no	yes	yes	no	yes	yes	nc	
13	GP	F	15	U	GT3	T	2	1	services	other	reputation	father	3	3	0	no	yes	no	yes	yes	yes	nc	
14	GP	M	15	U	LE3	T	4	4	health	services	course	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
15	GP	M	15	U	GT3	T	4	3	teacher	other	course	mother	2	2	0	no	yes	yes	no	yes	yes	nc	
16	GP	M	15	U	GT3	A	2	2	other	other	home	other	1	3	0	no	no	no	yes	yes	yes	ye	
17	GP	F	16	U	GT3	T	4	4	health	other	home	mother	1	1	0	no	yes	no	yes	yes	yes	nc	
18	GP	F	16	U	GT3	T	4	4	4	services	services	reputation	mother	1	3	0	no	yes	yes	yes	yes	nc	
19	GP	F	16	U	GT3	T	3	3	other	other	reputation	mother	3	2	0	yes	yes	no	yes	yes	no	nc	
20	GP	M	17	U	GT3	T	3	2	services	services	course	mother	1	1	3	no	yes	no	yes	yes	yes	nc	
21	GP	M	16	U	LE3	T	4	3	health	other	home	father	1	1	0	no	yes	yes	yes	yes	yes	nc	
22	GP	M	15	U	GT3	T	4	3	teacher	other	reputation	mother	1	2	0	no	no	no	yes	yes	yes	nc	
23	GP	M	15	U	GT3	T	4	4	health	health	other	father	1	1	0	no	yes	yes	no	yes	yes	nc	
24	GP	M	16	U	LE3	T	4	2	teacher	other	course	mother	1	2	0	no	no	no	yes	yes	yes	nc	
25	GP	M	16	U	LE3	T	2	2	other	other	reputation	mother	2	2	0	no	yes	no	yes	yes	yes	nc	
26	GP	F	15	R	GT3	T	2	4	services	health	course	mother	1	3	0	yes	yes	yes	yes	yes	yes	nc	
27	GP	F	16	U	GT3	T	2	2	services	services	home	mother	1	1	2	no	yes	yes	no	no	yes	nc	
28	GP	M	15	U	GT3	T	2	2	other	other	home	mother	1	1	0	no	yes	yes	no	yes	yes	nc	
29	GP	M	15	U	GT3	T	4	2	health	services	other	mother	1	1	0	no	yes	no	yes	yes	yes	nc	
30	GP	M	16	U	LE3	A	3	4	services	other	home	mother	1	2	0	yes	yes	no	yes	yes	yes	nc	

Figure 22- Unchanged output

5. Shutting down the Virtual environment

It is important to power off the Ubuntu virtual environment, as improper powering off might lead to the crashing of the OS.

1. Click on the battery icon in top right corner > click the power symbol > Power off... > confirm

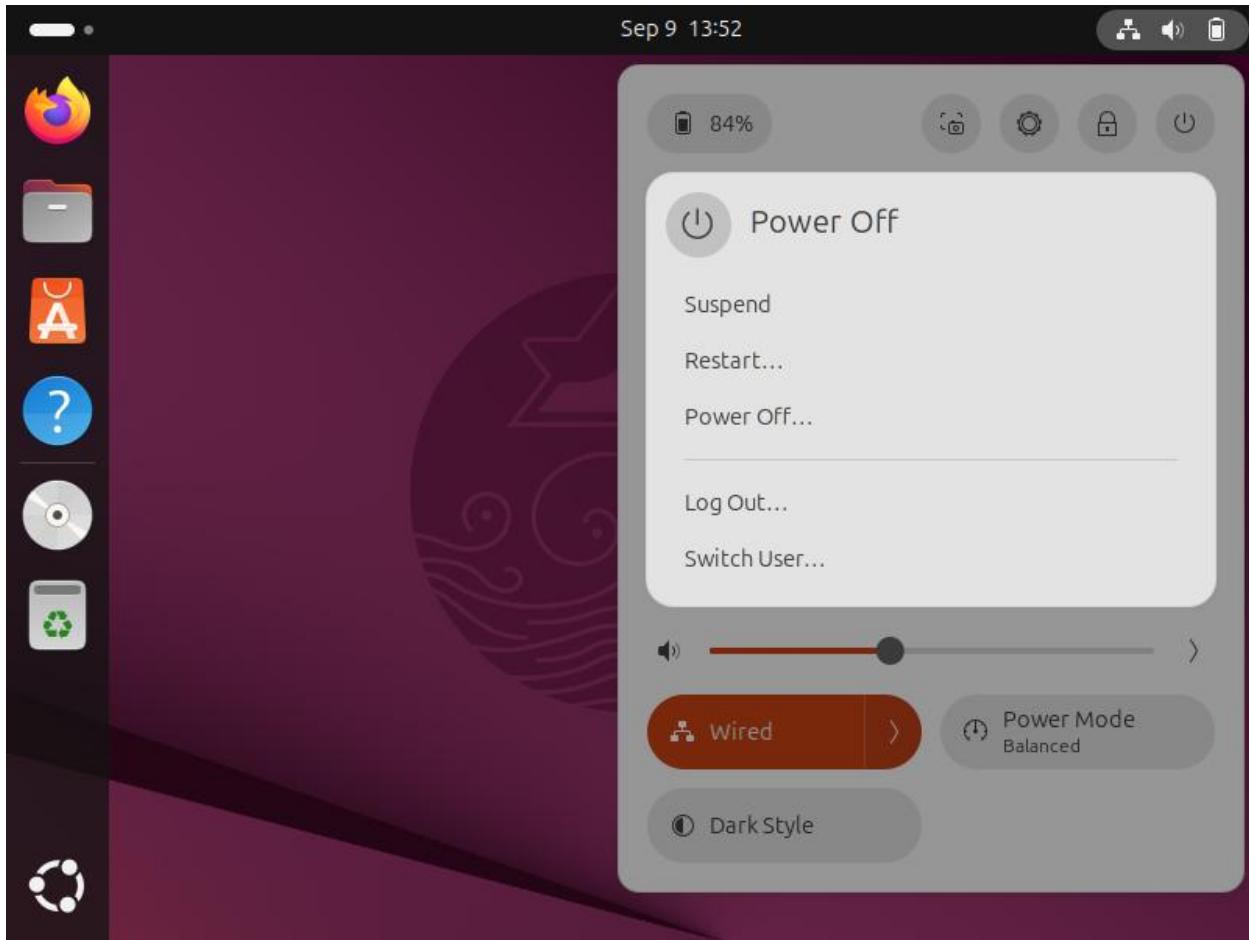


Figure 23- Shutting down Ubuntu

Key takeaways

Singly Linked List

It is a data structure; unlike arrays they offer **dynamic scaling**. They are made of interconnection blocks, the simple real-world parallel would be a **Train**, each block contain 2 parts one to have the **data** itself and the other to point to the location of the **next** block. By this way we can easily scale the number of block. Linked lists are the perfect choice when we need to allocate “n” data points, where **n is unknown**. They do have quite **a few tradeoffs** with array in terms of complexities both time and space.

Recursion

Recursion is a type of loops, written when we don't know the exit condition before hand. A safe comparison would be an **infinite loop** with a **break**; condition in it. Also we have normal and **tail recursions**.

File IO

We have touched the basics of reading and writing in a CSV file. Also we have used File Watcher service which is good for noticing any action performed on the file like creation, deletion and mortification, it returns if there is any event on the file which is per say the hint of event driven programming paradigm.

Multi Threads

It is a special case of programming where we use different program threads to accomplish a task in the same time, in the algorithm world it can be loosely equated to divide and conquer.

Conclusion

From the Above execution screenshots is the confirmed to have build a small memory database using single linked list, that performs the actions,

1. Reads the contents of CSV file and add it to Linked List recursively
2. Adopts to any insertion/deletion in the CSV file
3. Writes the linked List to the output CSV file.

FAQ

1. *Why not store the contents of the CSV as a comma separated string in the Linked List?*

It is advised to use the Object Oriented approach, as it is easier to access and extend in the future

2. *Why not use String data type for all the class variables of the Student class?*

String is not a primitive data structure and consumes a lot of memory space, Always use primitive data types like int char and Boolean when possible

3. *Why dependency injection?*

Dependency is a good software design practice, where it is easier to plug-in different initialization values

4. *Is it ok to open both Reader and Writer object simultaneously, wont it cause synchronization problem*

There won't be any synchronizations issues due to opening two files concurrently, since we read and write into two different files, So there is no need to use any Mutex locks.

5. *Why multi-threads*

File watcher is a blocking service, even if we do an infinite loop until keyboard interrupt, the File watcher will still be blocking and won't return the control to the main threads.

6. What is the difference between == and .equals() method in Java?

'==' does shallow comparison i.e. return two object points to the same memory location, can be used for comparing two primitive data type items on the other hand we .equals() method perform deep comparison i.e. it compares all the member variable of both the classes to say whether they are same, used when comparing two class variables. Note by default .equals() method does shallow comparison until overwritten manually.

7. What is the difference between write and append

Write operation overwrites the existing line and append operation goes to the new line to write a new line

8. What is static in Java

Object defined by static keywords gets initialized when the program starts by the JVM itself. For example main() method is defined static so it will be triggered by the JVM. We use static variables to define filenames and a static inner class. Unnecessary use of static keyword is not advised.

Acknowledgement

I remember encountering a similar question in one of my interviews, confirming the relevance of the assignment to industry standards. I would like to acknowledge Professor Dr. Wei "David" Dai, for assigning this Assignment as it is a great practice for me. Also I would like to appreciate PNW CES and CS department for providing me the adequate opportunities and letting take this course.

Also I would like to thank Kaggle dataset, which was a crucial part of this assignment also draw.io which was used to draw the UML diagram.

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Appendix

1. Using Java

1.1 Student Class

```
/*
 * @author: Kowshick Srinivasan
 * @version: 1.0
 * @Assignment: Hw2
 */

import java.util.Objects;

public class Student {
    String school;
    String mJob;
    String fJob;
    String reason;
```

```

String guardian;
String famSize;

//Can convert one letters to char instead of default string
//for efficient memory usage
char sex;
char address;
char pStatus;

//Can convert Integers to int instead of default string
//for efficient memory usage
int age;
int famRel;
int freeTime;
int goOut;
int dalc;
int walc;
int health;
int absence;
int travelTime;
int studyTime;
int failures;
int medu;
int fedu;

//Can convert yes/no to boolean instead of default string
//for efficient memory usage
boolean schoolsUp;
boolean farmsUp;
boolean paid;
boolean activities;
boolean nursery;
boolean higher;
boolean internet;
boolean romantic;
boolean passed;

//Constructor to initialize the class variables
public Student(String school, char sex, int age, char address,
               String famSize, char pStatus, int medu, int fedu,
               String mJob, String fJob, String reason,
               String guardian, int travelTime, int studyTime,
               int failures, boolean schoolsUp, boolean farmsUp,
               boolean paid, boolean activities, boolean nursery,
               boolean higher, boolean internet, boolean romantic,
               int famRel, int freeTime, int goOut, int dalc, int walc,
               int health, int absence, boolean passed) {
    this.school = school;
    this.sex = sex;
    this.age = age;
    this.address = address;
    this.famSize = famSize;
    this.pStatus = pStatus;
    this.medu = medu;
    this.fedu = fedu;
}

```

```

        this.mJob = mJob;
        this.fJob = fJob;
        this.reason = reason;
        this.guardian = guardian;
        this.travelTime = travelTime;
        this.studyTime = studyTime;
        this.failures = failures;
        this.schoolsUp = schoolsUp;
        this.farmsUp = farmsUp;
        this.paid = paid;
        this.activities = activities;
        this.nursery = nursery;
        this.higher = higher;
        this.internet = internet;
        this.romantic = romantic;
        this.famRel = famRel;
        this.freeTime = freeTime;
        this.goOut = goOut;
        this.dalc = dalc;
        this.walc = walc;
        this.health = health;
        this.absence = absence;
        this.passed = passed;
    }

    //To String method to convert student object to comma separated Strings
    @Override
    public String toString() {
        return school +
            "," + sex +
            "," + age +
            "," + address +
            "," + famSize +
            "," + pStatus +
            "," + medu +
            "," + fedu +
            "," + mJob +
            "," + fJob +
            "," + reason +
            "," + guardian +
            "," + travelTime +
            "," + studyTime +
            "," + failures +
            "," + convertBoolToString(schoolsUp) +
            "," + convertBoolToString(farmsUp) +
            "," + convertBoolToString(paid) +
            "," + convertBoolToString(activities) +
            "," + convertBoolToString(nursery) +
            "," + convertBoolToString(higher) +
            "," + convertBoolToString(internet) +
            "," + convertBoolToString(romantic) +
            "," + famRel +
            "," + freeTime +
            "," + goOut +
            "," + dalc +
            "," + walc +
            "," + health +

```

```

        "," + absence +
        "," + convertBoolToString(passed);
    }

//Convert the boolean object back to user specified String
private String convertBoolToString(boolean studentVariable) {
    return studentVariable?"yes":"no"; //If bool is True convert to yes else no
}

//Equals method compare two object of same type (deep comparison) to tell if they are both equal
@Override
public boolean equals(Object obj) {
    if (this == obj) return true; //If both are the same object
    if (!(obj instanceof Student student)) return false; // If your comparing with some other object tye
    //Convert the type of Object to Student
    return Objects.equals(school, student.school) &&
           Objects.equals(mJob, student.mJob) &&
           Objects.equals(fJob, student.fJob) &&
           Objects.equals(reason, student.reason) &&
           Objects.equals(guardian, student.guardian) &&
           Objects.equals(famSize, student.famSize) &&
           Objects.equals(sex, student.sex) &&
           Objects.equals(address, student.address) &&
           Objects.equals(pStatus, student.pStatus) &&
           Objects.equals(age, student.age) &&
           Objects.equals(famRel, student.famRel) &&
           Objects.equals(freeTime, student.freeTime) &&
           Objects.equals(goOut, student.goOut) &&
           Objects.equals(dalc, student.dalc) &&
           Objects.equals(walc, student.walc) &&
           Objects.equals(health, student.health) &&
           Objects.equals(absence, student.absence) &&
           Objects.equals(travelTime, student.travelTime) &&
           Objects.equals(studyTime, student.studyTime) &&
           Objects.equals(failures, student.failures) &&
           Objects.equals(medu, student.medu) &&
           Objects.equals(fedu, student.fedu) &&
           Objects.equals(schoolsUp, student.schoolsUp) &&
           Objects.equals(farmsUp, student.farmsUp) &&
           Objects.equals(paid, student.paid) &&
           Objects.equals(activities, student.activities) &&
           Objects.equals(nursery, student.nursery) &&
           Objects.equals(higher, student.higher) &&
           Objects.equals(internet, student.internet) &&
           Objects.equals(romantic, student.romantic) &&
           Objects.equals(passed, student.passed);
}
}

```

1.2 Linked List Class

```
/*
 * @author: Kowshick Srinivasan
 * @version: 1.0
 * @Assignment: Hw2
 */

/**
 * Class to define the structure of the linked list
 */
public class LinkedList {
    Node head; //Contains object of type Node

    public static class Node { //static inner class to define the structure
        of node

        Student student; //Contains object of student

        Node next; //Contains an object of itself

        Node(Student student) { //Constructor to initialise
            this.student = student;
            next = null; //the next node is null by default
        }
    }

    /**
     * @param prevItem The current last Node/pointer
     * @param student The student object that needs to be inserted
     * @param nextNode The following Node which needs to be pointed by the
     inserted node
     * @return new last node
     */
    public Node insert(Node prevItem, Student student, Node nextNode) {
        Node newStudent = new Node(student); //Create the new student node
        newStudent.next = nextNode;
        if (prevItem == null)
            this.head = newStudent; //If linked list is empty, make the new
        student as the first/head node
        else
            prevItem.next = newStudent; //Connect the previous node next to
        the new student node, extending the linked list chain
        return newStudent;
    }

    /**
     * The method is to delete the current node from the linked list.
     *
     * @param prevNode The current last Node/pointer
     * @param nextNode The immediate next node after the current Node
     */
    public void delete(Node prevNode, Node nextNode) {
        //We can assign the next node pointer of the previous node to the
        next node instead of the current node.
```

```

        // Since the current node is hanging in the heap space the garbage
        collector will remove it.
        if (prevNode == null) head = nextNode; //Delete at the head
        else prevNode.next = nextNode;
    }
}

```

1.3 MemoryDatabase class

```

import java.io.*;
import java.nio.file.*;
import java.util.Objects;
import java.util.Scanner;
/*
 * @author: Kowshick Srinivasan
 * @version: 1.0
 * @Assignment: Hw2
 */

/**
 * Memory database class that does:
 * <p>
 * a) load the student-data.csv file into the memory database through
recursive function.
 * <p>
 * b) When a row is added or removed from the CSV file, the memory database
will adapt to the changes.
 * <p>
 * c) export the memory database into a csv file through recursive function.
 */
public class MemoryDatabase {

    LinkedList list; //Object of the linked list

    private static final String BASEPATH =
"/home/kowshick/Downloads/AlgoIndHw2-main/IndHw2/Data"; // target directory

    private static final String FILENAME = "student-data.csv"; //input file
name

    private static final String OUTFILE = "student-op-data.csv"; //output
file name

    LinkedList.Node prevNode;

    Scanner sc; //Scanner object

    private static boolean running = true; //Condition variable

    //Constructor based dependency injection
    public MemoryDatabase(LinkedList list, Scanner sc, LinkedList.Node
prevNode) {
        this.list = list;
        this.sc = sc;
    }
}

```

```

        this.prevNode = prevNode;
    }

    public static void main(String[] args) {

        Scanner scanner = new Scanner(System.in);
        MemoryDatabase database = new MemoryDatabase(
            new LinkedList() //Initialize the list object
            , new Scanner(System.in), null); //Initialize the scanner
        object
        File inputFile = new File(BASEPATH,FILENAME);
        File outputFile = new File(BASEPATH,OUTFILE);

        //Since we used try with resources, we won't be needing a finally
        block
        try (BufferedReader br = new BufferedReader(new
        FileReader(inputFile)); //Buffered reader to enable to the Java methods to
        read from the given file
            PrintWriter printWriter = new PrintWriter(new
        FileWriter(outputFile))) //Buffered writer to enable the Java methods to
        write on the given file
        {
            String header = br.readLine(); //read the Header of the csv
            database.read(br, database.list.head); //Read the student
            details from the file and add it to the linked list
            System.out.println("Press 0 to exit"); //KeyBoard interrupt to
            signal make watcher thread to stop and join back to the main
            Thread watcherThread = new Thread(() -> { //Load the watcher
            method to the watcherThread
                try {
                    database.watcher();
                } catch (Exception e) {
                    throw new RuntimeException(e);
                }
            });
            watcherThread.start(); //Start the watcher thread
            while (true) {
                if (scanner.hasNext() && Objects.equals(scanner.nextLine(),
                "0")) { //If there is any keyboard input, and it is 0
                    running = false; //change the contention variable to
                    false
                    //watcherThread.join(); //Resume after the completion
                    of watcher thread
                    System.out.println("Stopping watcher..."); //Stop the
                    watcher service
                    break;
                }
            }
        }

        printWriter.println(header); //print the Header of the csv
        database.print(database.list.head, printWriter); //Method to
        print the traverse the Linked list and print in the csv

    } catch (Exception e) { //Global catch block to handle all the
}

```

```

exception thrown by the program
        e.printStackTrace(System.out); //print the exception stack trace
in console

    }

}

/***
 * Method recursively read each student details from the CSV file and
adds it to the end of the linked list
 *
 * @param br      : The BufferedReader object
 * @param current : Current Node/pointer of the linked list
 * @return        : Completion status of the read operation
 */
private int read(BufferedReader br, LinkedList.Node current) throws
IOException {
    String l = br.readLine(); //Read each line
    if (l == null) return 0; //When reached EOF return
    String[] line = l.split(","); //Split the row using "," as the
separator
    Student student = convertLineToStudent(line); //Convert the String
array to the student class
    return read(br, list.insert(current, student, null)); //Recursively
call the function with the buffered reader object and updated last
Node/Pointer
}

/***
 * Accepts the String array and convert it to student object
 *
 * @param line Original String array formed after comma separation of the
line
 * @return Student object
 */
private Student convertLineToStudent(String[] line) {
    return new Student(line[0], line[1].charAt(0),
Integer.parseInt(line[2]), line[3].charAt(0), line[4], line[5].charAt(0),
        Integer.parseInt(line[6]), Integer.parseInt(line[7]),
line[8], line[9], line[10], line[11],
        Integer.parseInt(line[12]), Integer.parseInt(line[13]),
Integer.parseInt(line[14]), line[15].equals("yes"), line[16].equals("yes"),
line[17].equals("yes"), line[18].equals("yes"), line[19].equals("yes"),
        line[20].equals("yes"), line[21].equals("yes"),
line[22].equals("yes"), Integer.parseInt(line[23]),
Integer.parseInt(line[24]), Integer.parseInt(line[25]),
Integer.parseInt(line[26]),
        Integer.parseInt(line[27]), Integer.parseInt(line[28]),
Integer.parseInt(line[29]), line[30].equals("yes"));

}

/***

```

```

        * Recursively prints the student data to the csv file
        *
        * @param current      : Accepts the current NODe/pointer of the Linked
List
        * @param printWriter : Accepts the Printed writer object
        * @return : return the completion status of the printing action
        */
    private int print(LinkedList.Node current, PrintWriter printWriter) {
        String row = current.student.toString(); //Converts the student
object to comma separated string
        printWriter.println(row); //Prints the string to the csv file
        if (current.next == null) //When reached end node return completion
status
            return 0;
        return print(current.next, printWriter); //recursively call the print
method with updated last node pointer
    }

    /**
     * Watches for any changes in the csv file
     */
    private void watcher() throws Exception {
        WatchService watchService =
FileSystems.getDefault().newWatchService(); //create a watcher service
        Path path = Paths.get(BASEPATH);
        path.register(watchService, StandardWatchEventKinds.ENTRY_MODIFY);
//Notify when there is a modification event

        while (running) { //run the loop until the condition variable is
true
            WatchKey key = watchService.take(); // blocks until an event
            for (WatchEvent<?> event : key.pollEvents()) {
                WatchEvent.Kind<?> kind = event.kind();
                Path changed = (Path) event.context();
                if (changed.endsWith(FILENAME) && kind ==
StandardWatchEventKinds.ENTRY_MODIFY) {
                    System.out.println("student-data.csv has changed!");
//Notify there is a change detected in the file
                    BufferedReader br = new BufferedReader(new
FileReader(FILENAME)); //buffered reader object of the file
                    br.readLine(); //skip the header
                    reload(list.head, br); //Reload only the changes
                }
            }
            boolean valid = key.reset();
            if (!valid) break;
        }
    }

    private int reload(LinkedList.Node current, BufferedReader br) throws
IOException {
        String row = br.readLine();
        if (current.next != null && row != null) { //When both the linked
list and file is not at the end,

```

```

    // i.e. insertion/deletion happens at head in the middle
    String[] line = row.split(",");
    Student newStudent = convertLineToStudent(line);
    //Change detected
    if (!newStudent.equals(current.student)) { //There is a change
in the current node and the file row, investigate further
        LinkedList.Node nextNode = current.next;
        if (nextNode.next == null ||
nextNode.student.equals(newStudent)) { //if the current node is the last or
if the next node is same as the current row,
            // then the current row has been deleted, so we need to
delete current node
            list.delete(prevNode, nextNode); //deletion operation
        } else
            list.insert(prevNode, newStudent, nextNode); //Insertion
operation
    }
    prevNode = current; //Store the current node
    return reload(current.next, br); //recursively call with the
next node and reader object
} else if (current.next == null && row != null) { //If the linked
list has reached its end but not the file,
    // then there is something to be inserted at the end of the
Linked list
    String[] line = row.split(",");
    Student newStudent = convertLineToStudent(line);
    LinkedList.Node newNode = list.insert(prevNode, newStudent,
null);
    prevNode = newNode; //Store the current node
    return reload(newNode, br); //recursively call with the next
node and reader object
} else if (current.next != null) { //If the File has reached its
end and not the Linked List,
    // there is something to be deleted from the end of the
LinkedList
    list.delete(prevNode, null); //delete all the Node that are
excess than the File
    //No need to recursively call since we need to delete everything
that are excess
}
return 0; //both File and Linked list has reached the end
}
}

```

2.Using Python

2.1 Student Class

```

#@author Kowshick Srinivasan
#@version: 1.0
#@Assignment: Hw2
class Student:
    def __init__(self, school,
                 sex,

```

```
    age,
    address,
    fam_size,
    p_status,
    medu,
    fedu,
    m_job,
    f_job,
    reason,
    guardian,
    travel_time,
    study_time,
    failures,
    schools_up,
    farms_up,
    paid,
    activities,
    nursery,
    higher,
    internet,
    romantic,
    fam_rel,
    free_time,
    go_out,
    dalc,
    walc,
    health,
    absence,
    passed):
    self.school = school
    self.sex = sex
    self.age = age
    self.address = address
    self.fam_size = fam_size
    self.p_status = p_status
    self.medu = medu
    self.fedu = fedu
    self.m_job = m_job
    self.f_job = f_job
    self.reason = reason
    self.guardian = guardian
    self.travel_time = travel_time
    self.study_time = study_time
    self.failures = failures
    self.schools_up = schools_up
    self.farms_up = farms_up
    self.paid = paid
    self.activities = activities
    self.nursery = nursery
    self.higher = higher
    self.internet = internet
    self.romantic = romantic
    self.fam_rel = fam_rel
    self.free_time = free_time
    self.go_out = go_out
    self.dalc = dalc
    self.walc = walc
```

```

        self.health = health
        self.absence = absence
        self.passed = passed

    def __str__(self):
        return [self.school, self.sex, self.age, self.address, self.fam_size,
self.p_status, self.medu, self.fedu,
            self.m_job, self.f_job, self.reason, self.guardian,
self.travel_time, self.study_time, self.failures,
            self.convert_bool_to_string(self.schools_up),
self.convert_bool_to_string(self.farms_up),
self.convert_bool_to_string(self.paid),
            self.convert_bool_to_string(self.activities),
self.convert_bool_to_string(self.nursery),
self.convert_bool_to_string(self.higher),

self.convert_bool_to_string(self.internet),self.convert_bool_to_string(self.romantic),
self.fam_rel, self.free_time, self.go_out,
            self.dalc, self.walc, self.health,
self.absence,self.convert_bool_to_string(self.passed) ]

    def __eq__(self, obj):
        if not isinstance(obj, Student):
            return False
        return (self.school == obj.school and
            self.sex == obj.sex and
            self.age == obj.age and
            self.address == obj.address and
            self.fam_size == obj.fam_size and
            self.p_status == obj.p_status and
            self.medu == obj.medu and
            self.fedu == obj.fedu and
            self.m_job == obj.m_job and
            self.f_job == obj.f_job and
            self.reason == obj.reason and
            self.guardian == obj.guardian and
            self.travel_time == obj.travel_time and
            self.study_time == obj.study_time and
            self.failures == obj.failures and
            self.schools_up == obj.schools_up and
            self.farms_up == obj.farms_up and
            self.paid == obj.paid and
            self.activities == obj.activities and
            self.nursery == obj.nursery and
            self.internet == obj.internet and
            self.higher == obj.higher and
            self.romantic == obj.romantic and
            self.fam_rel == obj.fam_rel and
            self.free_time == obj.free_time and
            self.go_out == obj.go_out and
            self.dalc == obj.dalc and
            self.walc == obj.walc and
            self.health == obj.health and
            self.absence == obj.absence and
            self.passed == obj.passed)

```

```

def convert_bool_to_string(self, boolean_variable):
    if boolean_variable:
        return "yes"
    else:
        return "no"

#author Kowshick Srinivasan
#@version: 1.0
#@Assignment: Hw2
class Node: #class to define the structure of node
    def __init__(self, student):
        self.student = student #Contains object of student
        self.next = None #Contains an object of itself, the next node is null by default

class LinkedList:
    def __init__(self):
        self.head = None #Contains object of type Node

    def insert(self, current_node, student, next_node):
        """
            :param current_node: The current last Node/pointer
            :param student: The student object that needs to be inserted
            :param next_node: The following Node which needs to be pointed by the inserted node
            :return: new last node
        """
        new_student = Node(student) #Create the new student node
        new_student.next = next_node
        if current_node is None:
            self.head = new_student #If linked list is empty, make the new student as the first/head node
        else:
            current_node.next = new_student #Connect the previous node next to the new student node, extending the linked list chain
        return new_student

    def delete(self, prev_node, next_node):
        """
            The method is to delete the current node from the linked list.
            :param prev_node: The current last Node/ pointer
            :param next_node: The immediate next node after the current Node
        """
        # We can assign the next node pointer of the previous node to the next node instead of the current node.
        # Since the current node is hanging in the heap space the garbage collector will remove it.
        if prev_node is None:
            self.head = next_node # Delete at the head
        else:
            prev_node.next = next_node

```

2.2 Linked List Class

2.3 MemoryDatabase class

```
#@author Kowshick Srinivasan
#@version: 1.0
#@Assignment: Hw2
import csv
import os
import threading

from LinkedList import LinkedList
from Student import Student

def convert_bool(param):
    if param == "yes":
        return True
    else:
        return False

def convert_to_student(row):
    line = list(row)
    return Student(line[0], line[1], int(line[2]), line[3], line[4], line[5],
                  int(line[6]), int(line[7]), line[8], line[9], line[10],
    line[11],
                  int(line[12]), int(line[13]), int(line[14]),
    convert_bool(line[15]), convert_bool(line[16]),
                  convert_bool(line[17]), convert_bool(line[18]),
    convert_bool(line[19]),
                  convert_bool(line[20]), convert_bool(line[21]),
    convert_bool(line[22]), int(line[23]), int(line[24]),
                  int(line[25]), int(line[26]),
                  int(line[27]), int(line[28]), int(line[29]),
    convert_bool(line[30]))

# Memory database class that does:
# a) load the student-data.csv file into the memory database through
recursive function.
# b) When a row is added or removed from the CSV file, the memory database
will adapt to the changes.
# c) export the memory database into a csv file through recursive function.
class MemoryDatabase:
    BASEPATH = r"/home/kowshick/Downloads/AlgoIndHw2-main/IndHw2/Data"
    FILENAME = os.path.join(BASEPATH, 'student-data.csv')
    OUTFILE = os.path.join(BASEPATH, 'student-op-data.csv')

    def read(self, current_node, input_csv):
        """
        Recursive method to read the CSV file and add the contents to the
back of the Linked list
        :param current_node: The current Node
        :param input_csv: Reader object
        :return: Completion status of the read operation
        """

```

```

row = next(input_csv, None)
if row is None:
    return 0
student = convert_to_student(row)
return self.read(self.list.insert(current_node, student, None),
input_csv)

# Constructor based dependency injection
def __init__(self):
    self.list = LinkedList()
    self.running = True
    self.prev_node = None

def run(self):
    with open(self.FILENAME, newline="") as inputFile:
        input_csv = csv.reader(inputFile)
        header = next(input_csv, None) # read the Header of the csv
        self.read(self.list.head, input_csv) # Read the student details
from the file and add it to the linked list
        print('enter 0 to stop watching') # KeyBoard interrupt to signal
make watcher thread to stop and join back to the main
        watcher_thread = threading.Thread(target=self.file_watcher) # Load
the watcher method to the watcherThread
        watcher_thread.start() # Start the watcher thread

        if input() == '0': # Blocking-instruction, makes the main thread to
wait until there is user input 0
            self.running = False # Signal the watcher thread to stop

    watcher_thread.join() # Resume after the completion of watcher
thread

    with open(self.OUTFILE, mode='w', newline="") as outputFile:
        output_csv_writer = csv.writer(outputFile)
        output_csv_writer.writerow(header) # print the Header of the csv
        self.printer(self.list.head,
                    output_csv_writer) # Method to print the traverse
the Linked list and print in the csv

def printer(self, current, output_csv_writer):
    """
    Recursively prints the student data to the csv file
    :param current: Accepts the current NODe/ pointer of the Linked List
    :param output_csv_writer: Accepts the Printer writer object
    :return: completion status of the printing action
    """
    row = current.student.__str__()
    output_csv_writer.writerow(row)
    if current.next is None:
        return 0
    return self.printer(current.next, output_csv_writer)

# Watches for any changes in the csv file
def file_watcher(self):
    last_modified = None
    if os.path.exists(self.FILENAME):
        last_modified = os.path.getmtime(self.FILENAME)

```

```

        while self.running: # run the loop until the condition variable is
true
            if os.path.exists(self.FILENAME):
                current_modified = os.path.getmtime(self.FILENAME)
                if last_modified is None or current_modified !=

last_modified:
                print("changes detected in file")
                with open(self.FILENAME, mode='r', newline='') as
modified_file:
                    modified_csv = csv.reader(modified_file)
                    next(modified_csv, None) # skip header
                    self.reload(self.list.head, modified_csv) # Reload
only the changes
                last_modified = current_modified

def reload(self, current_node, input_csv):
    row = next(input_csv, None)
    # When both the linked list and file is not at the end,
    # i.e. insertion/deletion happens at head in the middle
    if current_node.next is not None and row is not None:
        new_student = convert_to_student(row)
        # There is a change in the current node and the file row,
investigate further
        if not new_student.__eq__(current_node.student): #####problem
            next_node = current_node.next
            # if the current node is the last or if the next node is same
as the current row,
            # then the current row has been deleted, so we need to delete
current node
            if next_node.next is None or
next_node.student.__eq__(new_student):
                self.list.delete(self.prev_node, next_node) # deletion
operation
            else:
                self.list.insert(self.prev_node, new_student, next_node)
# Insertion operation

                self.prev_node = current_node # Store the current node
                return self.reload(current_node.next, input_csv) # recursively
call with the next node and reader object
            # If the linked list has reached its end but not the file,
            # then there is something to be inserted at the end of the Linked
list
        elif current_node.next is None and row is not None:
            new_student = convert_to_student(row)
            new_node = self.list.insert(self.prev_node, new_student, None)
            self.prev_node = new_node # Store the current node
            return self.reload(new_node, input_csv) # recursively call with
the next node and reader object
        # If the File has reached its end and not the Linked List,
        # there is something to be deleted from the end of the LinkedList
    elif current_node.next is not None:
        self.list.delete(self.prev_node, None)
        # No need to recursively call since we need to delete everything
that are excess
    return 0 # both File and Linked list has reached the end

```

```
if __name__ == '__main__':
    db = MemoryDatabase()
    db.run()
```

The above source code can also found in <https://github.com/kowshick20/AlgoIndHw2.git>

The source code can also be found in the onlineGDB

1. JAVA: <https://onlinegdb.com/CdqjP8PKI>
2. Python: <https://onlinegdb.com/9X9gvdQdy>