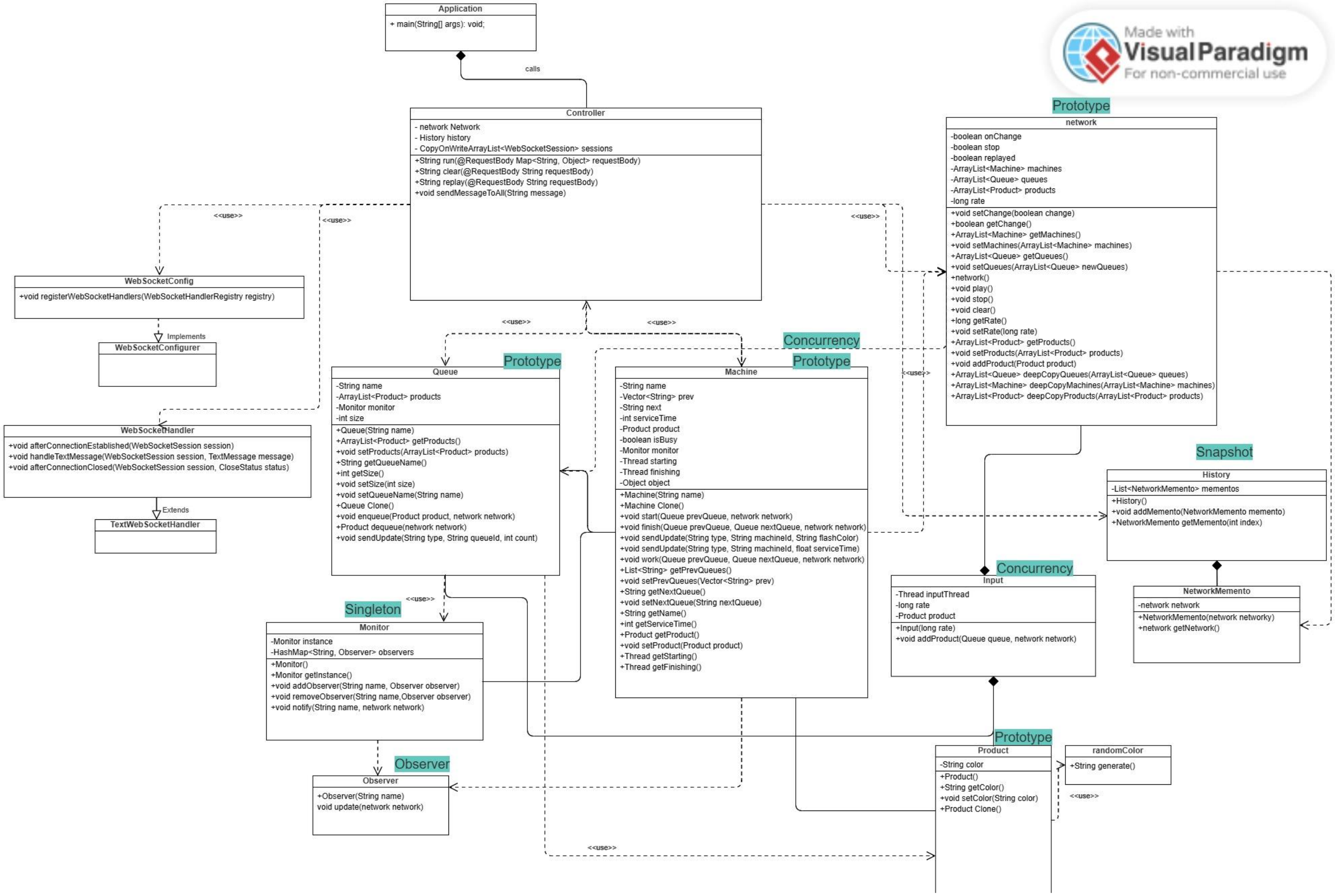
❖Names and IDs:

- Badr Elsayed - **22010664**
- Adham Anas - **22010601**
- Nour Khaled - **22011319**
- Ali El-Deen Maher – **22010934**

❖Steps required to run code:

1. Backend:
    - Open the Backend folder using IntelliJ IDE or any other IDE, run the Application.java class.
2. Frontend:
    - Open the Frontend folder using visual studio IDE, then open the terminal of the IDE, and write “npm install” in the terminal.
    - Then write “npm run dev” in the terminal to open the project, usually on port “http://localhost:5173/”
3. Then you can use the application.

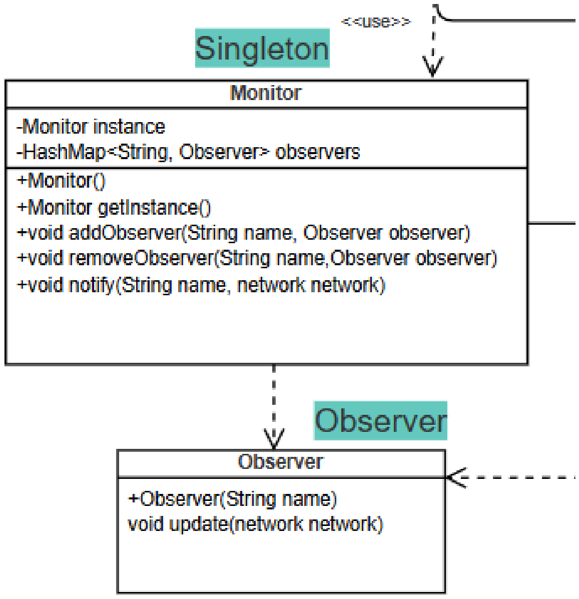
❖UML diagram:


Application
+ main(String[] args): void;
calls
Controller
- network Network
- History history
- CopyOnWriteArrayList<WebSocketSession> sessions
+String run(@RequestBody Map<String, Object> requestBody)
+String clear(@RequestBody String requestBody)
+String replay(@RequestBody String requestBody)
+void sendMessageToAll(String message)
<<use>>
<<use>>
<<use>>
<<use>>
<<use>>
WebSocketConfig
+void registerWebSocketHandlers(WebSocketHandlerRegistry registry)
Implements
WebSocketConfigurer
WebSocketHandler
+void afterConnectionEstablished(WebSocketSession session)
+void handleTextMessage(WebSocketSession session, TextMessage message)
+void afterConnectionClosed(WebSocketSession session, CloseStatus status)
Extends
TextWebSocketHandler
Prototype
Queue
-String name
-ArrayList<Product> products
-Monitor monitor
-int size
+Queue(String name)
+ArrayList<Product> getProducts()
+void setProducts(ArrayList<Product> products)
+String getQueueName()
+int getSize()
+void setSize(int size)
+void setQueueName(String name)
+Queue Clone()
+void enqueue(Product product, network network)
+Product dequeue(network network)
+void sendUpdate(String type, String queueId, int count)
Concurrency
Prototype
Machine
-String name
-Vector<String> prev
-String next
-int serviceTime
-Product product
-boolean isBusy
-Monitor monitor
-Thread starting
-Thread finishing
-Object object
+Machine(String name)
+Machine Clone()
+void start(Queue prevQueue, network network)
+void finish(Queue prevQueue, Queue nextQueue, network network)
+void sendUpdate(String type, String machineId, String flashColor)
+void sendUpdate(String type, String machineId, float serviceTime)
+void work(Queue prevQueue, Queue nextQueue, network network)
+List<String> getPrevQueues()
+void setPrevQueues(Vector<String> prev)
+String getNextQueue()
+void setNextQueue(String nextQueue)
+String getName()
+int getServiceTime()
+Product getProduct()
+void setProduct(Product product)
+Thread getStarting()
+Thread getFinishing()
Prototype
network
-boolean onChange
-boolean stop
-boolean replayed
-ArrayList<Machine> machines
-ArrayList<Queue> queues
-ArrayList<Product> products
-long rate
+void setChange(boolean change)
+boolean getChange()
+ArrayList<Machine> getMachines()
+void setMachines(ArrayList<Machine> machines)
+ArrayList<Queue> getQueues()
+void setQueues(ArrayList<Queue> newQueues)
+network()
+void play()
+void stop()
+void clear()
+long getRate()
+void setRate(long rate)
+ArrayList<Product> getProducts()
+void setProducts(ArrayList<Product> products)
+void addProduct(Product product)
+ArrayList<Queue> deepCopyQueues(ArrayList<Queue> queues)
+ArrayList<Machine> deepCopyMachines(ArrayList<Machine> machines)
+ArrayList<Product> deepCopyProducts(ArrayList<Product> products)
<<use>>
Snapshot
History
-List<NetworkMemento> mementos
+History()
+void addMemento(NetworkMemento memento)
+NetworkMemento getMemento(int index)
NetworkMemento
-network network
+NetworkMemento(network networky)
+network getNetwork()
Concurrency
Input
-Thread inputThread
-long rate
-Product product
+Input(long rate)
+void addProduct(Queue queue, network network)
Singleton
<<use>>
Monitor
-Monitor instance
-HashMap<String, Observer> observers
+Monitor()
+Monitor getInstance()
+void addObserver(String name, Observer observer)
+void removeObserver(String name,Observer observer)
+void notify(String name, network network)
Observer
Observer
+Observer(String name)
void update(network network)
Prototype
Product
-String color
+Product()
+String getColor()
+void setColor(String color)
+Product Clone()
randomColor
+String generate()
<<use>>
<<use>>

❖Design Patterns:

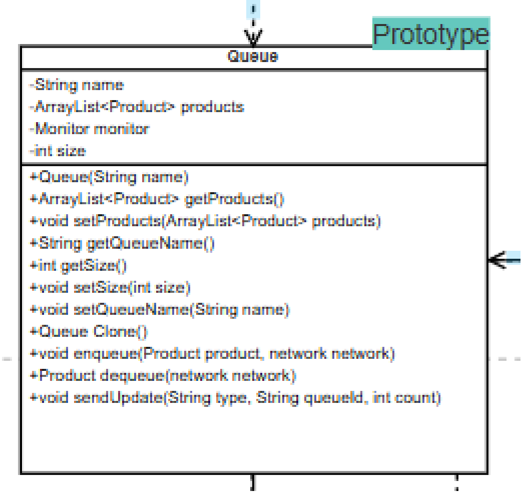
1. Singleton design pattern
    - This design pattern ensures that there is only one instance of the **Monitor** class throughout the application. This central **Monitor** instance manages the **observers**. Singelton helps conserve memory and enables reusability.
    -

2. Observer design pattern
    - This design pattern was used to implement a system where objects **(observers)** are notified of changes in the **network**. The **Monitor** class maintains a list of **observers**, and when the state of the **network** changes, all registered **observers** are updated accordingly.

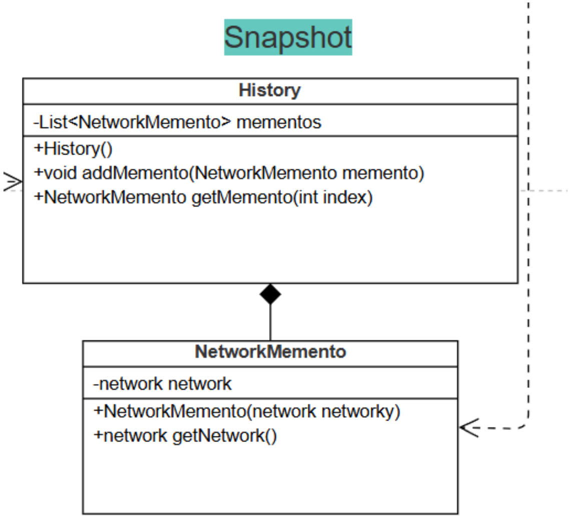


<<use>>
Singleton
Monitor
-Monitor instance
-HashMap<String, Observer> observers
+Monitor()
+Monitor getInstance()
+void addObserver(String name, Observer observer)
+void removeObserver(String name,Observer observer)
+void notify(String name, network network)
Observer
Observer
+Observer(String name)
void update(network network)

3. Prototype design pattern
    - This design pattern enables the cloning of **Machine, Queue, Product and Network** objects. It help maximize the efficiency of object creation by cloning from an existing template.

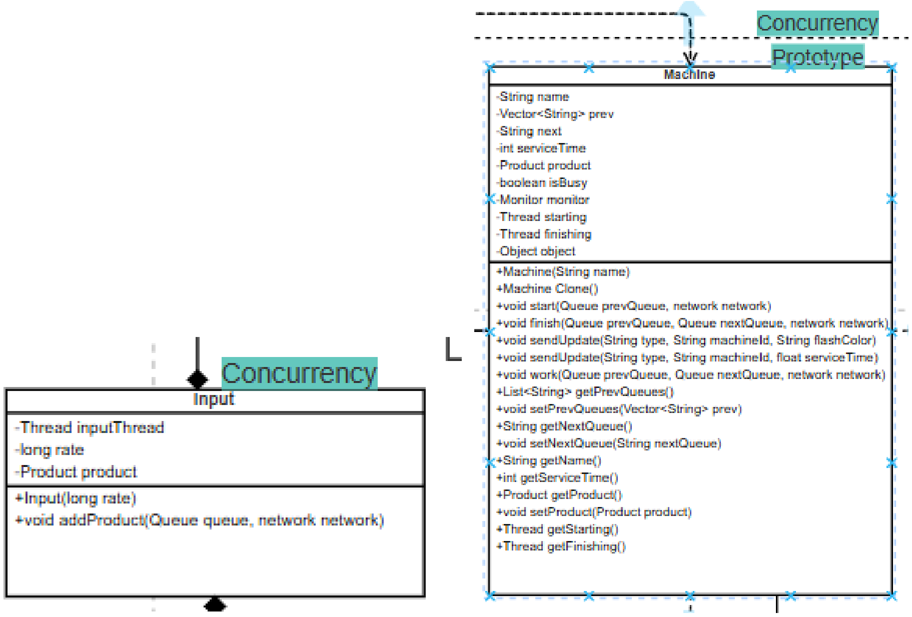

Prototype
Queue
-String name
-ArrayList<Product> products
-Monitor monitor
-int size
+Queue(String name)
+ArrayList<Product> getProducts()
+void setProducts(ArrayList<Product> products)
+String getQueueName()
+int getSize()
+void setSize(int size)
+void setQueueName(String name)
+Queue Clone()
+void enqueue(Product product, network network)
+Product dequeue(network network)
+void sendUpdate(String type, String queueId, int count)

4. Snapshot design pattern
    - This design pattern was implemented in the **NetworkMemento** and **History** classes. It allows capturing and restoring the state of the **network** at specific points in time.


Snapshot
History
-List<NetworkMemento> mementos
+History()
+void addMemento(NetworkMemento memento)
+NetworkMemento getMemento(int index)
NetworkMemento
-network network
+NetworkMemento(network networky)
+network getNetwork()

5. Concurrency design pattern

- This design pattern was implemented in **Machine** and **Input** to handle parallel processing. The classes uses concurrency by using threads to manage and perform tasks asynchronously, allowing multiple machines to operate simultaneously.

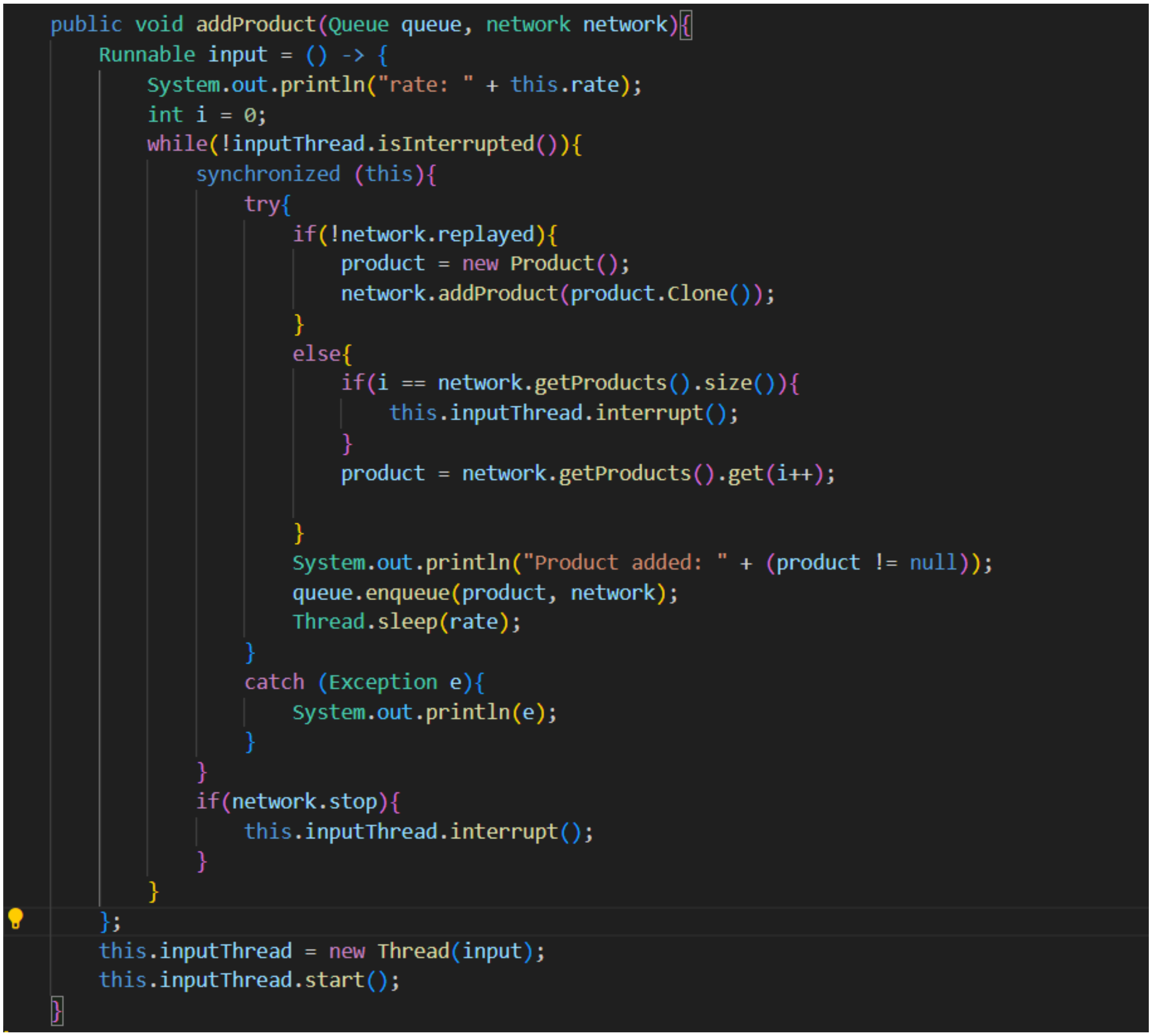

Concurrency
Input
-Thread inputThread
-long rate
-Product product
+Input(long rate)
+void addProduct(Queue queue, network network)
Concurrency
Prototype
Machine
-String name
-Vector<String> prev
-String next
-int serviceTime
-Product product
-boolean isBusy
-Monitor monitor
-Thread starting
-Thread finishing
-Object object
+Machine(String name)
+Machine Clone()
+void start(Queue prevQueue, network network)
+void finish(Queue prevQueue, Queue nextQueue, network network)
+void sendUpdate(String type, String machineId, String flashColor)
+void sendUpdate(String type, String machineId, float serviceTime)
+void work(Queue prevQueue, Queue nextQueue, network network)
+List<String> getPrevQueues()
+void setPrevQueues(Vector<String> prev)
+String getNextQueue()
+void setNextQueue(String nextQueue)
+String getName()
+int getServiceTime()
+Product getProduct()
+void setProduct(Product product)
+Thread getStarting()
+Thread getFinishing()

❖Design Patterns snapshots:

1. **Concurrency**

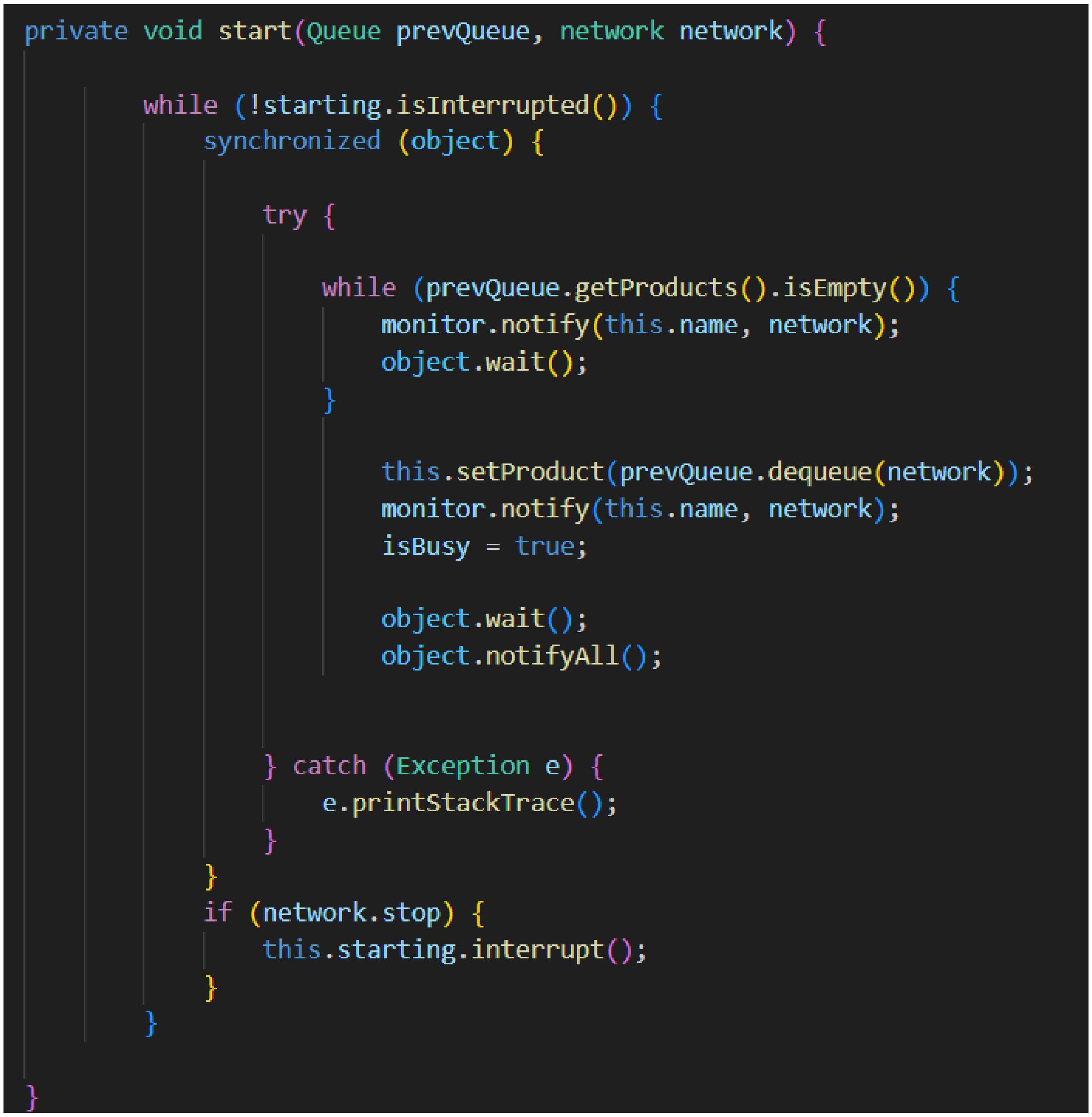
   Generating product thread:

   Hint : (including also the call of the originator to notify observers)



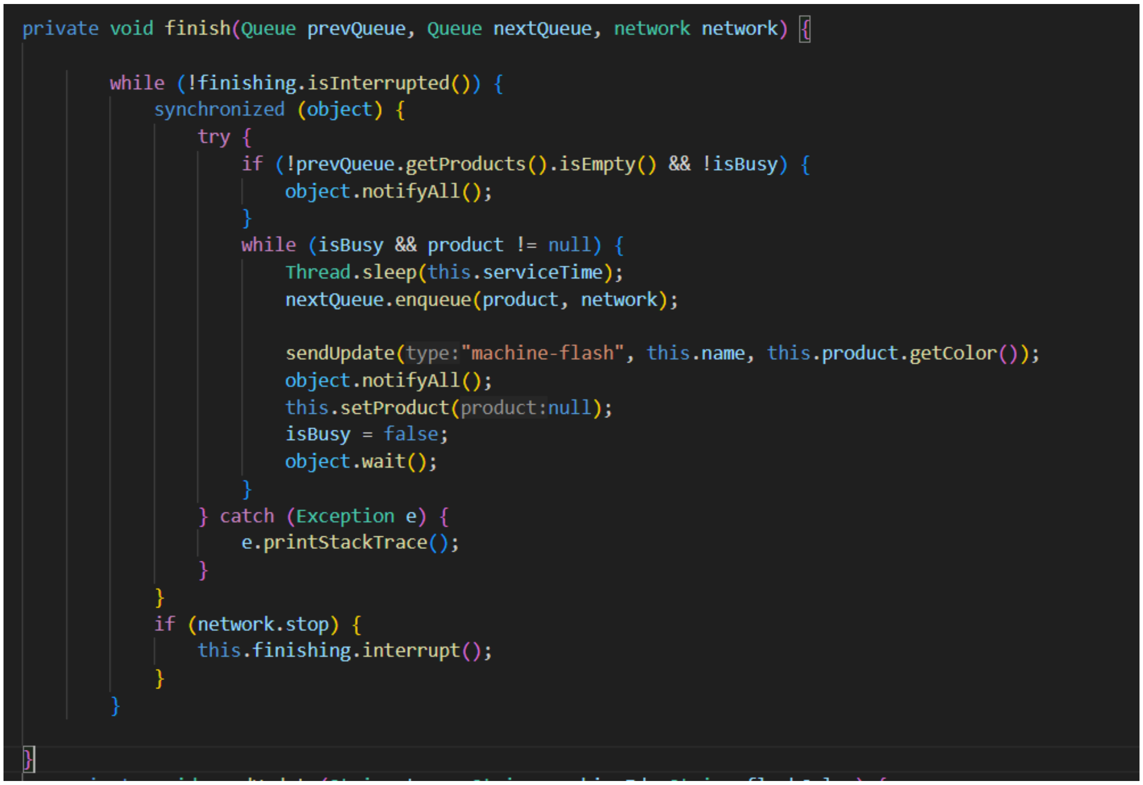
```
public void addProduct(Queue queue, network network){
    Runnable input = () -> {
        System.out.println("rate: " + this.rate);
        int i = 0;
        while(!inputThread.isInterrupted()){
            synchronized (this){
                try{
                    if(!network.replayed){
                        product = new Product();
                        network.addProduct(product.Clone());
                    }
                    else{
                        if(i == network.getProducts().size()){
                            this.inputThread.interrupt();
                        }
                        product = network.getProducts().get(i++);

                    }
                    System.out.println("Product added: " + (product != null));
                    queue.enqueue(product, network);
                    Thread.sleep(rate);
                }
                catch (Exception e){
                    System.out.println(e);
                }
            }
            if(network.stop){
                this.inputThread.interrupt();
            }
        }
    };
    this.inputThread = new Thread(input);
    this.inputThread.start();
}
```

Starting or receiving products at the machine thread Hint : (including also the call of the originator to notify observers)



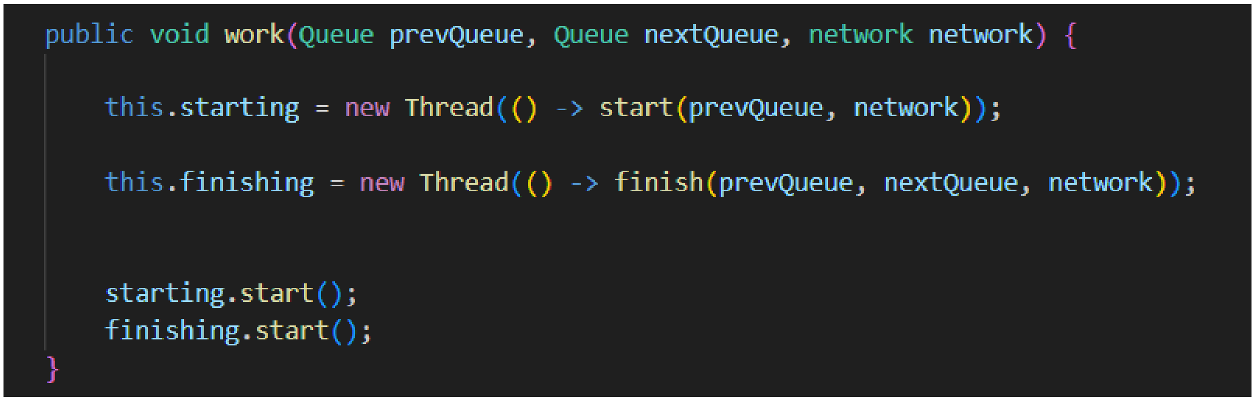
```java
private void start(Queue prevQueue, network network) {

        while (!starting.isInterrupted()) {
            synchronized (object) {

                try {

                    while (prevQueue.getProducts().isEmpty()) {
                        monitor.notify(this.name, network);
                        object.wait();
                    }

                        this.setProduct(prevQueue.dequeue(network));
                        monitor.notify(this.name, network);
                        isBusy = true;

                        object.wait();
                        object.notifyAll();


                } catch (Exception e) {
                    e.printStackTrace();
                }
            }
            if (network.stop) {
                this.starting.interrupt();
            }
        }

}
```

Finishing or producing products at the machine thread



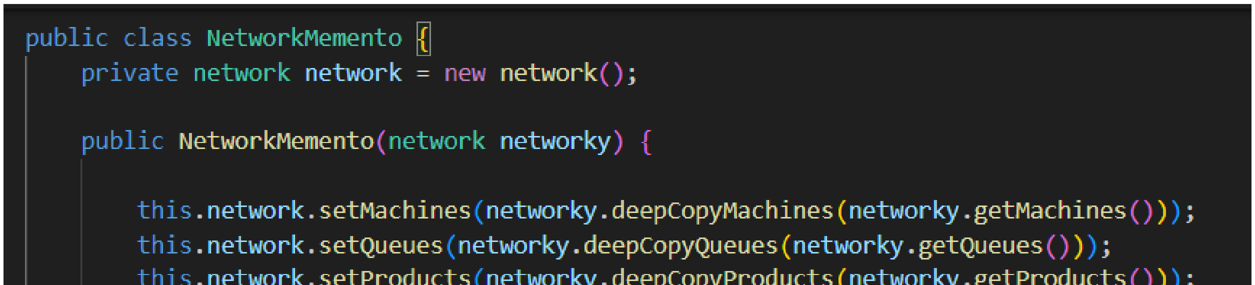
```java
private void finish(Queue prevQueue, Queue nextQueue, network network) {

        while (!finishing.isInterrupted()) {
            synchronized (object) {
                try {
                    if (!prevQueue.getProducts().isEmpty() && !isBusy) {
                        object.notifyAll();
                    }
                    while (isBusy && product != null) {
                        Thread.sleep(this.serviceTime);
                        nextQueue.enqueue(product, network);

                        sendUpdate(type:"machine-flash", this.name, this.product.getColor());
                        object.notifyAll();
                        this.setProduct(product:null);
                        isBusy = false;
                        object.wait();
                    }
                } catch (Exception e) {
                    e.printStackTrace();
                }
            }
            if (network.stop) {
                this.finishing.interrupt();
            }
        }

}
```

Working of the 2 threads concurrently



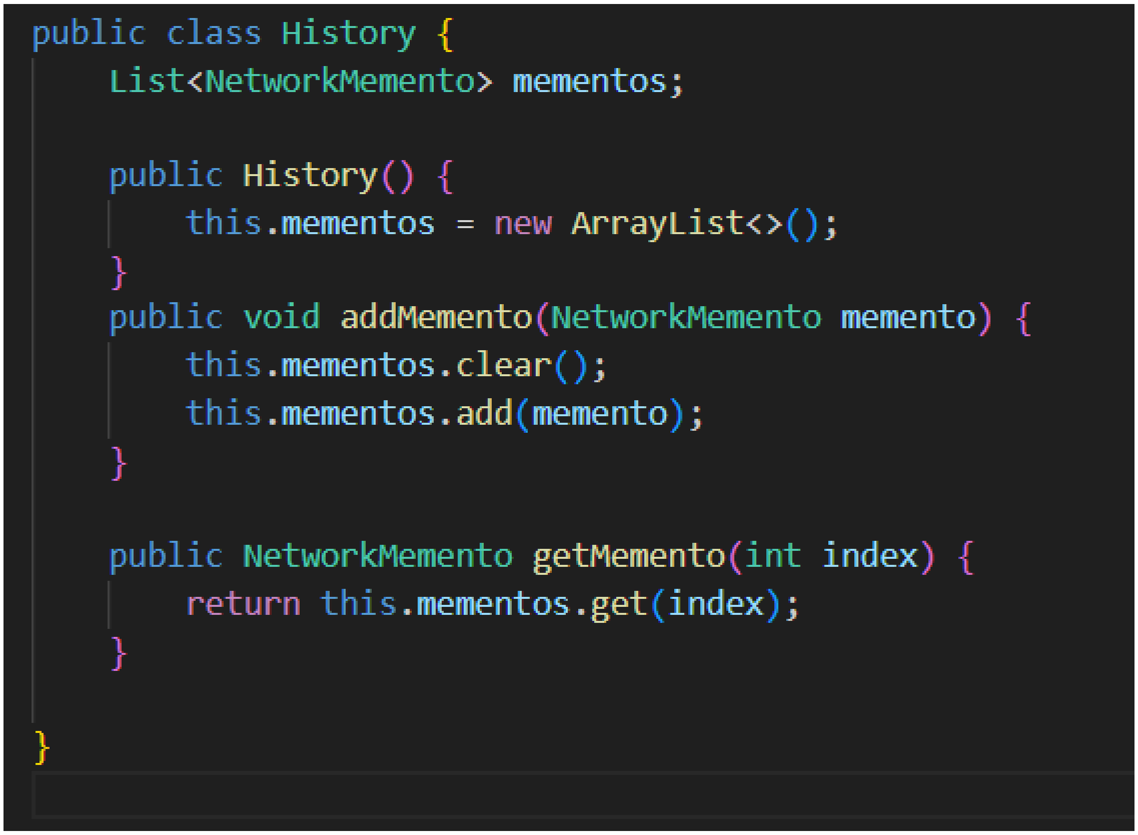
```java
public void work(Queue prevQueue, Queue nextQueue, network network) {

    this.starting = new Thread(() -> start(prevQueue, network));

    this.finishing = new Thread(() -> finish(prevQueue, nextQueue, network));


    starting.start();
    finishing.start();
}
```

2. **Snapshot (Memento)**



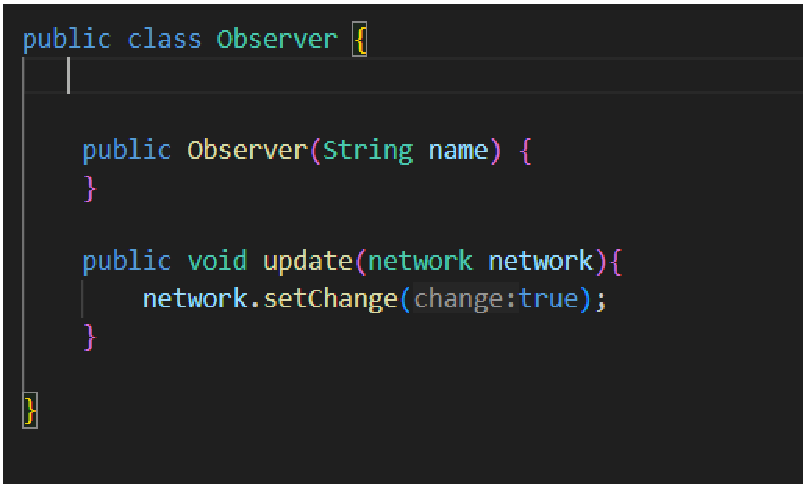
```java
public class NetworkMemento {
    private network network = new network();

    public NetworkMemento(network networky) {

        this.network.setMachines(networky.deepCopyMachines(networky.getMachines()));
        this.network.setQueues(networky.deepCopyQueues(networky.getQueues()));
        this.network.setProducts(networky.deepCopyProducts(networky.getProducts()));
```

caretaker (history)



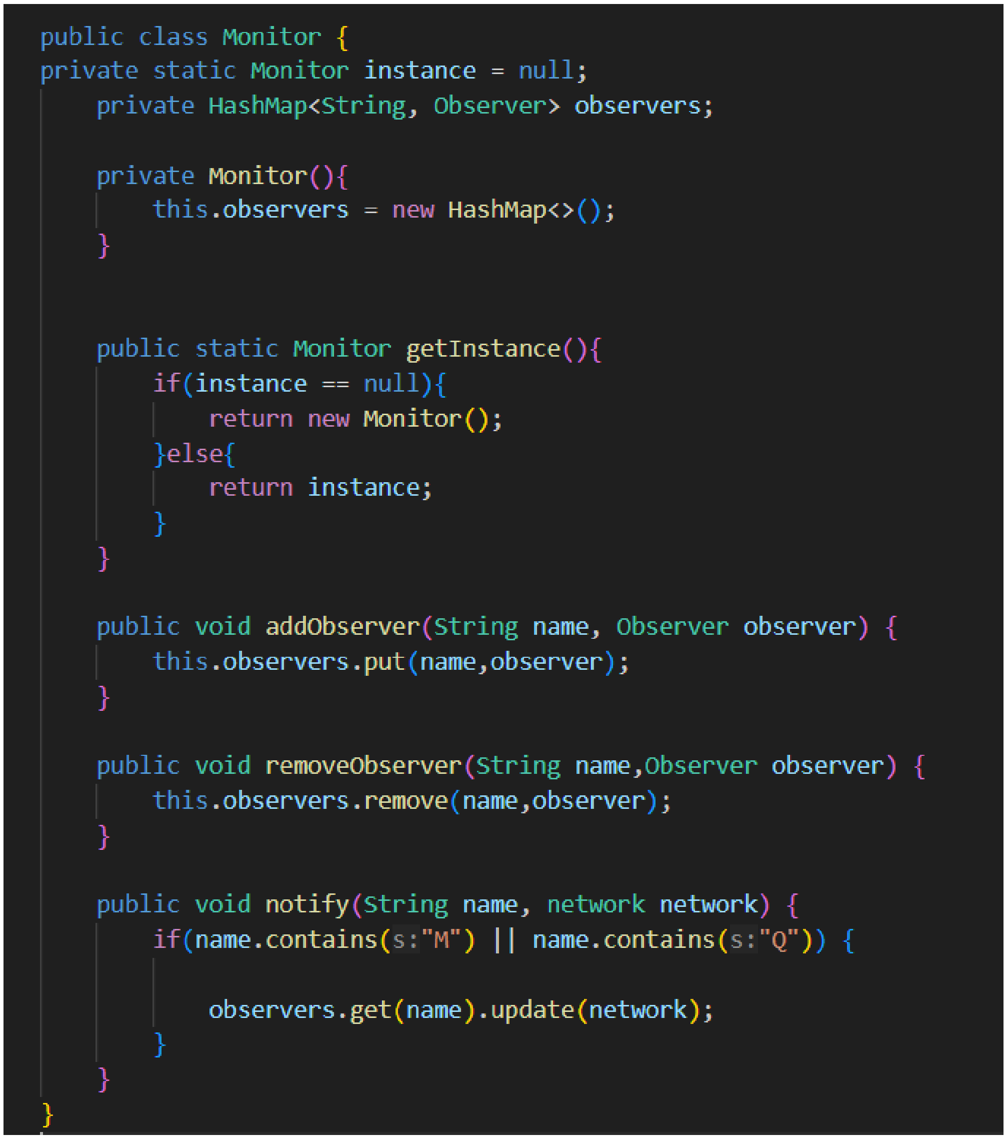
```java
public class History {
    List<NetworkMemento> mementos;

    public History() {
        this.mementos = new ArrayList<>();
    }
    public void addMemento(NetworkMemento memento) {
        this.mementos.clear();
        this.mementos.add(memento);
    }

    public NetworkMemento getMemento(int index) {
        return this.mementos.get(index);
    }

}
```

3. **Observer**



```
public class Observer {
    

    public Observer(String name) {
    }

    public void update(network network){
        network.setChange(change:true);
    }

}
```

Monitor (manager for observer)



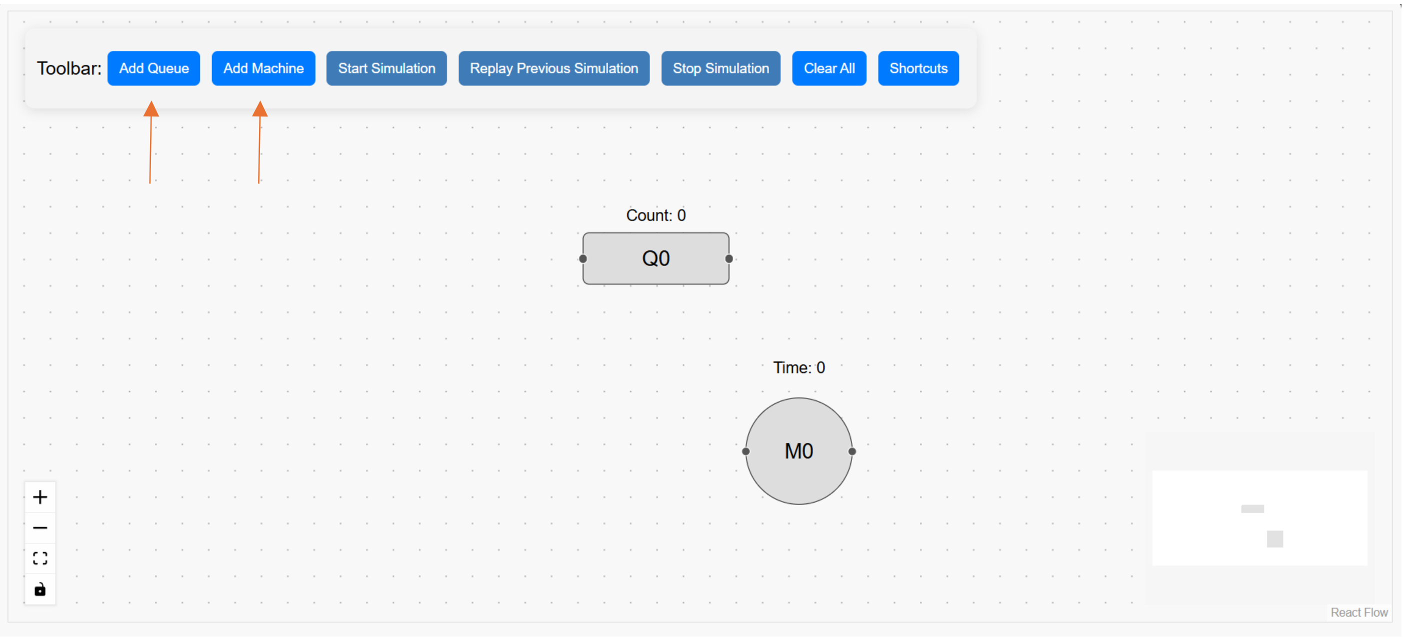
```
public class Monitor {
private static Monitor instance = null;
    private HashMap<String, Observer> observers;

    private Monitor(){
        this.observers = new HashMap<>();
    }


    public static Monitor getInstance(){
        if(instance == null){
            return new Monitor();
        }else{
            return instance;
        }
    }

    public void addObserver(String name, Observer observer) {
        this.observers.put(name,observer);
    }

    public void removeObserver(String name,Observer observer) {
        this.observers.remove(name,observer);
    }

    public void notify(String name, network network) {
        if(name.contains(s:"M") || name.contains(s:"Q")) {

            observers.get(name).update(network);
        }
    }
}
```

❖Design decisions:

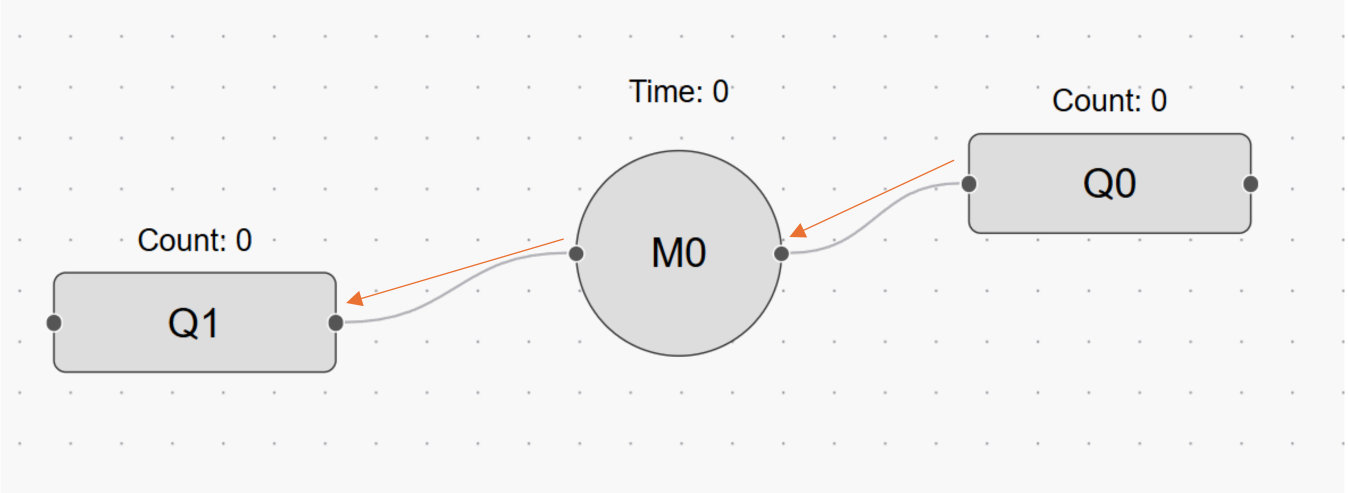
- Input (First) Queue must be Q0
- User can stop the simulation completely but can’t pause/resume it.
- A machine can only output in a single Queue.
- Machine time is assumed to be in range of [5, 25] seconds.
- Q0 input federate is in range of [5, 10] seconds.
- Number of input products has no limits.

❖Snapshots UI and User guide:

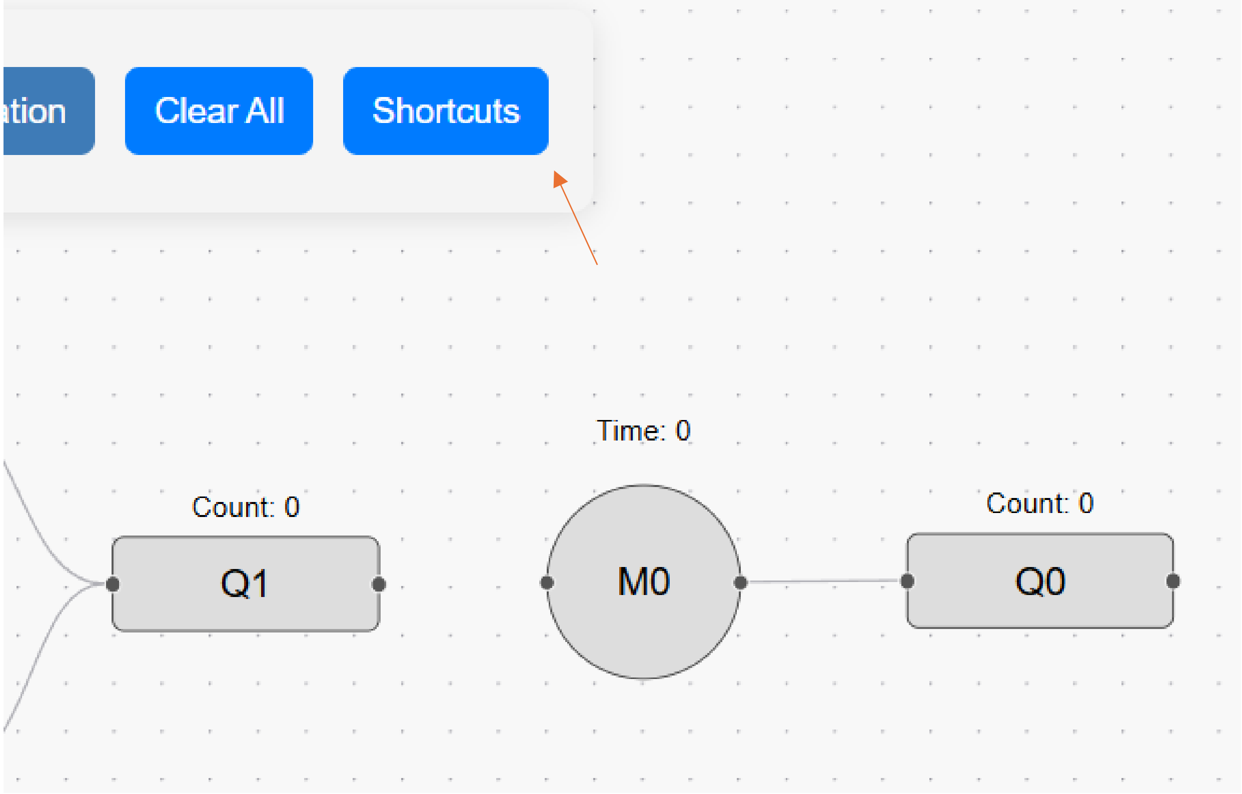
1. Start by **adding** the Queues and Machines that you want, when you click an “Add” button, a Queue/Machine will appear on the board.



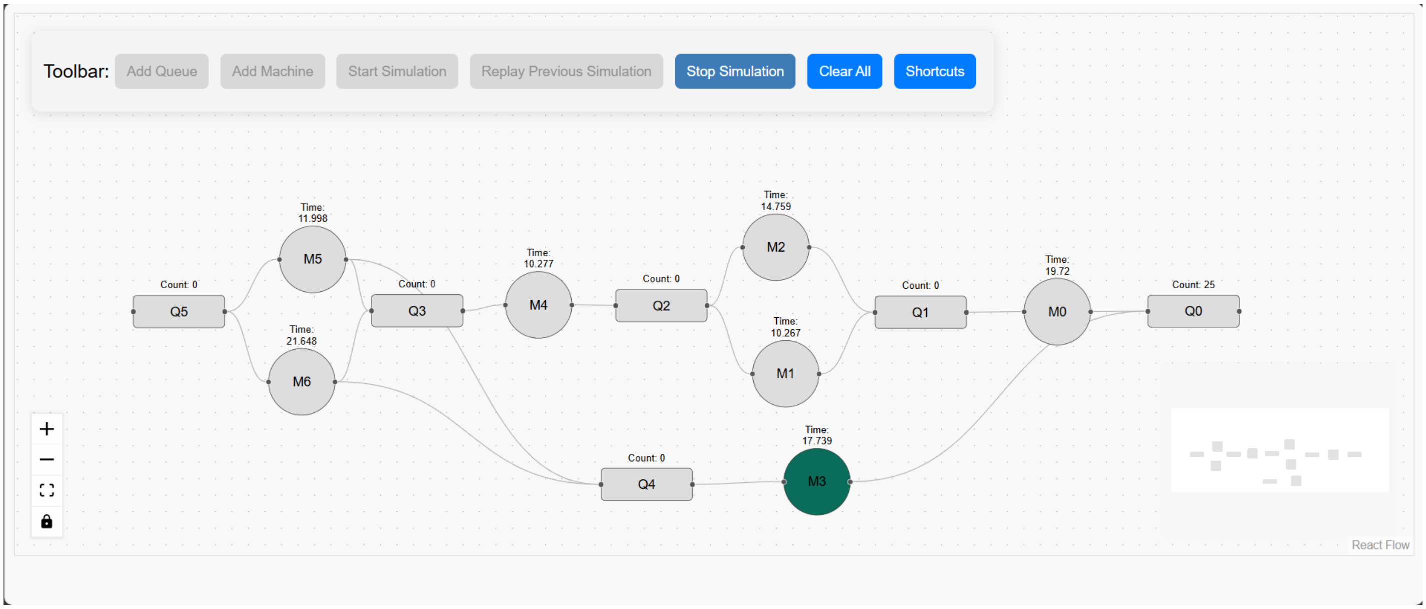
2. Rearrange the Queues and Machines by dragging them, then connect them by grabbing and dragging one end to the other. Note: The flow of simulation is from right to left, meaning that Q0 is the input and Q1 is the final output, so keep that in mind!



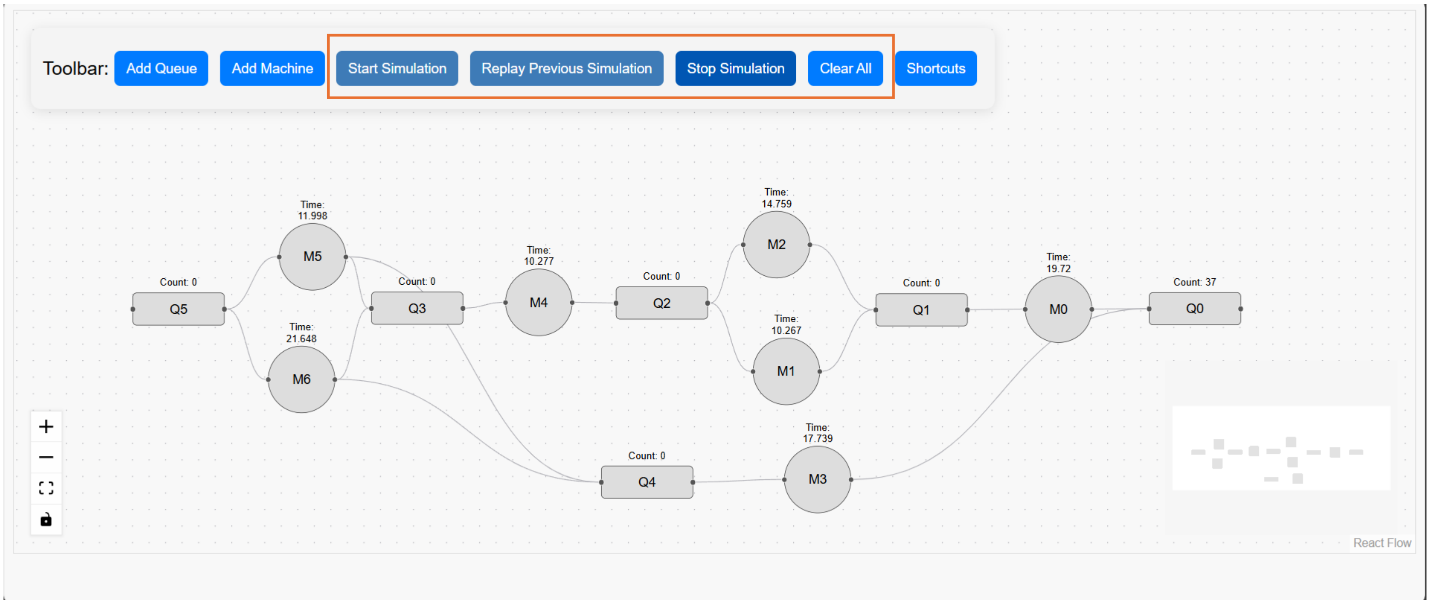
3. Made a mistake? Delete a Queue / Machine or an edge by selecting it and clicking “**Backspace**” on the keyboard, you can also see this info in the “**Shortcuts**” button in case you forgot what to press.

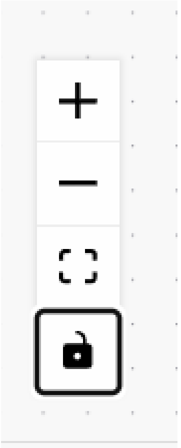


4. When all good, press “**Start Simulation**” to begin. You’ll see the current number of products in each Queue and the time a Machine takes to service/process a product.
   Each machine will flash the color of the product it’s inside when it finishes servicing the product,
   Each product from Q0 up till Q5 will have a unique random color.



5. Press “**Stop Simulation**” to stop the simulation.
   Press **“Clear All”** to start fresh (will obviously stop simulation).
   You can start simulation again with new random values and colors when you click “**Start Simulation**”.
   Or click “**Replay Previous Simulation**” to replay the last played simulation with the same values and colors!





6. Lastly, you may have wondered what’s in the bottom left. It’s a control panel! You can
   1- Zoom in
   2- Zoom out
   3- Fit view
   4- Toggle interactivity, which includes (Select, Delete, Drag)

   The bottom right is just a mini-map (overview) of the whole board.