MODELING OF SMART GRID TRAFFICS USING NON-PREEMPTIVE PRIORITY QUEUES

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- Smart Grid Model and Components.
- Future Smart grid components.
- Classification of Smart Grid Traffic.
- Brief explanation of Preemptive, Non-Preemptive and Weighted Round Robin methods.
- Proposed model and Simulation Results.
- Advantages and Disadvantages of the proposed model.

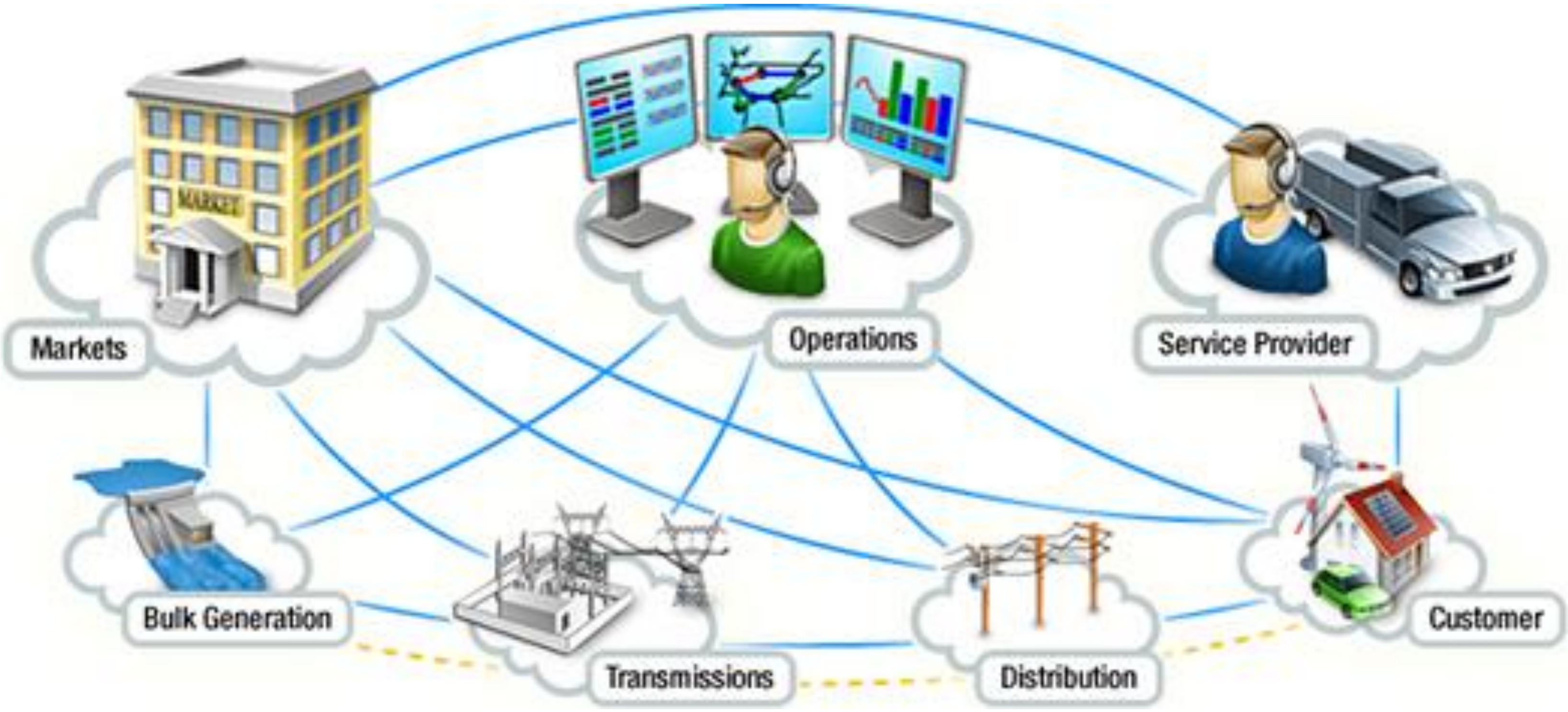
Need for this paper

Smart grid has various applications making it very complex to manage network traffics

Efficient control of network traffic to maximize the throughput of the system

Simulating the smart grid traffics using non preemptive queues

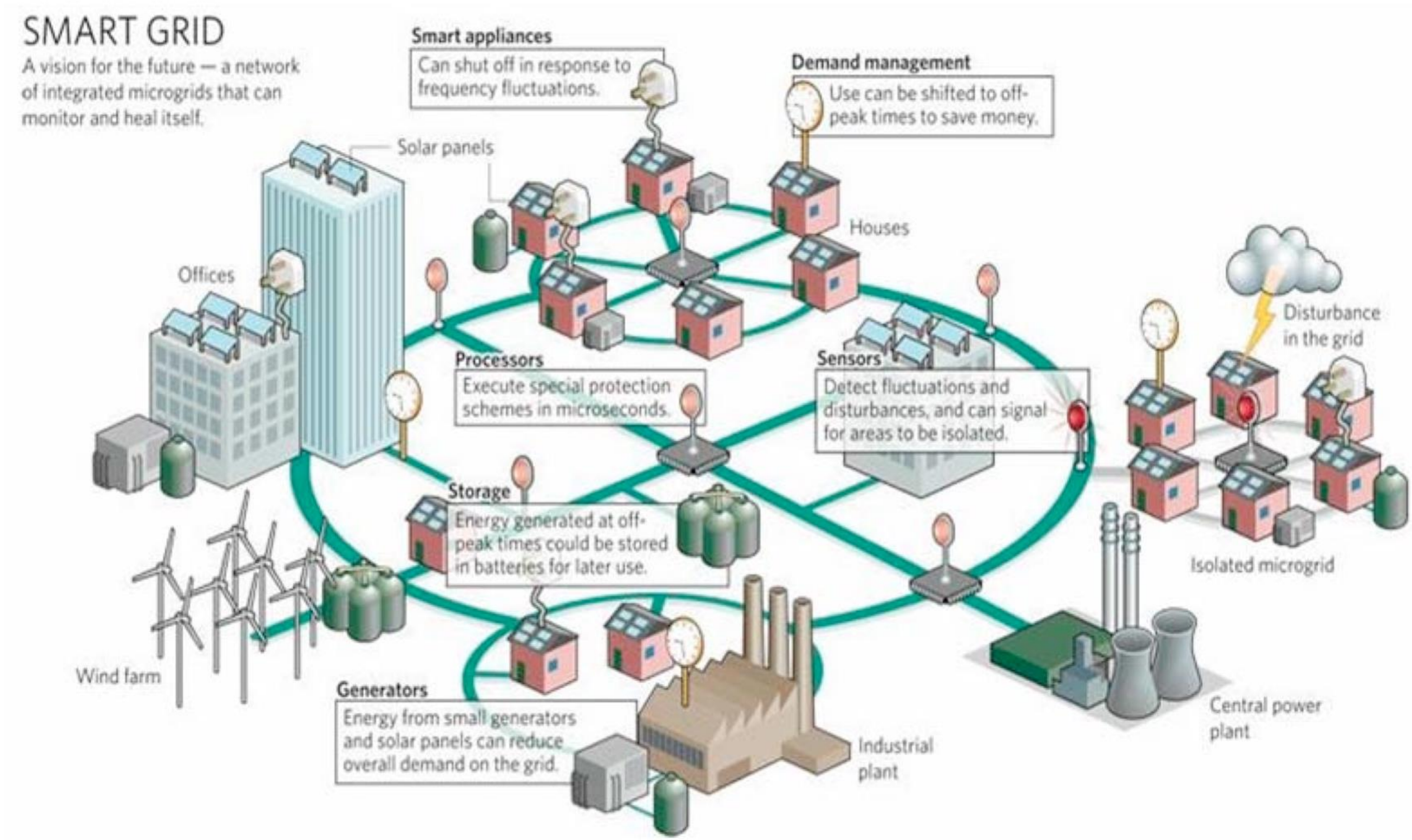
Smart Grid Model



Smart Grid Components

- **Customer:** At customer domain, the electricity is consumed. This domain is usually partitioned into sub-domains for home, commercial building, and industrial.
- **Market:** This domain includes the operators and participants in electricity markets. In this domain the grid assets are bought and sold.
- **Service providers:** Service providers are organizations which provide services to electrical customers and utilities.
- **Operations:** In this domain the movement of electricity is managed. Example – Monitoring and Control.
- **Bulk generation:** In this domain by using other forms of energy the electricity is generated. There are two different sources for energy generation: renewable energy and nonrenewable energy.
- **Transmission:** Transmission is the process of carrying the bulk electricity over long distances. Using electrical transmission lines and multiple substations, the generated electrical power is transmitted from generation sources to distribution through multiple substations.
- **Distribution:** This domain is responsible to distribute the electricity to and from customers. The customer domain and their smart meters, distributed storage and distributed generation are connected to the transmission domain using distribution domain.

Smarter Grid



Why is traffic classification required?

Each application in the smart grid has traffic with different requirements

Utilities need to manage the traffic requirements into similar classes so that they can process the multiple applications

The traffics are tabled on the basis of delay, bandwidth and packet loss

Classification of Smart Grid Traffics

Traffic Class	Latency(ms)	Bandwidth(kb/s)	Applications
Class 1	8-10	64	Teleprotection
Class 2	100	1.2-64	WACS
Class 3	16	2048	PMU
Class 4	200	512	SCADA
Class 5	200	8-64	VoIP

Non-Preemptive Priority Queuing(Method 1)

Priority Scheduling

- Selects the processes with the highest priority currently ready to run. If there is more than one process having the currently highest priority, you need a second scheduling algorithm to choose among these processes.

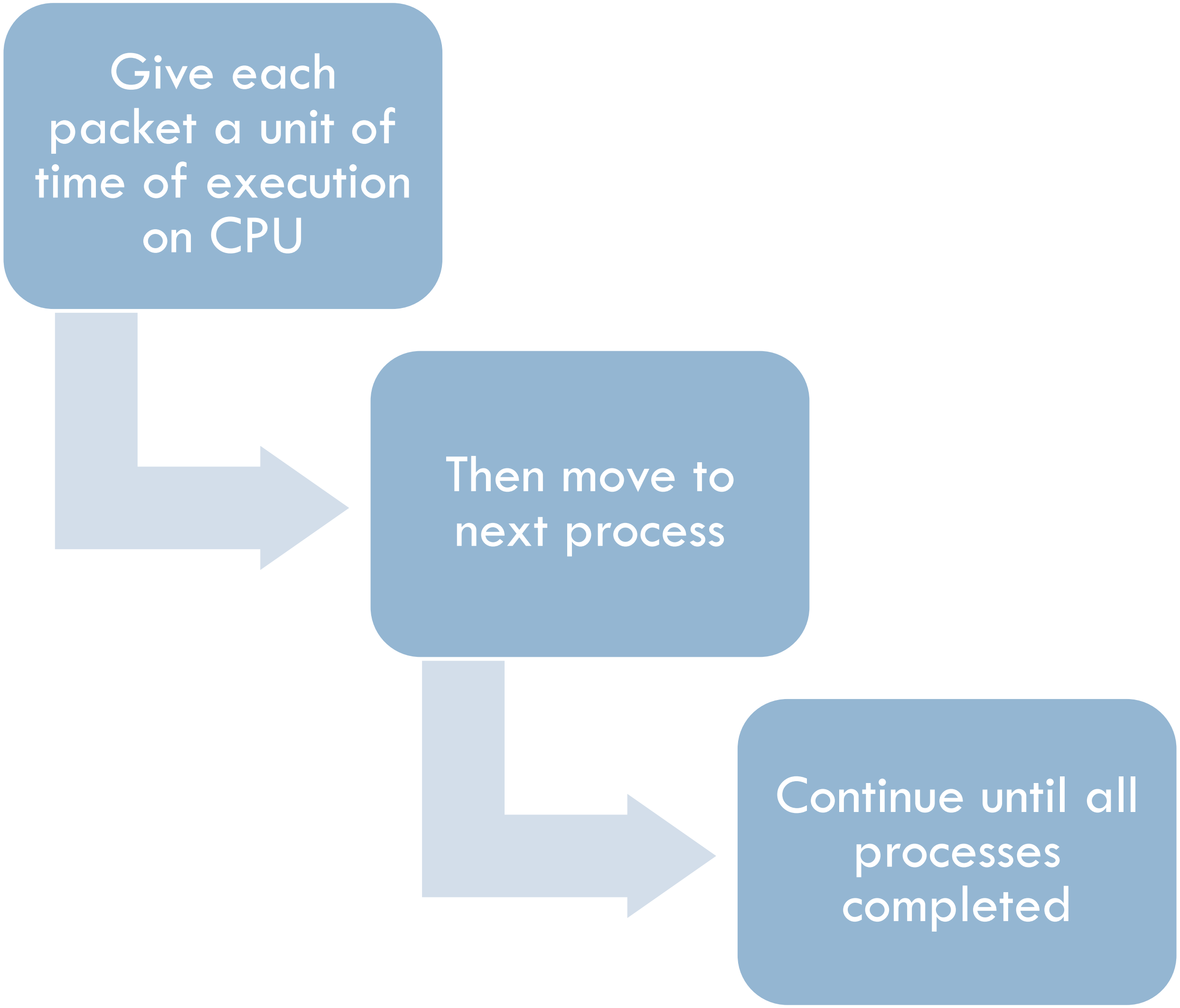
Non-preemptive Priority Scheduling

- Selects a new process to run if the running process finished its work or yields (voluntarily) to the scheduler.

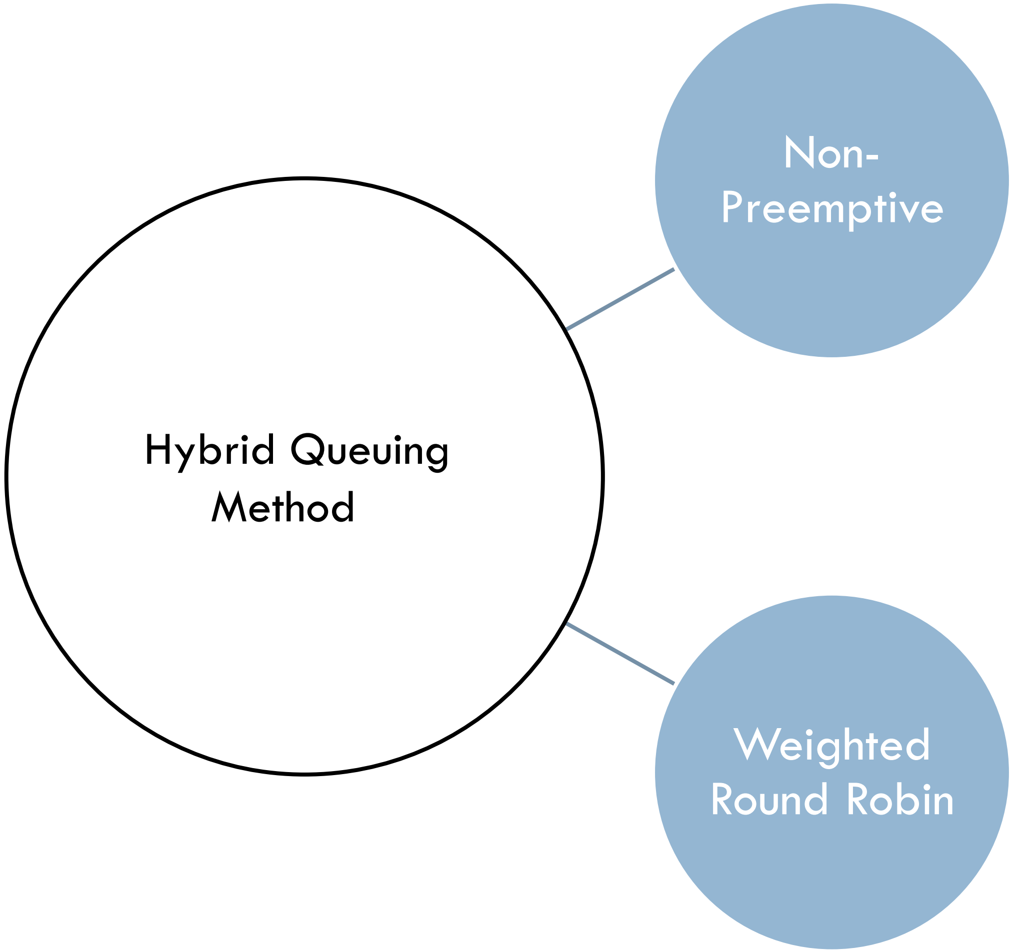
Preemptive Priority Scheduling

- If a new process having a higher priority than the currently running process arrives, it gets selected immediately.

RR (Round Robin) Scheduling



Hybrid Queuing (Method 2)



- Applied for the first queue with low delay

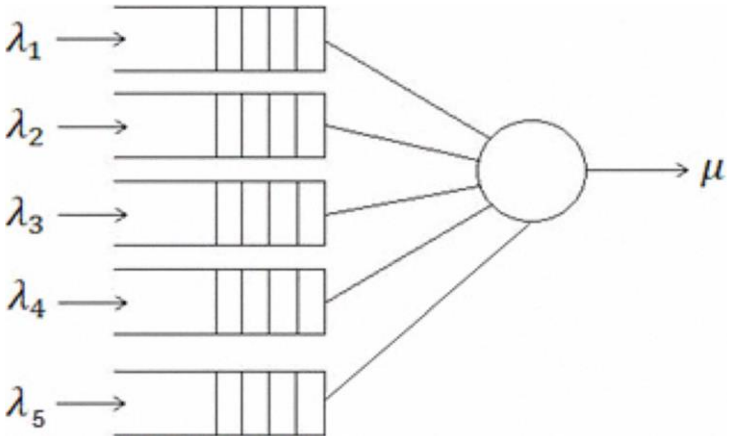
- Applied for queues with high delay
- Weights can be selected either internally or externally.

Proposed Model

At the network node traffic class identifier is added to the packets.

Each node is put into proper queue based on its traffic class.

Since there are five classes, 5 M/M/1 queues with different specifications are required



Proposed Model (contd.)

- Mean Arrival Time

$\lambda_i = \frac{B_i}{L_i}$ where Bi is the bandwidth; Li is the packet size(512 bits)

- Mean Service Time

$\mu_i = \frac{C}{L_i}$ where C is the output bandwidth given as

$$C = \alpha \sum_{i=1}^{k} B_i \quad 0 < \alpha \leq 1$$

- Packets with priority class ı arrive in a Poisson's ratio with rate of λ_i. The service and arrival times are exponentially distributed.

Proposed model (contd.)

- W_i represents the mean waiting time

$$W_i = \frac{\sum_{j=1}^{K} \lambda_j {h_j}^2}{2(1 - \sum_{j=1}^{i-1} \rho_j)}$$

- Where ρ_i is the traffic intensity of the class.
- Total System class is T_i

$$T_i = \frac{1}{\mu_i} + \frac{\sum_{j=1}^{K} \lambda_j {h^2}_j}{2(1 - \sum_{j=1}^{i-1} \rho_j)}$$

Where ${h^2}_j$ is the second moment of service time class j.

Evaluation Results

Non-Preemptive Queuing(Method 1)

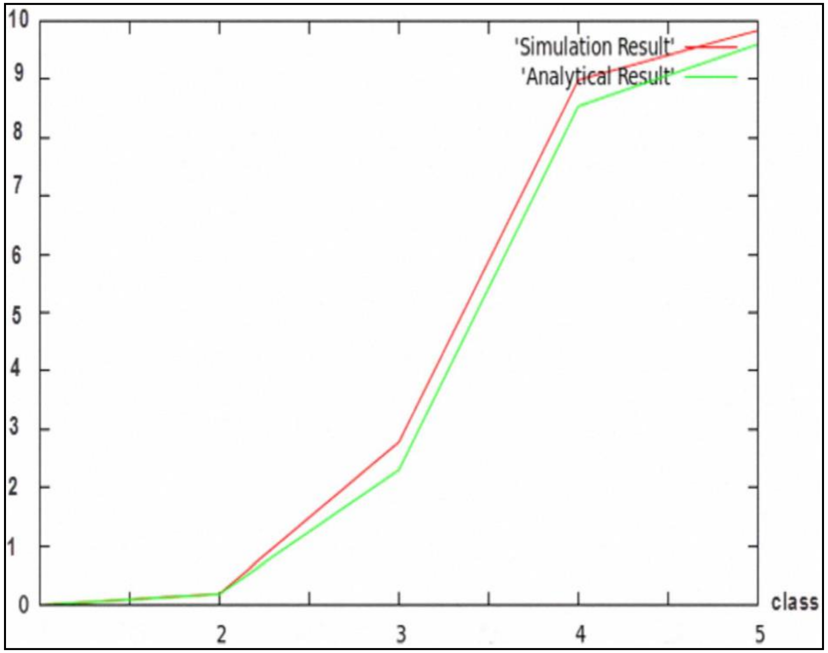
Traffic Class	λ_i	Analytical W_i	Simulation W_i
Class 1	128	0	0
Class 2	64	1.85e-4	1.90e-4
Class 3	4096	2.30e-3	2.78e-3
Class 4	1024	8.56e-3	8.99e-3
Class 5	64	9.60e-3	9.84e-3

Hybrid Queuing (Method 2)

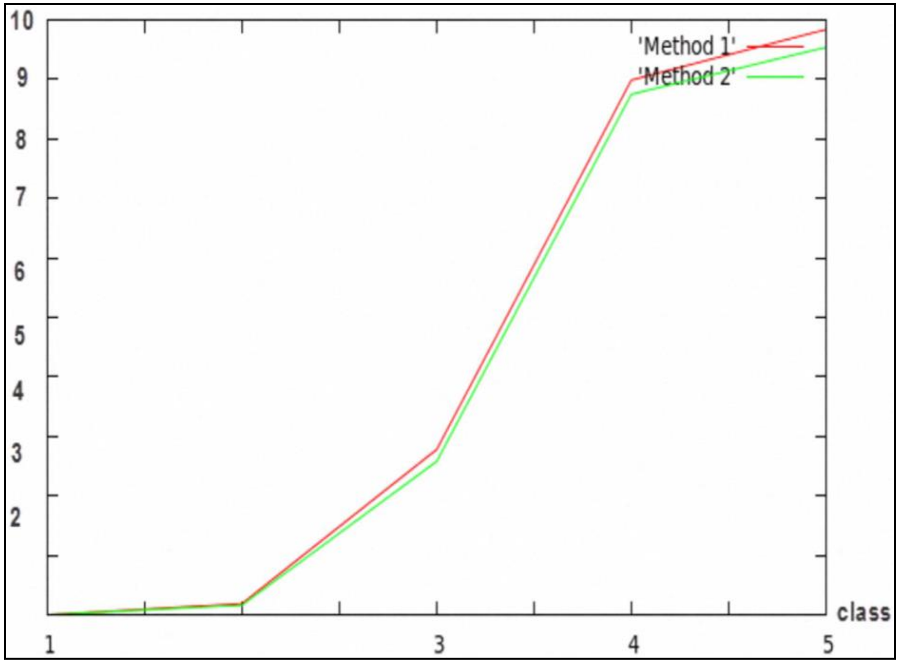
Traffic Class	λ_i	Simulation W_i
Class 1	128	0
Class 2	64	1.64e-4
Class 3	4096	2.58e-3
Class 4	1024	8.75e-3
Class 5	64	9.54e-3

Simulation Results

SIMULATION AND ANALYTICAL RESULTS OF METHOD I



COMPARISON BETWEEN METHOD I AND METHOD 2



Analysis of the Simulation Results

In method 1the difference between analysis and simulation is very small in the mean of waiting time and the Smart Grid traffics required latency is satisfied. The comparison is depicted.

In the second case using the hybrid method, even better results are achieved. The error percentage between the analytical method and the simulation is very low.

Advantages &Disadvantages of Non-Preemptive Priority Scheduling

Advantages:

- The main advantage is that they ensure fairness to all jobs, regardless of its priority and also provide quick response time depending on the CPU time the job needs.
- Less computational resources needed for scheduling.

Disadvantages:

- Can leads to starvation (not met the deadline) especially for those real time tasks (or high priority tasks).

QUESTIONS?