# Implementation of Dijkstra's Algorithm in a Dynamic Microgrid

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**Abstract**:Unlike conventional utility grids, microgrids comprise generators, storage devices and loads at all levels of the system. Power generation, distribution and consumption levels are not discrete and power flow may occur at any direction. At any point in time, microgrid may be disconnected from the utility grid and continue its operation under islanding conditions. Furthermore, some microgrids may have changing structures with alternative paths and the coupling point for a device or a part of the microgrid may change due to the altering conditions. Considering all of these challenges, it is required to develop a new protection concept/scheme for a safe and secure operation. Maintaining proper selective operation of relays in these new systems and new dynamic microgrid structures is also a challenge in itself. To provide security, cryptography algorithm should be used.There are two types of cryptography Algorithm namely- Private key Cryptography and Public Key Cryptography. Private Key Cryptography Algorithm uses symmetric Key for encryption and decryption and this key is usually transmitted through an insecure method to the receiver for decryption purpose which makes the algorithm less secure. Instead Public Key Cryptography Algorithm uses two different keys-Public Key for encryption and Private Key for decryption. So,the private Key need not be transmitted as it is privately owned by the receiver which makes this algorithm more secure. Here, In this paper Public Key Cryptography Algorithm i.e. RSA algorithm has been implemented to prevent it from Intrusion Attacks.

**Keywords:** Dijkstra's Algorithm, Distributed Generation, Relay Programming, Central Protection, Selectivity, Graph Theory, RSA, Intrusion, MATLAB.

**INTRODUCTION:** Distributed generation (DG) allows power generation near consumption points and eliminates the need for transmission lines and the losses associated with them. Also, provides flexibility in continues power distribution. This feature makes the DG very popular as it agrees with the growing environmental awareness and concerns. Some DG units may be based on Renewable Energy (RE) resources such as wind turbines, solar systems or wave generators . In such cases, the utilization of these cleaner energy resources also reduces greenhouse gas emissions making DG very popular as it concurs with the growing environmental awareness and concerns. Consequently, DG is hoped to replace the bulk generation in centralized power stations, in the near future. However, the design of existing distribution systems is not suitable for significant penetration of DG. These systems are designed assuming that the network will be passive and the power flow will only be unidirectional, i.e. downstream. When DGs are connected to these networks, the characteristics of the system change and key technical challenges arise which were previously unknown . In order to address these issues, the microgrid concept is introduced. A microgrid is a collection of loads and microgenerators along with some local storage and behaves just like a model-citizen from grid side thanks to intelligent control . Although a microgrid is itself composed of many generators and loads, it appears as a net load or a net generator to the broader grid with well-behaved characteristics [6], i.e. either as a load receiving power or as a power supply providing power with stable voltage and frequency. Microgrids have dynamic structures which change very often. The following may be counted among the reasons for the changes in the microgrid structure.

- New DG or load deployments
- Islanding of the system
- Fault conditions

- Reconfiguration of the structure for reasons such as maintenance

This algorithm is practically used in routing and other network related protocols. For a given source vertex (node) in graph, the algorithm finds the path with lowest cost (i.e. the shortest path) between that node and every other node present in the network. It can also be used for finding costs of shortest path from source vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined. For example, if the vertices (nodes) of the graph represent cities and edge path costs represent driving distances between pairs of cities connected by a direct road, Dijkstra's algorithm can be used to find the shortest path between one city and all other cities.

## METHODOLOGY:

In this paper, MATLAB is being used to implement the dijkstra's algorithm.

Step involved in algorithm:

1) Enter the number of nodes. Let suppose n=10.
2) Make connection matrix and weight matrix. Denote connection matrix with 'a' and weight matrix with 'f'.
3) Enter Source node.
4) Enter Destination node.
5) Find the neighbour matrix which contains the nodes having direct path from source node.It is denoted by matrix'b'.
6) Calculate the minimum distance path from source node to destination node. It is denoted by matrix 'h'.
7) Calculate the distance from each node.
8) Calculate the minimum distance from source node to destination node.

**A Flow Chart**

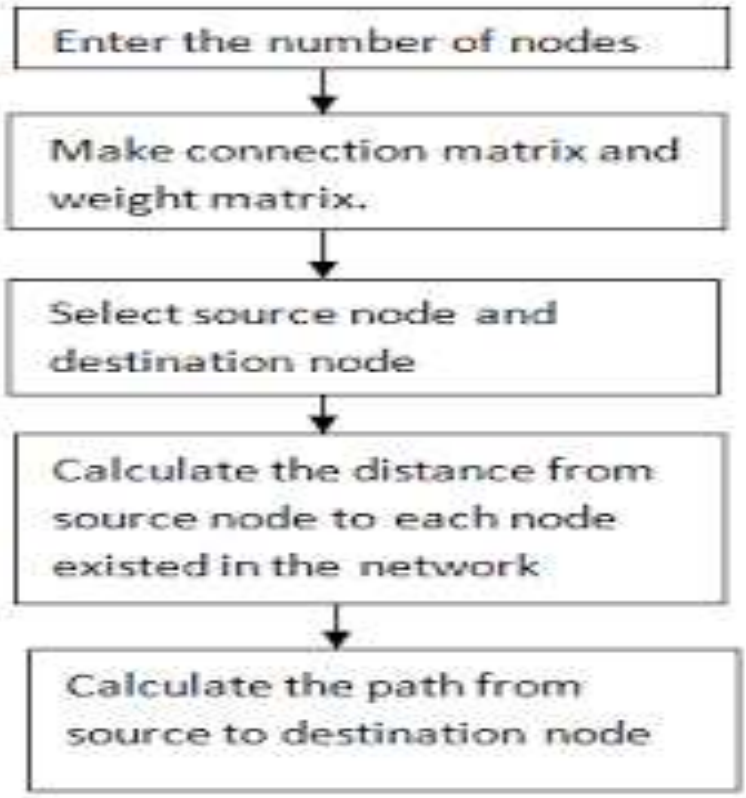


Figure 1: Flow Chart Of Algorithm

**Example Of Algorithm:**

The above algorithm can be explained and understood better using an example. The example will briefly explain each step that is taken and how Dist is calculated

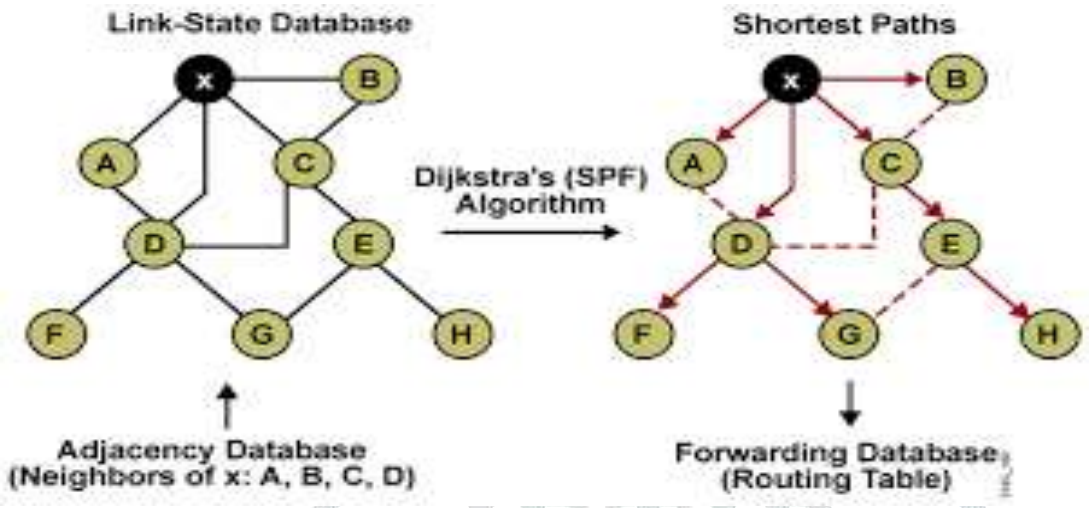


Figure 2:Weighted -Directed Graph

The above weighted graph has 5 vertices from A-E.The value between the two vertices is known as the edge cost between two vertices. For example the edge cost between A and C is 1.Using the above graph the Dijkstra's algorithm is used to determine the shortest path from the source A to the remaining vertices.

## SELECTIVITY ISSUES AND RELAY HIERARCHY

Selectivity is a well known protection concept which means isolating the fault with the nearest relay in an effort to minimize its effect on the rest of the system . This requires that in case of a fault, the relays should react according to a hierarchy. In conventional protection systems designed for passive networks, the relays which are downstream and closer to the fault point are required to operate first. However, if the fault current is very large and downstream relays are not capable of interrupting it, then other relays with larger capacities are expected to operate and isolate the fault. However, implementation of selectivity is not that straightforward with the introduction of DGs. The very concepts of downstream and upstream relays are prone to change according to the status of the microgrid. The operating mode, i.e. grid-connected or islanded-mode, changing network structure with alternative paths and new deployments are some of the factors that would alter the selectivity parameters. In this network, all branches have generation and load, and various alternative network structures can be formed through the combination of relays. As first case, assume that the circuit breakers CB1, CB2, CB3, CB4, CB6 and CB7 are closed whereas CB5 remains open. When a fault occurs at the terminals of Load 2, then the most downstream relay will be Load 2's own relay (represented by the little box) and selectivity implies that it should interrupt the connection. If Load 2's relay fails to achieve that in a predetermined time (delay), then the proper sequence for the selective operation should be CB6, CB4 and finally CB2. In similar fashion, should a fault occur at the terminals of Load 3, the proper selective operation requires the following sequence: Load 3's relay, CB7, CB4 and CB2.

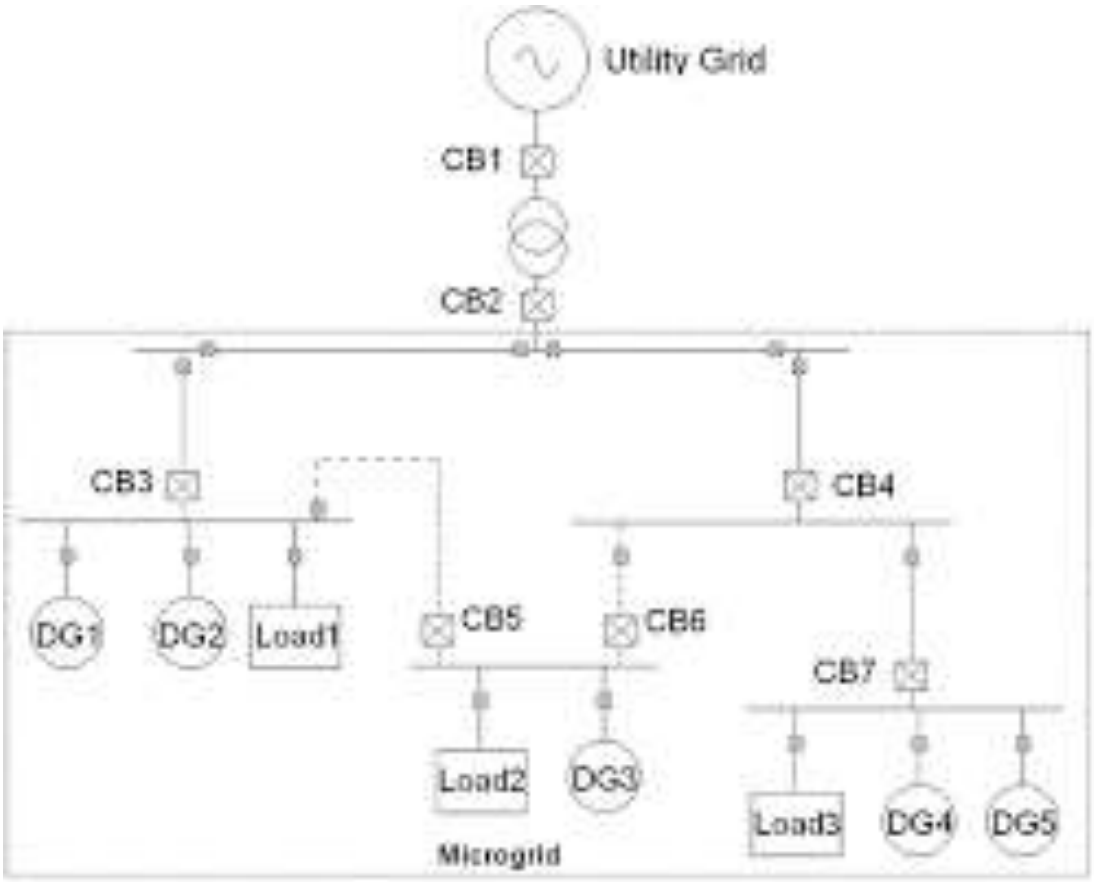


Fig. 3. A sample microgrid

## Applying RSA Algorithm for public Key Encryption:

The RSA algorithm implements public key cryptography. This is done on numbering of nodes. i.e node 3 data destined for node 8 is being spoofed as if node 22 is sending data to node 35. In RSA algorithm two different keys are used: Public Key Known to every communicating entity in the network . Private Key:-Known only to the user. Generally, the receiver's public key is used for encrypting information and is sent to the receiver who decrypts it by his unique private key (known only to him). This make sures confidentiality because it is assumed that only the key is known to the receiver. In case of RSA algorithm, both the plain-text and the cipher-text are integers between 0 to (n-1) for some n[10]. The steps for RSA algorithm are

Step 1 : Select two prime nos – p & q
Step 2 : Calculate n as a product of p & q, i.e. n=pq
Step 3 : Calculate m as a product of (p-1) & (q-1) i.e. m = (p1)(q-1)
Step 4 : Select any integer e

## RESULTS AND DISCUSSIONS:

The Intrusion Protection System in Dijkstra's Algorithm using Public Key Cryptography i.e RSA has been developed. The figure shows below is the snapshot for a network consisting of 10 nodes in MATLAB.

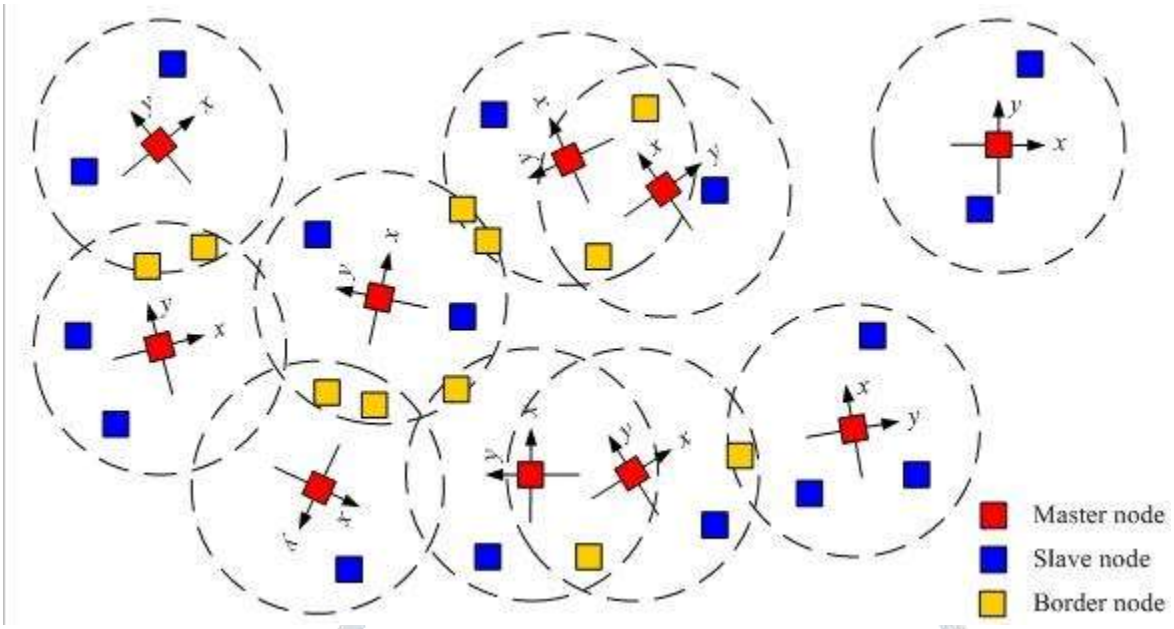


Figure 4: Wireless Sensor Network of 10 nodes

The below figure depicts the data path from Source node to Destination node selected by applying Dijkstra's Algorithm. The data is sent from node 4 to node 7 via node 3

Figure 5: Data Path Using Dijkstra's Algorithm

Another figure shows the implementation of RSA Algorithm. The nodes have been renumbered i.e. node 4 has been encrypted to 25, node 3 to 59, node 7 to 43.

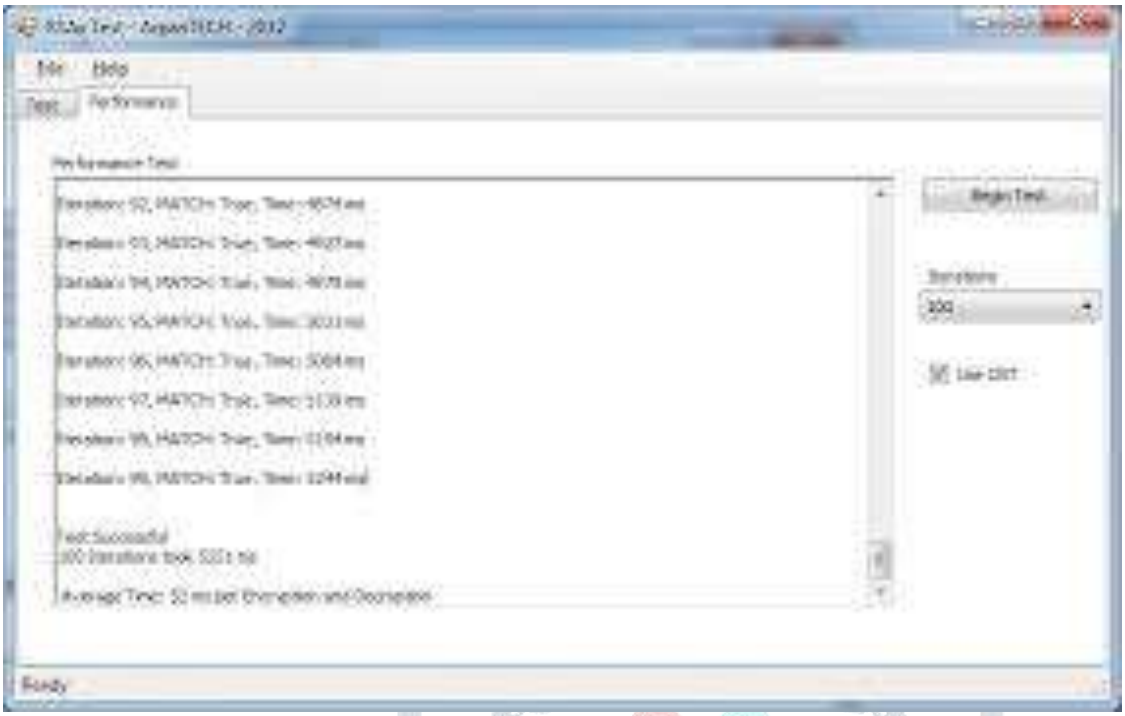

Figure 6: RSA Encryption Result

## IMPLEMENTATION WITH IEC COMMUNICATION STANDARDS:

The implementation of the proposed system requires a communication system set up between the microgrid components. There are various standards drafted or published in an effort to standardize the modeling and communication in ENs. IEC 61850, for example, is an international standard for substation automation that has started out as the Electric Power Research Institute's (EPRI's) UCA 2.0. IEC 61850 effectively reduces the diversity and complexity of utility automated solutions minimizing operating, maintenance and engineering costs . Due to the rising number of DG deployments, International Electrotechnical Commission published an extension of IEC 61850-7-4 (Compatible logical node classes and data classes). This extension aimed at having logical nodes and data classes that will help in modeling RE based DG systems effectively. Currently, modeling the communication system for grid components is a very popular topic [21]. It is proposed to connect components to a central unit, as shown in Figure 6, for monitoring and management purposes. The relay hierarchy detection system proposed in this paper can be easily integrated with these communication/monitoring systems. Should the connection and disconnection data be provided by the communication system, the dynamic connections and new deployments can easily be recognized. Hence, the system can be represented with graph theory and the proposed method can be implemented to meet the desired objectives.

## CONCLUSION:

I have completed the Intrusion Protection System in Dijkstra's Algorithm using public Key Cryptography Algorithm i.e RSA. Dijkstra's Algorithm finds the shortest path from Source node to destination node. Here user can give the source and destination node. Using DIJKSTRA'S algorithm, the shortest path and shortest

distance is calculated from source node to destination node. It repeatedly chooses the nodes with minimum distances and reaches at the destination node. After reaching the destination node, it displays the path with minimum distance. But this path can be traced by cryptanalysis. I have chosen RSA which is very secure Algorithm as it does encryption and decryption using 2 different keys.

Microgrids have dynamic structures which change more often than the conventional large networks. Supplying power through alternative paths, new deployments and other factors hinder the selective operation in case of a fault. This requires that a new method should be implemented which updates the selective operation of relays in parallel with the existing microgrid structure. However, in order to achieve this goal a robust method is required to extract the relay hierarchy for a specific microgrid structure and assign suitable selective levels (or time delays). Some of the previous publications incorporate look-up tables with predetermined network structure data. This approach cannot respond to the dynamic changing structure of the network.

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