# Prevention of Power Grid Blackouts by Guiding Self-Organization of Interacting Components—A Bus Dependency Matrix Based Approach

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***Introduction:***

Blackout in a power system can be triggered anywhere in the system initiating various cascading damages of several components within the grid, which can propagate to any place in the system and costs up to billions of dollars. It is initiated as a sequence of very small initial self organizing failures of various components that successively deteriorates the ability of the power grid to continue its intended functionality. Technology is progressing day by day and there have been huge investments in system reliability and security. But blackout is still occurring all over the world. The latest reported large-scale blackout is found to be California blackout in the early September of 2011 [1].

In this research, we study power grid blackouts using self-organization theory. An analysis has been carried out in order to reveal the indices for critical characteristics and the blackout mechanisms in power systems. A matrix called bus dependency matrix has been proposed which gives a deterministic measure of relative importance of various nodes of power grids [2]. This matrix considers the dynamical flows through the grid in order to quantify relative pair dependency of power grid nodes. This is an attempt to how the system can be prevented from entering critical states from the information of the dynamic bus dependency matrix.

***Bus Dependency Matrix:***

Let, $P_{st}$ be the maximum power flowing in the shortest electrical path between buses $s$ and $t$, and $P_{st}(k)$ is the maximum of inflow and outflow at bus $k$ within the shortest electrical path between buses $s$ and $t$. Then,

$$r_{st}(k) = \frac{P_{st}(k)}{P_{st}}$$

where, the ratio $r_{st}(k)$ is an index of the degree to which buses $s$ and $t$ needs bus $k$ to transmit power between them along the shortest electrical path.

For a power grid with $n$ number of buses the dependency of bus $s$ upon bus $k$ to transmit power on any other buses in the network can be represented as follows:

$$d_{sk} = \sum_{\substack{t=1 \\ s\neq t\neq k\in V}}^{n} r_{st}(k) = \sum_{\substack{t=1 \\ s\neq t\neq k\in V}}^{n} \frac{P_{st}(k)}{P_{st}}$$

The dependency of bus pairs for the whole system can be calculated and the result can be summarized in a matrix called bus dependency matrix $\mathbf{D}$ as follows:

$$\mathbf{D} = \begin{bmatrix} d_{11} & d_{12} & \cdots & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ d_{n1} & d_{n2} & \cdots & \cdots & d_{nn} \end{bmatrix}$$

1. http://www.guardian.co.uk/world/2011/sep/09/blackout-california-arizona-mexico-san-diego
2. A. B. M. Nasiruzzaman, H. R. Pota, and F. R. Islam, (2011). "Complex Network Framework Based Dependency Matrix of Electric Power Grid.." *21st AUPEC*. 25-28 Sep. (pp. 1-6).