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Importance Measures on Networks

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Abstract

In this paper the importance of network components is analyzed by combining sensitivity techniques and several network performance functions, like the shortest-route problem or the maximum-flow problem. The uncertainty of each network component is modeled by a known probabilistic distribution. Hence the network performance is considered as a non-deterministic variable and in turn, the sensitivity analysis allows ranking the importance of each element. An example related to different importance measures in a network illustrates the approach.

Keywords: Importance Measures, Networks; Sensitivity Analysis

1. Motivation and main results

Many real systems like electric power systems are modeled using a network approach: each node represents a substation and each edge, a transmission link connecting two substations. It is assumed that each node/edge has an associated characteristic that represents, for example, its capacity. The importance of a component i (IC_i) is defined as its contribution to a specific network function of merit (FOM) such as the short distance between two nodes or the maximum flow that the network could transmit, among others. To quantify IC_i, it is assumed that the characteristic of each component is modeled as a known probabilistic function. Under this assumption sensitivity analysis techniques (Saltelli et al, 2004) are applied considering the appropriate FOM and system components can be ranked.

To illustrate the approach a network with 20 nodes/30 directed links is considered. Table 1 shows the nominal capacity associated to each link. Each link capacity is modeled as a uniform probability distribution function with bounds defined as ± 10 % of the nominal value. Figure 1 shows the IC_i using the FAST technique as implemented in SimLab software. For each sample generated by SimLab, the max-flow between the source and terminal node is evaluated using the Ford-Fulkerson algorithm (Evans & Minieka, 1978). From this figure, it is clear that link 25 is the most important link of the system, followed by links 26, 27, 28. Of course, other sensitivity techniques could be used to assess the importance of components using the same FOM, additional ones or other importance measures.

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Table 1: Network Data

Link	from-to	Capacity	Link	from-to	Capacity	Link	from-to	Capacity	Link	from-to	Capacity
1	1,6	8	**9**	3,12	7	**17**	10,17	11	**25**	18, *t*	14
2	1,7	4	**10**	4,13	8	**18**	11,17	13	**26**	*s*,1	11
3	1,8	9	**11**	4,14	15	**19**	12,20	13	**27**	*s*,2	8
4	2,8	13	**12**	5,15	8	**20**	13,18	13	**28**	*s*,3	11
5	2,9	7	**13**	6,16	10	**21**	14,18	4	**29**	*s*,4	13
6	2,10	6	**14**	7,16	4	**22**	15,18	9	**30**	*s*,5	6
7	3,10	5	**15**	8,16	7	**23**	16,*t*	15	*s*= source node		
8	3,11	12	**16**	9,17	10	**24**	17, ,*t*	11	*t* = terminal node		

As an example, assume that each link has a reliability of 0.95. The probability that the max flow is ≥ 36 units is 0.7458. Under this scenario, the importance of each link could be evaluated using the Birnbaum Importance Measure (BIM_i), defined as the network probability variation considering that link *i* is operating or failed. Figure 2 shows how the rank of components varies considering the previous IC_i and the BIM_i. For example, the most important component using IC is 26 while considering BIM the most important component is 23. At this point, a composite rank could be defined, for example using an "Ordered weighted Average" (Yager, 1988).

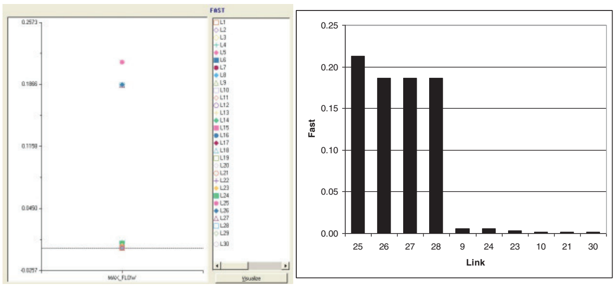

Figure 1: FAST results for max flow: Left: Total rank; Right: The first 10 most important links

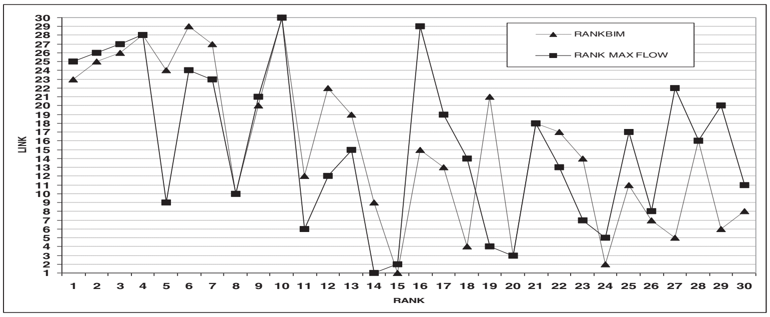

Figure 2: Rank of components under IC and BIM

2. References

Evans, J., Minieka E., 1978. Optimization Algorithms for Networks and Graphs. Second Editions, Revised and Expanded.

Saltelli A., Tarantola S., Campolongo F. and Ratto M., 2004: "Sensitivity Analysis in practice. A Guide to Assessing Scientific Models", John Wiley & Sons.

Yager R.R., 1988: "On ordered weighted averaging aggregation operators in multi-criteria decision making," IEEE Trans. Syst., Man, Cybern., vol.18, pp. 183–190