Comparing Interaction Graphs on Cascading Outages under Different Loading Conditions

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INTRODUCTION

- Cascading outages are considered the most severe threats to system security and reliability.
- Interaction graphs on cascading outages of power systems provide valuable insights into how cascading outages evolve and propagate, enabling further development of mitigation strategies to support decision-making.
- The sensitivity of the interaction graph's topology to the system's loading condition has not been studied sufficiently.

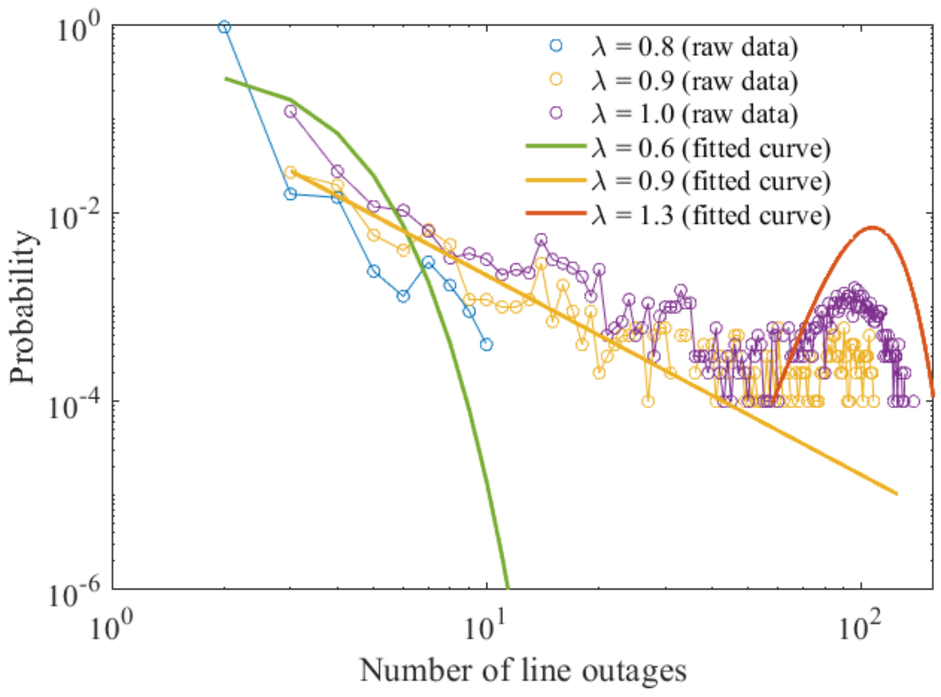
CONSTRUCTION OF AN INTERACTION GRAPH

1) An interaction matrix **B** is constructed based on cascading outage data.
2) Each node corresponds to a specific component, while each link corresponds to a nonzero element in the interaction matrix **B**.
3) The weight of a link is determined by the expected number of component failures propagated through the link.
4) Key links are identified as those having significant weights. Key components are identified as nodes exhibiting significant out-strength, which is the sum of weights of all links starting from a node.

COMPARISION OF INTERACTION GRAPHS

System: NPCC 140-bus system

- **Cascade size distribution**



- Low load (exponential)
- Critical load (power law)
- High load (heavy tail)

Fig.1 Cascade size distributions under different loading conditions

- **Key components and key links**

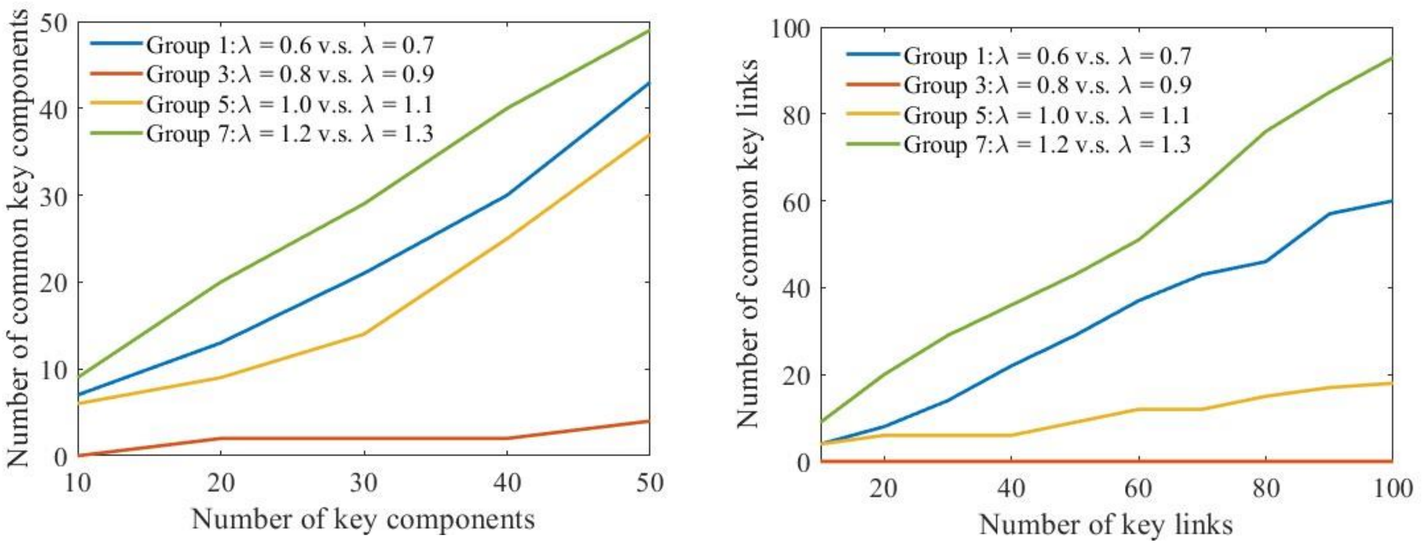


Fig.2 Comparisons of key components and links

- **Interaction graphs**

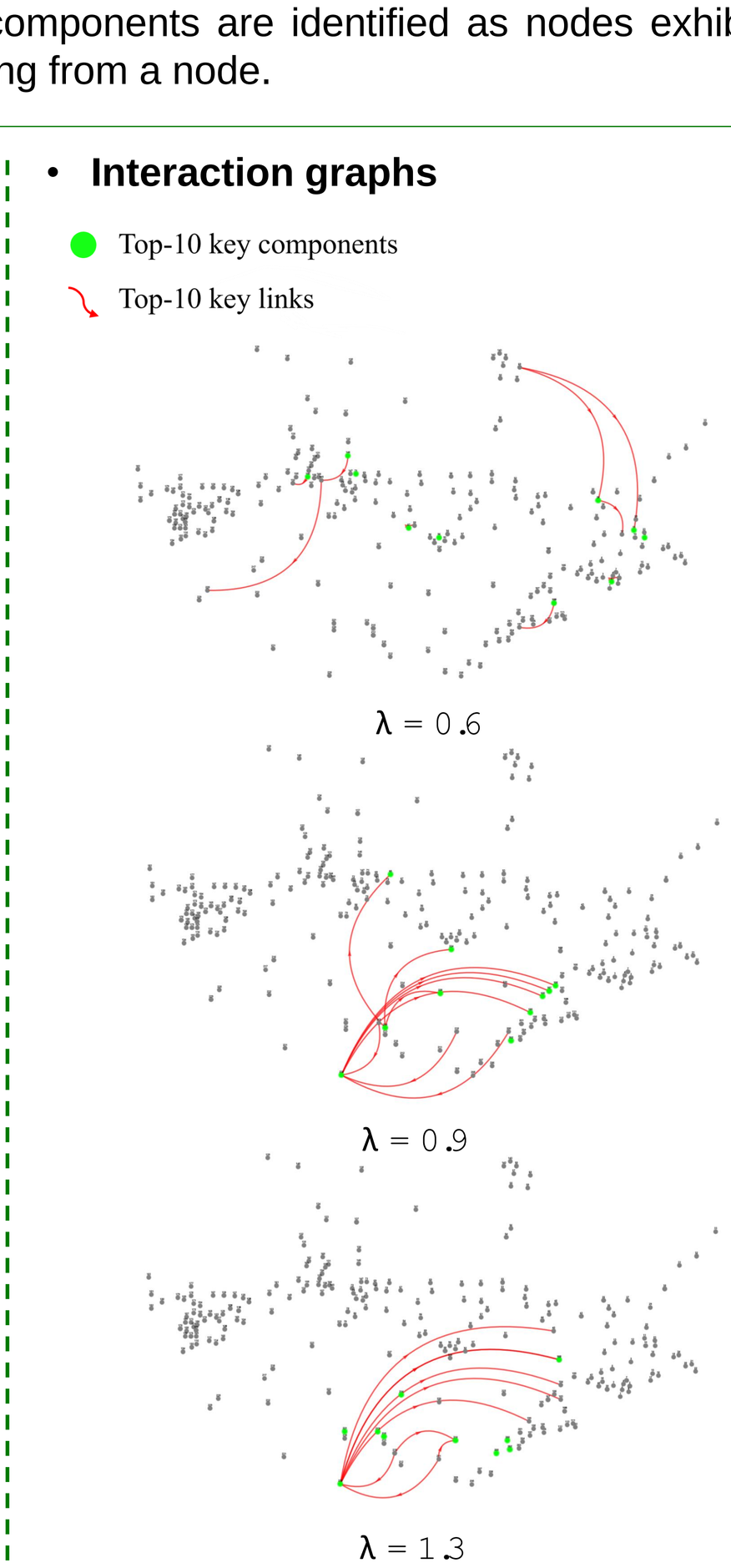


Fig.3 Interaction graphs under three typical loading levels

CONCLUSIONS

- The cascade size distribution varies with the loading condition; for effective prevention and mitigation of cascading outages, interaction graphs need to be constructed respectively for different load levels.