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Electrical & Computer ENGINEERING

Zooming-in and Zooming-out Computer Methods for Contingency Screening in Large Scale Power Networks

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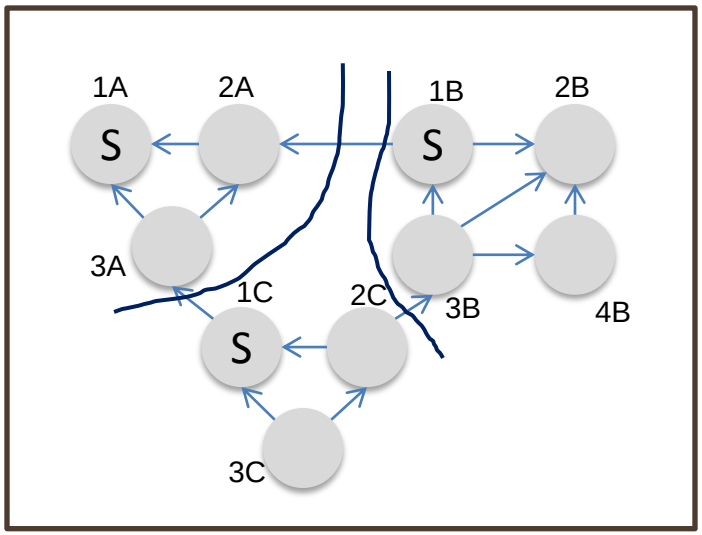
Motivation

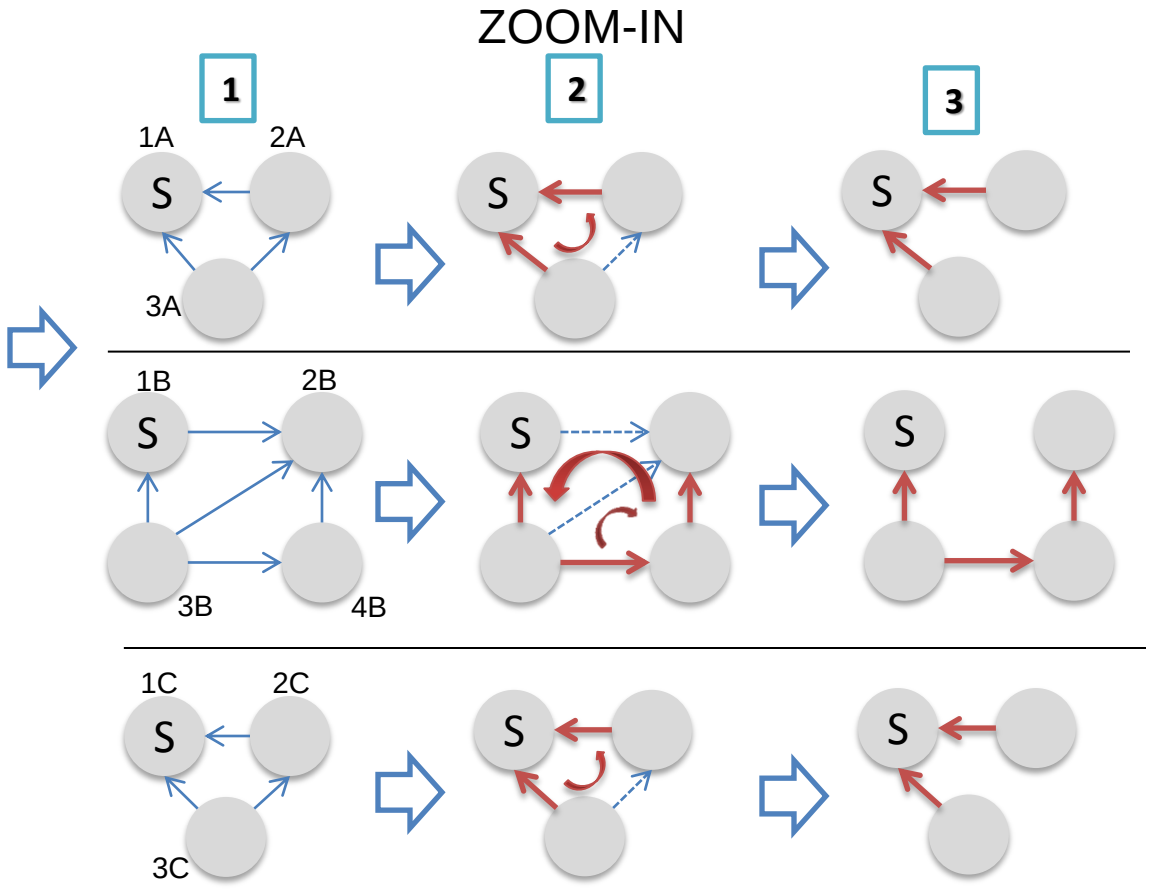
- **Contingency Analysis**:
  - Each contingency very similar to the original network
  - Why re-compute the whole DF matrix?
- **Efficient distributed algorithm for solving ”DC” power flow**
- **Enable re-use of power flow data in normal operation and contingencies**
  - Repeat computations in the area with a contingency only
- **Minimize exchange of information in multi-area environments**

Outline

- **Distributed coordinated "DC" Power Flow Algorithm**
  - Internal Line Outage
    - algorithm
    - exchange of information
  - Tie-Line Outage
    - algorithm
    - exchange of information
- **AC Contingency Screening**
  - using continuation homotopy methods
- **Conclusion and Future Work**

10-bus example: ZOOM-IN tree transf.[1-3]

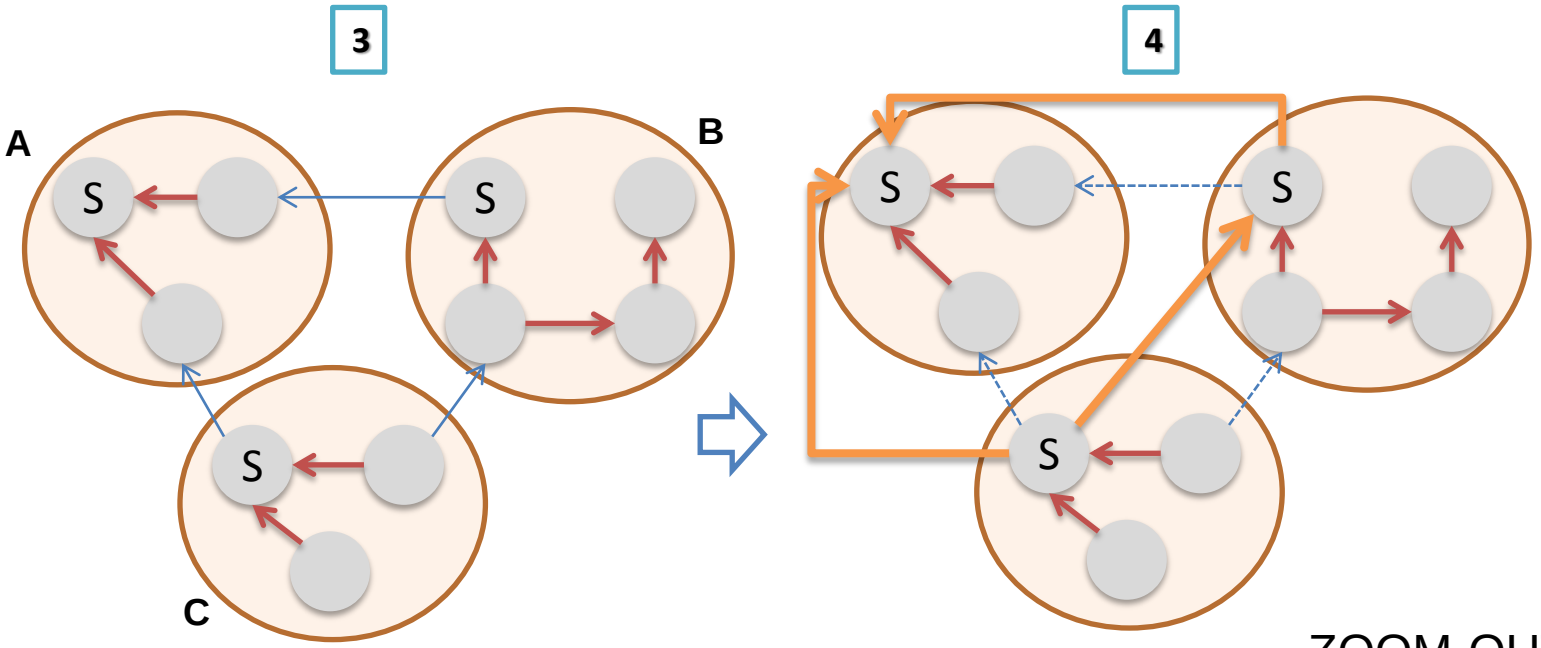


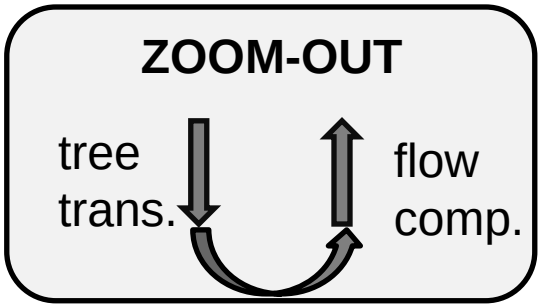


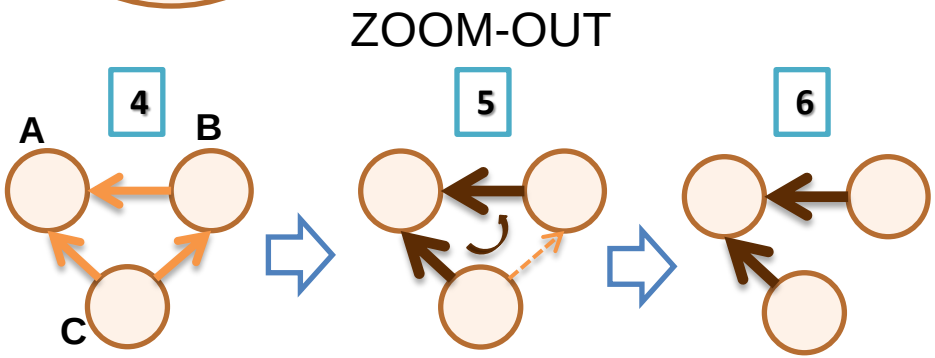
ZOOM-IN (area k)

tree trans. ⇓ ⇑ flow comp.

10-bus example: ZOOM-OUT tree transf.







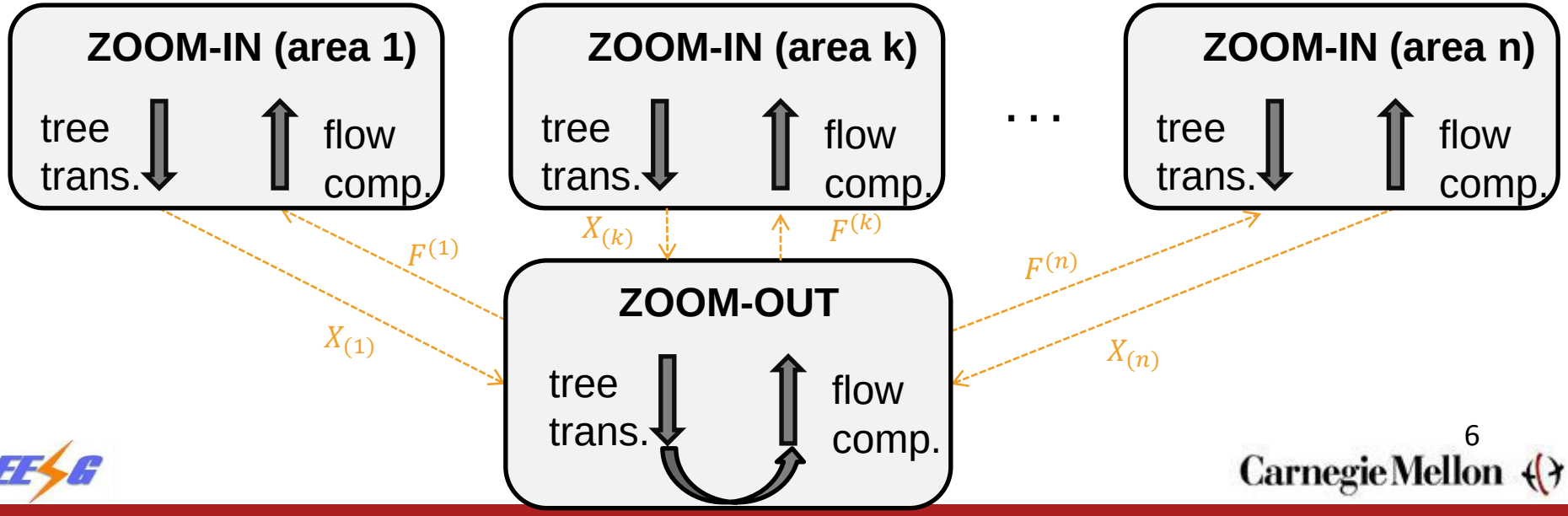
Network Transformations and Exchange of Information

- **Bidirectional transformations[2]**
  - "down": topological transformations into a spanning tree

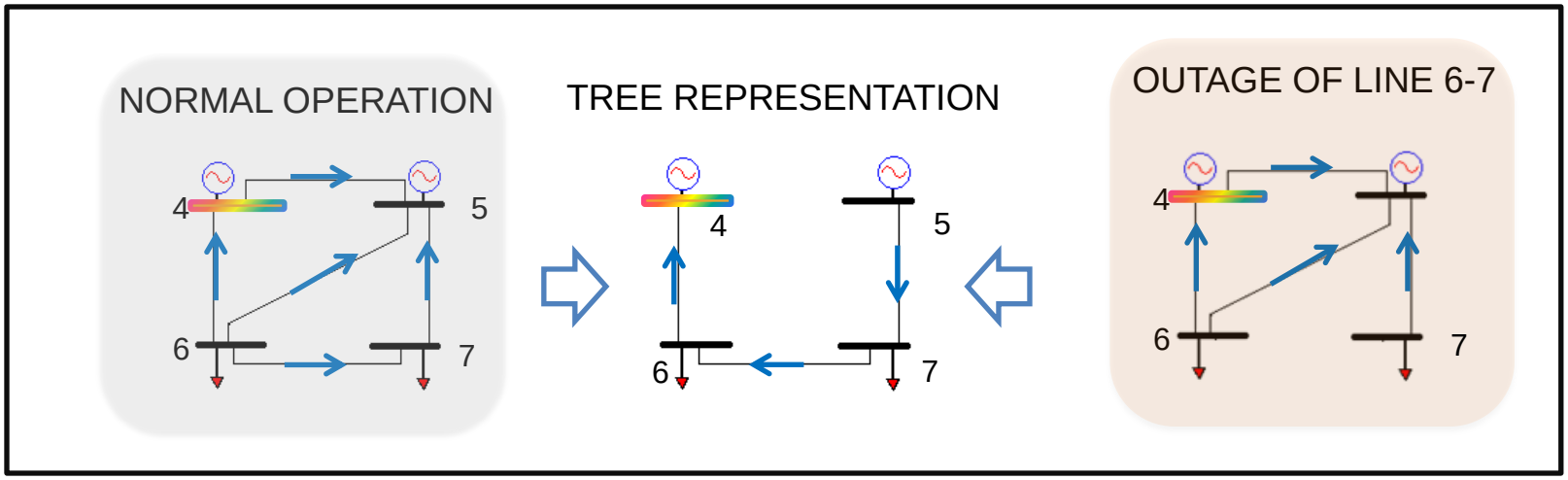
$$X_{22} = C_{12}^{T} \cdot X_{11} \cdot C_{12}$$

  - "up": computes line flows

$$F^{1} = C_{12} \cdot F^{2}$$



Internal Contingency



ZOOM-IN (area 1)

tree trans. ↓ ↑ flow comp.

ZOOM-IN (area k)

tree trans. ↓ ↑ flow comp.

...

ZOOM-IN (area n)

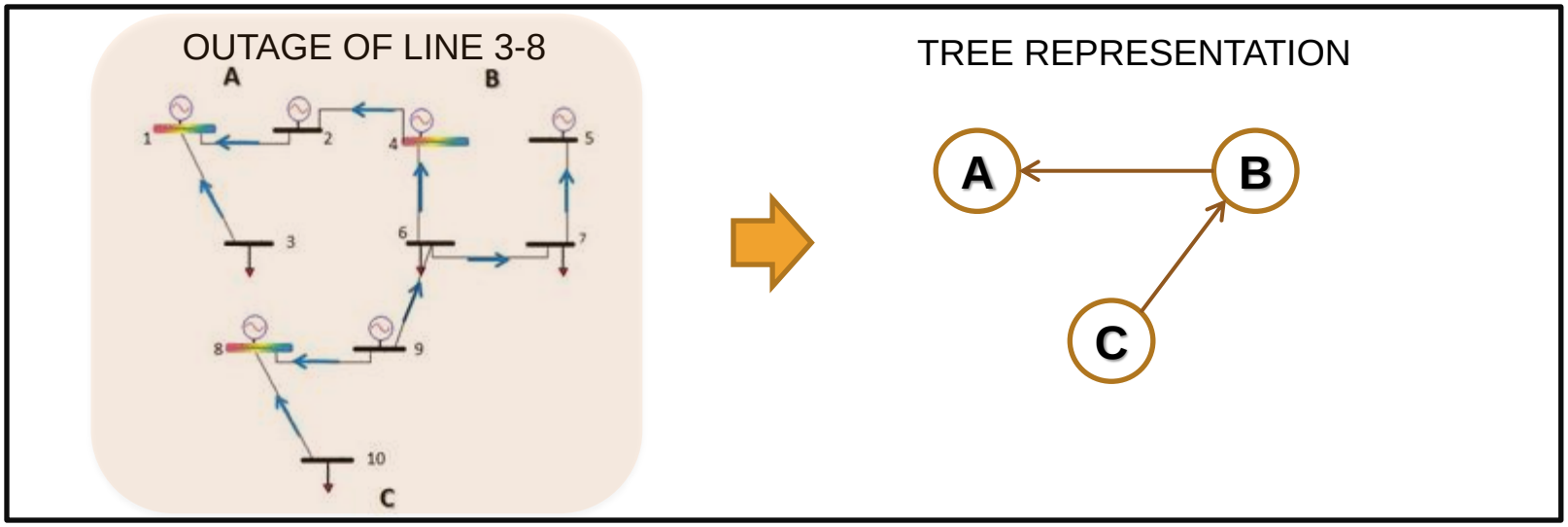
tree trans. ↓ ↑ flow comp.

$F^{(1)}$ $X_{(k)}^{new}$ $F^{(k)}$ $F^{(n)}$

ZOOM-OUT

tree trans. ↓ ↑ flow comp.

Tie-line Contingency



ZOOM-IN (area 1)

tree trans. ↓ ↑ flow comp.

$F^{(1)}$

ZOOM-IN (area k)

tree trans. ↓ ↑ flow comp.

$F^{(k)}$

. . .

ZOOM-IN (area n)

tree trans. ↓ ↑ flow comp.

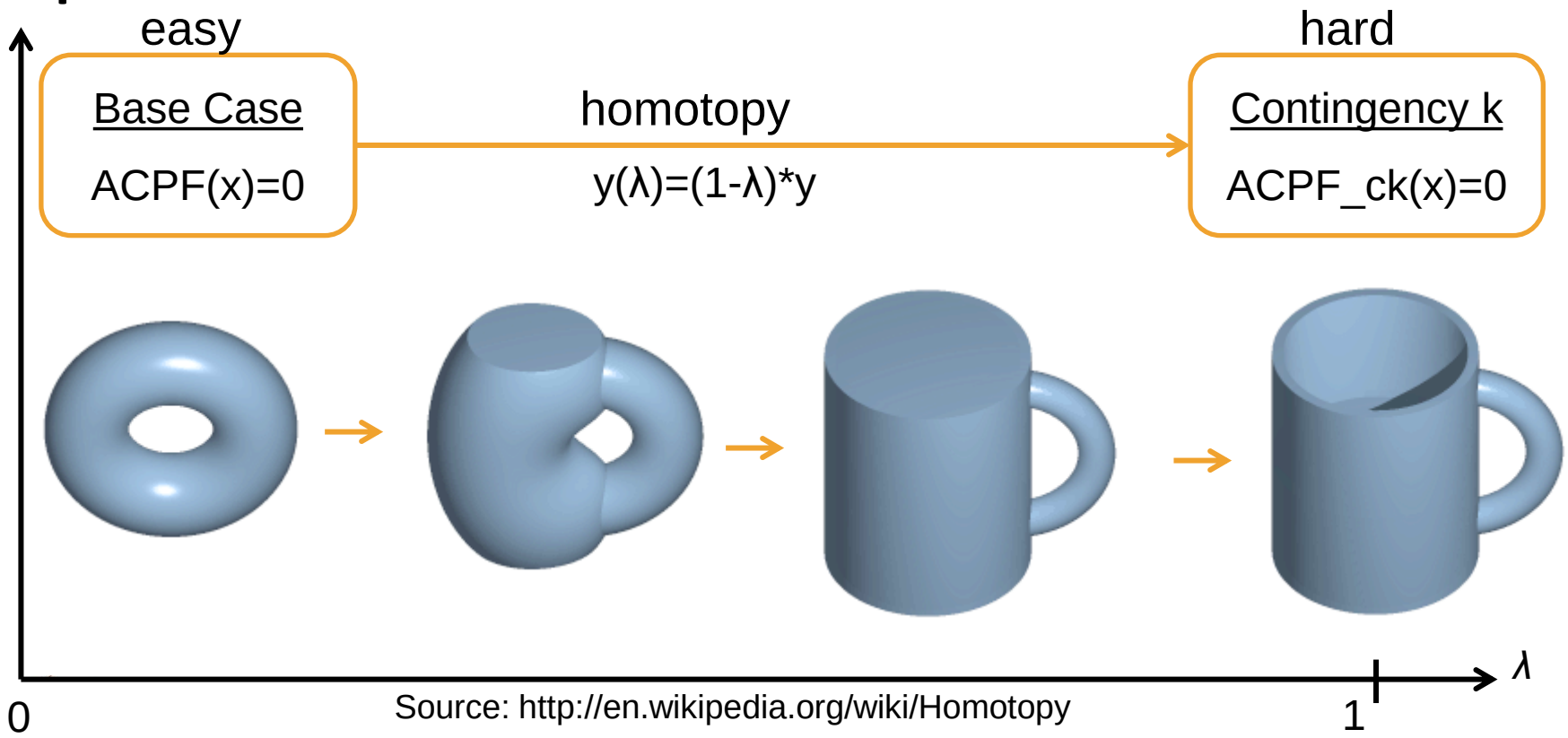
$F^{(n)}$

ZOOM-OUT

tree trans. ↓ ↑ flow comp.

New approach to AC Contingency Screening

- **Improves chances for global convergence**
- **Used for solving systems of nonlinear equations: f(x)=0**
- **Constructs a sequence of problems that lead to the problem of the interest**

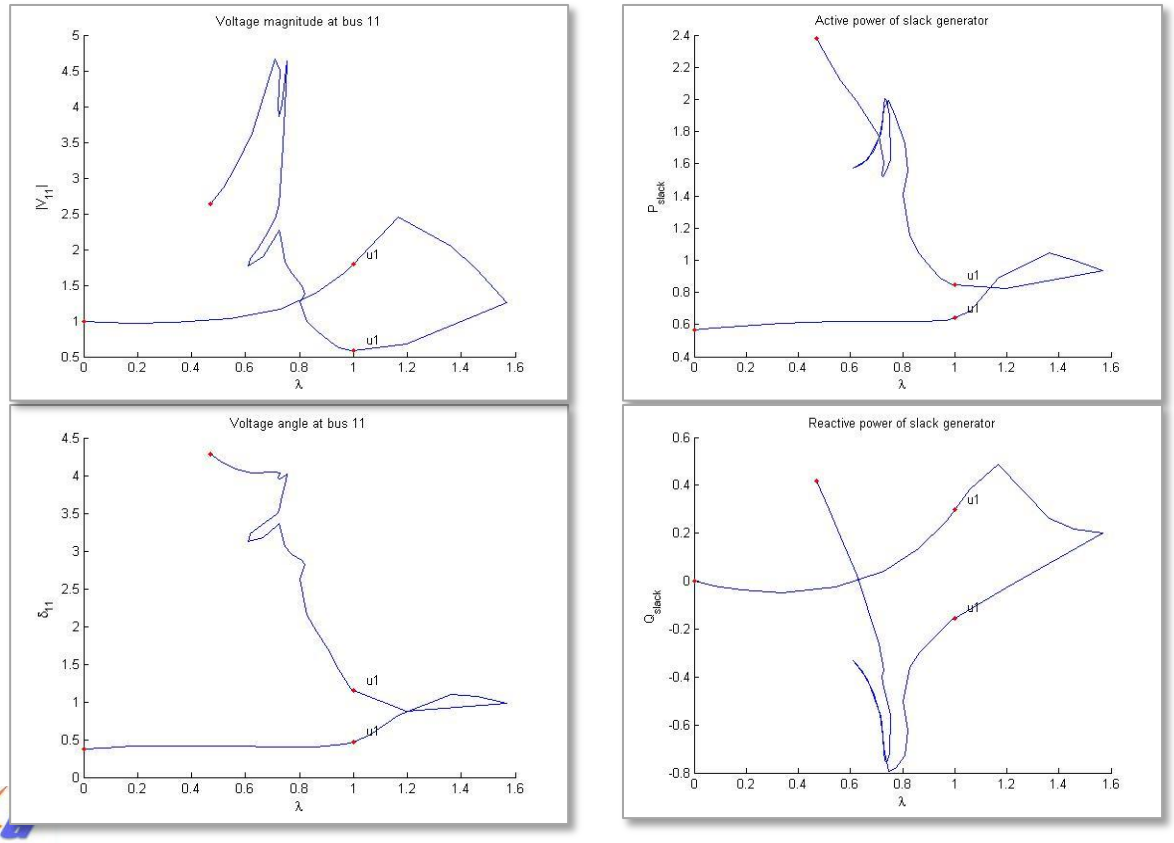


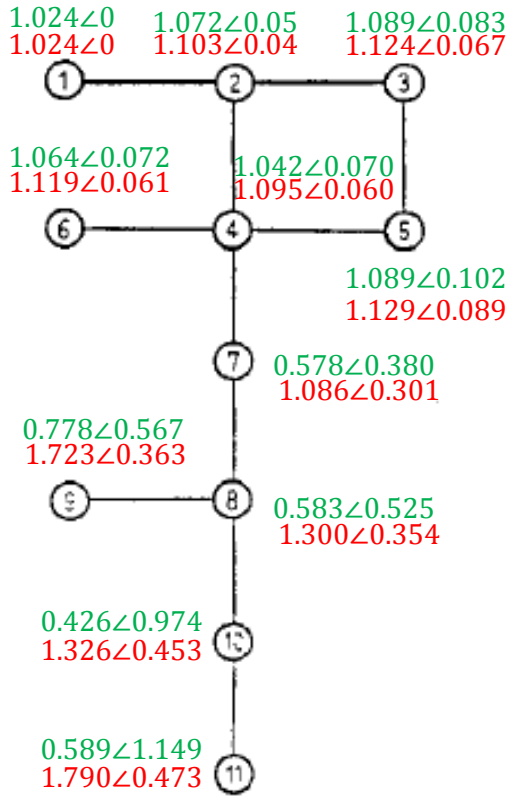
Source: http://en.wikipedia.org/wiki/Homotopy

Homotopy for Ill-Conditioned Systems [4]

- **Converges in cases when Newton-Raphson fails to converge**
- **Example: 11-bus system[5]**

DCPF → homotopy → ACPF





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Conclusions & Future Work

- **Algorithm for Contingency Screening**
  - more efficient distributed algorithm than the existing methods
  - given fixed clustering into areas was assumed
- **What is the optimal clustering for**
  - maximum computational efficiency
  - minimum the amount of information exchange
- **AC contingency screening based on homotopy**
  - examine different homotopy functions

References

- [1] H. H. Happ ,“Diakoptics and Piecewise Methods“, IEEE Transactions on Power Apparatus and Systems, 1970
- [2] Sanja Cvijić, Marija Ilić, “Contingency Screening in a Multi-Control Area System Using Coordinated DC Power Flow”, ISGT Europe 2011, Manchester, December 2011
- [3] Sanja Cvijic, Marija Ilic “Contingency Screening in a Multi-Control Area System Using Coordinated DC Power Flow”, Carnegie Mellon University provisional patent filing, August 5, 2011
- [4] Peter Feldmann, Sanja Cvijic, “ Power Flow and Optimal Power Flow analysis using Homotopy methods”, IBM provisional patent filing: YOR8-2011-0847, August 22, 2011
- [5] S. Iwamoto, Y. Nakanishi and Y. Tamura, “A Load Flow Calculation for lcl-Conditioned Power Systems”, Electrical Engineering in Japan