Contingency Analysis (CA)

What is a contingency?

- Contingency is an abnormal condition in electrical network that can put the whole system or a part of the system under stress.
- It occurs as a result of sudden opening of a transmission line, generator tripping, sudden change in generation, sudden change in load value, etc.

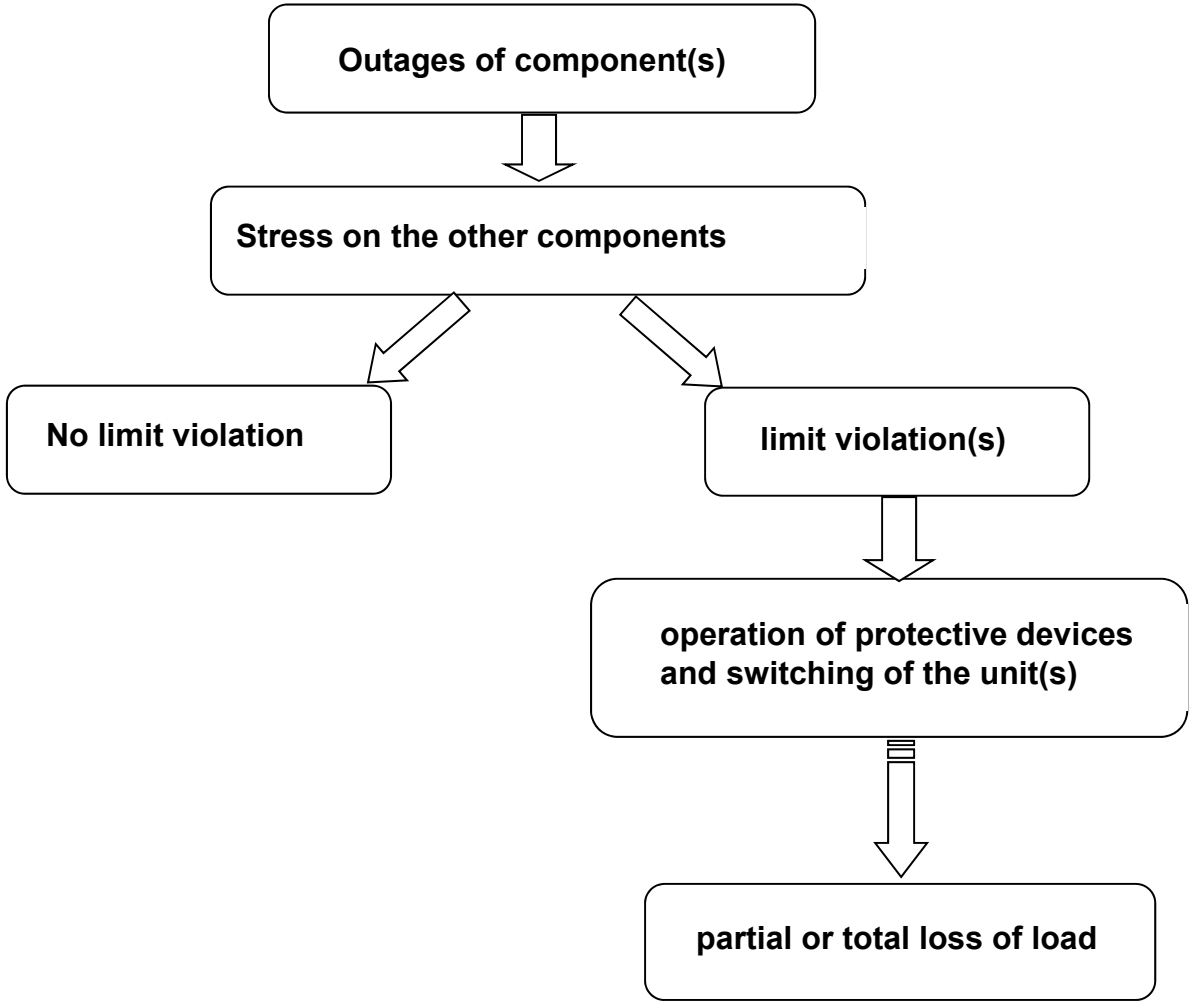
What is a “Contingency Analysis (CA)”?

- CA is performed by assuming a set of hypothetical equipment outages and / or breaker operations
- Contingency Analysis reports which hypothetical contingencies would cause component limit violations.

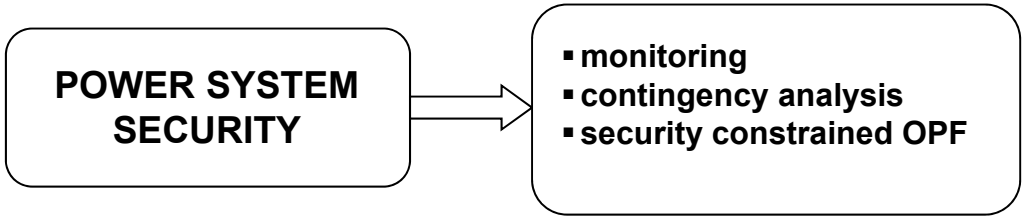
Contingency analysis (CA)

- Contingency Analysis (CA) is one of the "security analysis" applications in a power utility control center
- Its purpose is to identify the overloads and problems that can occur due to a contingency.
- CA is a tool for analyzing and reporting lists of contingencies and associated violations.
- CA, as an on-line tool, shows operators what would be the effects of future outages in terms of violations.

Security impact of an outage



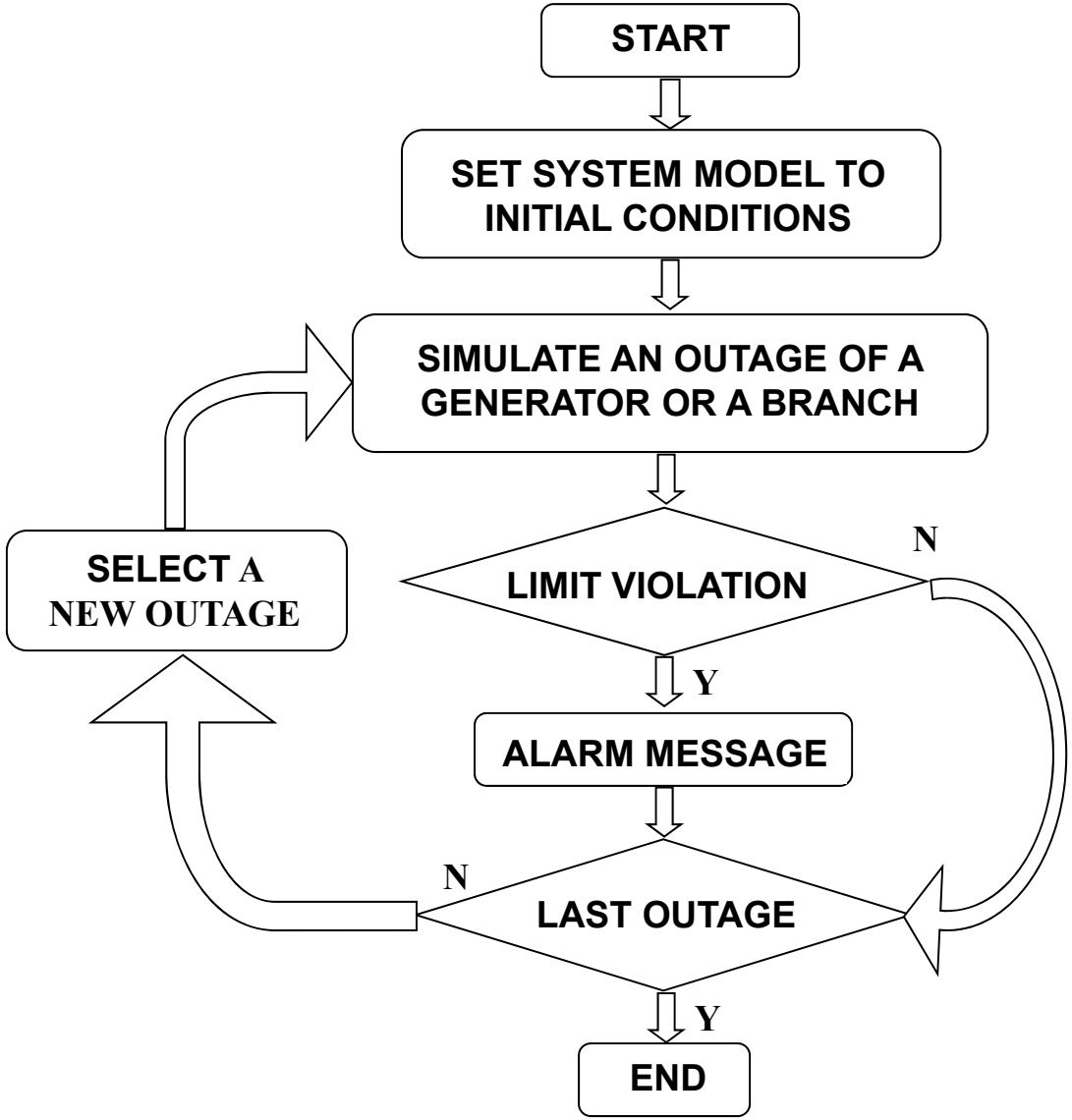
Objective of CA



Monitoring : Data collection and state estimation

The objective of steady state contingency analysis is to investigate the effects of generation and transmission unit outages on MW line flows and bus voltage magnitudes.

CA procedure



Why a simplified CA procedure is required

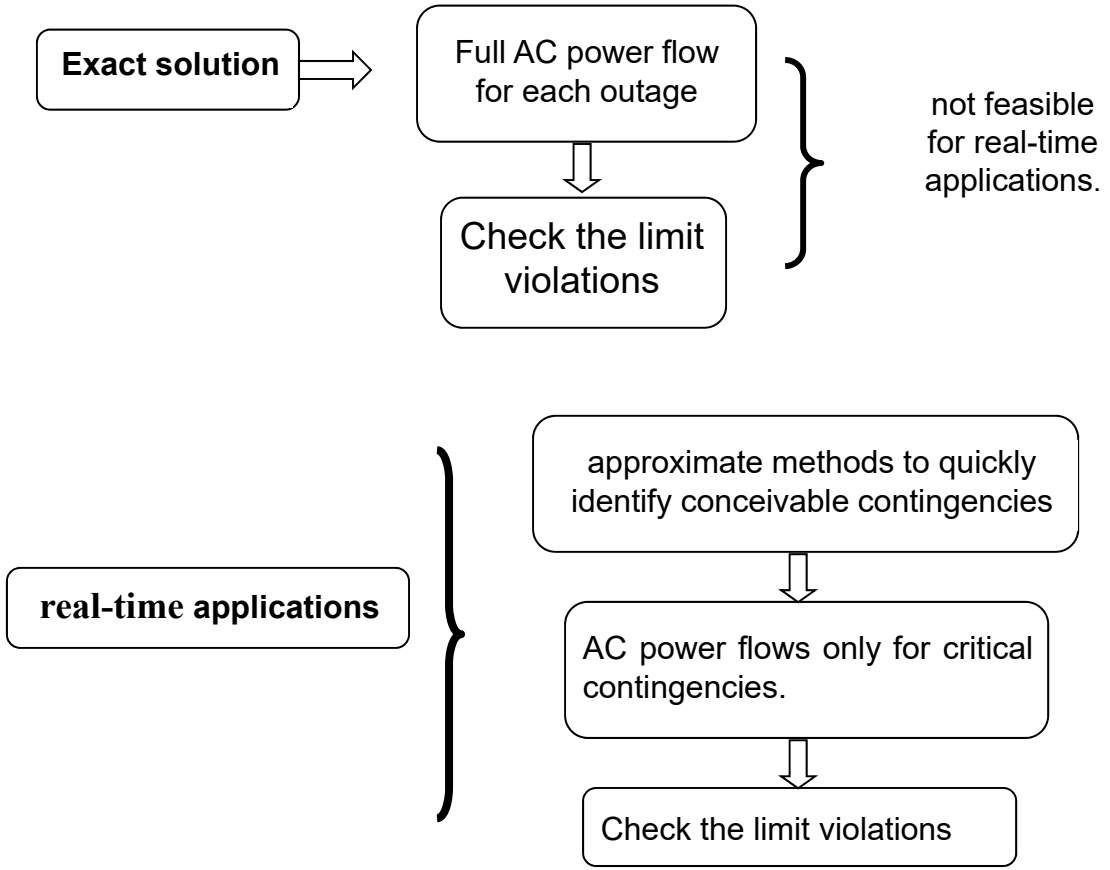
- A typical power system contains a very large number of elements.
- For carrying out CA, outages of all these elements need to be carried out one-by-one corresponding to any given operating condition.
- The operating point of the system changes quite frequently with change in loading/generating conditions.
- With the change in system operating conditions, CA needs to be carried out again at the new operating point.
- Thus, for proper monitoring of system security, a large number of outage cases need to be simulated repeatedly over a short span of time.

Why a simplified CA procedure is required

- Ideally, these outage cases should be studied with the help of full AC power flow analysis.
- However, analysis of thousands of outage cases with full AC power flow technique will involve a significant amount of computation time and as a result, it might not be possible to complete this entire exercise before a new operating condition emerges.
- Therefore, instead of using full non-linear AC power flow analysis, approximate, but much faster techniques are used to estimate the post contingency values of different quantities of interest.

Real time CA

- Real-time application of CA requires fast and reliable computation methods due to the high number of possible outages even in a moderate power system.
  - ✓ conflict between the accuracy of the method applied and the calculation speed.



Approximate CA

Contingency ranking

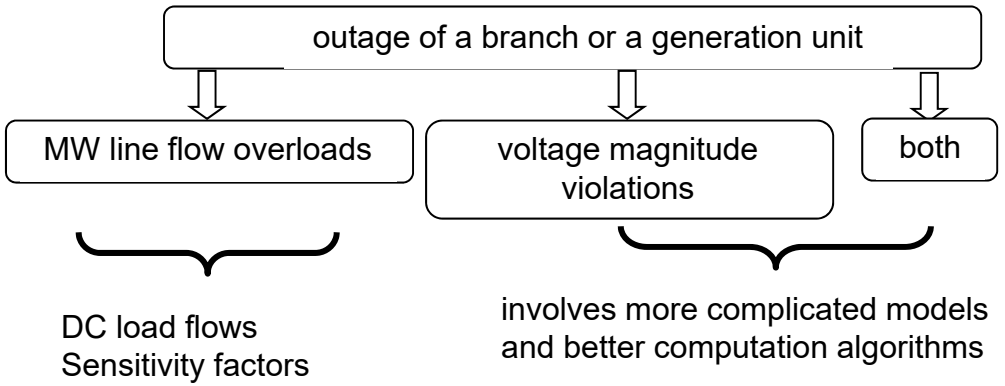
contingencies are ranked in an approximate order based on a performance index.

contingencies are tested beginning with the most severe one and proceeding down to the less severe ones up to a threshold value.

Contingency screening

Explicit contingency screening is performed for all contingencies, following an approximate solution (DC load flow, one iteration load flow, linear distribution or sensitivity factors etc.)

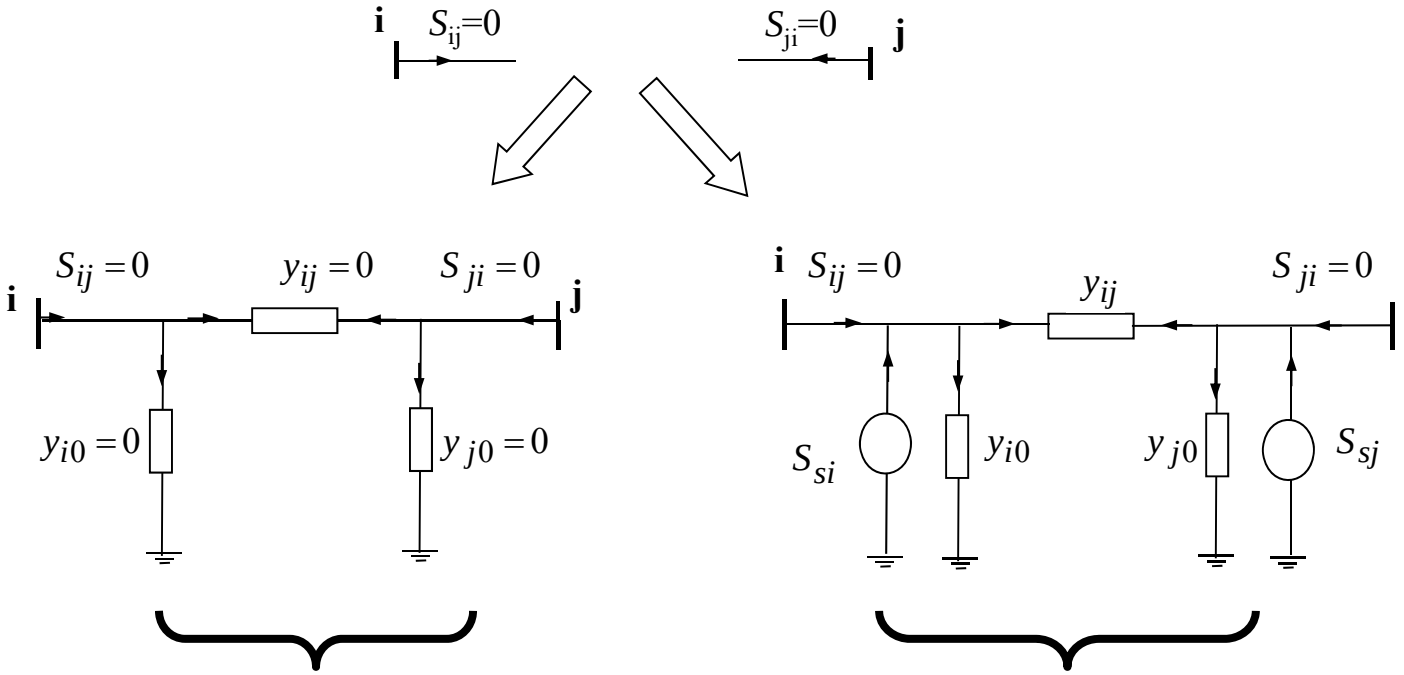
Hybrid methods utilizing both the ranking and the screening



Line outage simulation

An outage of a line can either be simulated by setting its impedance, $y_{ij} = 0$ or by injecting hypothetical powers at both ends of the line.

- **The latter method is preferred to preserve the original base case bus admittance matrix.**



Z-Matrix techniques
Modification of Z_{BUS} is required for each outage

Determination of the hypothetical sources so that all the reactive power circulates through the outaged line while maintaining the same voltage magnitude changes in the system