




Reliability @ Risk Concept

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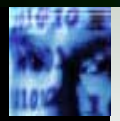
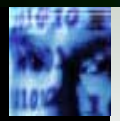
December 16, 2004






The Problem

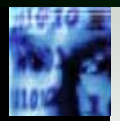
- Reliability analysis used today was developed in 1967
  - N-1 Contingency Analysis
  - Deterministic analysis of quantitative events
- Analysis needed to perform:
  - Probabilistic analysis including both quantitative and qualitative events
  - Move from “Safe/Not Safe” analysis to include “How Safe” analysis






Events Affecting Reliable Operation

- Quantitative
  - Real time limit violations
  - N-1 contingency limit violations
- Qualitative
  - Weather
  - Scheduled outages
  - Disturbances
  - Control or protection system failures
  - Human issues



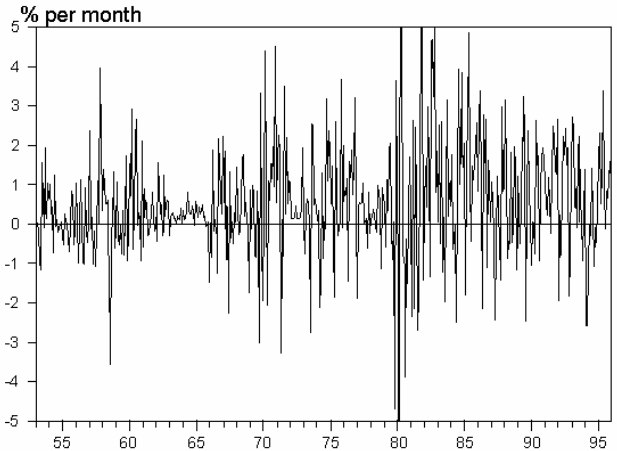


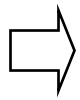

Value at Risk (V@R)

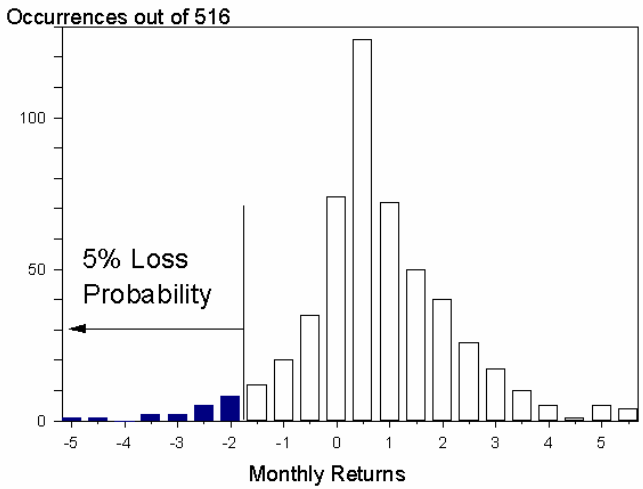
- Risk assessment method used in financial industry
- Uses statistical techniques to provide a summary measure of maximum risk over a time horizon

V@R Example

Potential Investment Loss Problem

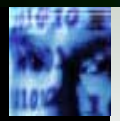






Monthly returns over 516 months

5% probability of monthly return lower than –1.7%



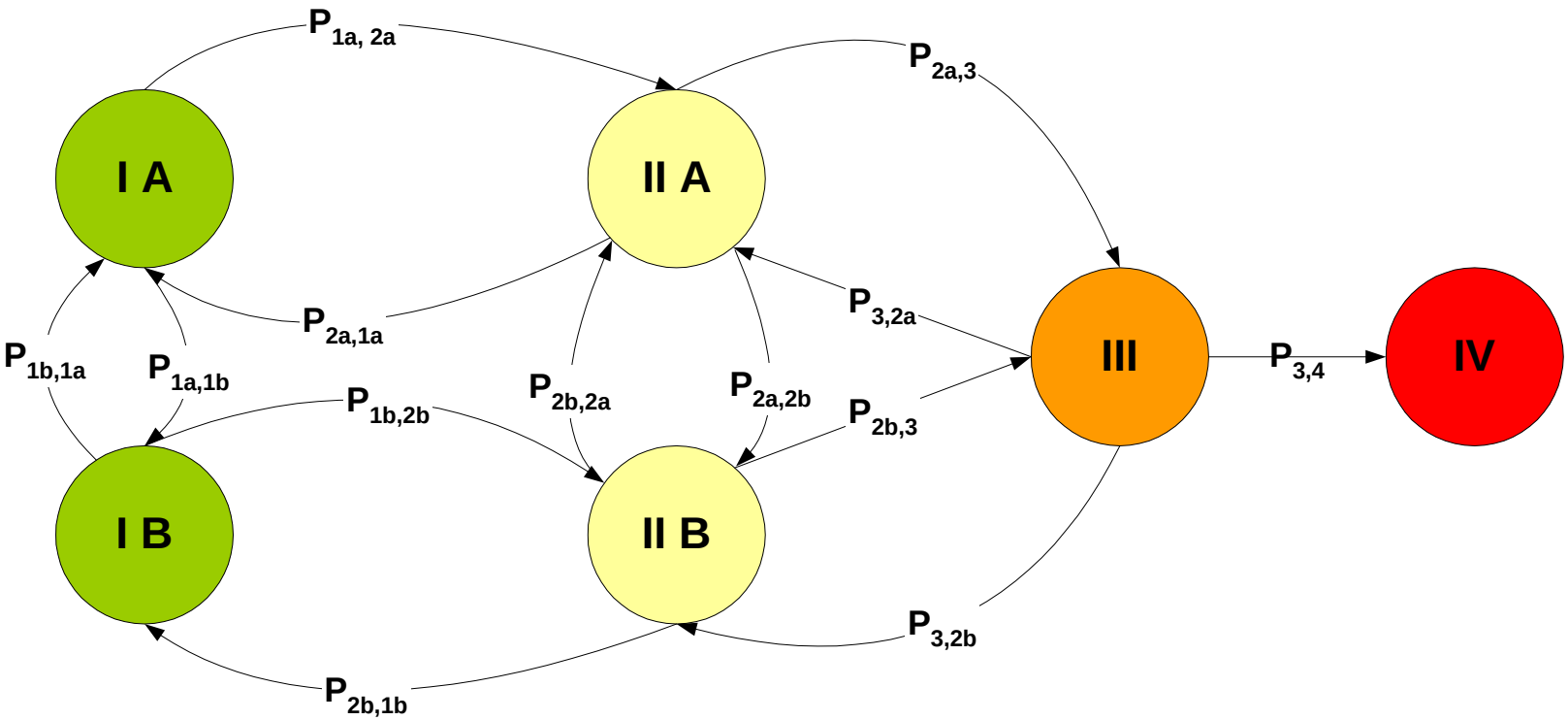



V@R Concept Applied to Power System Operations – R@R

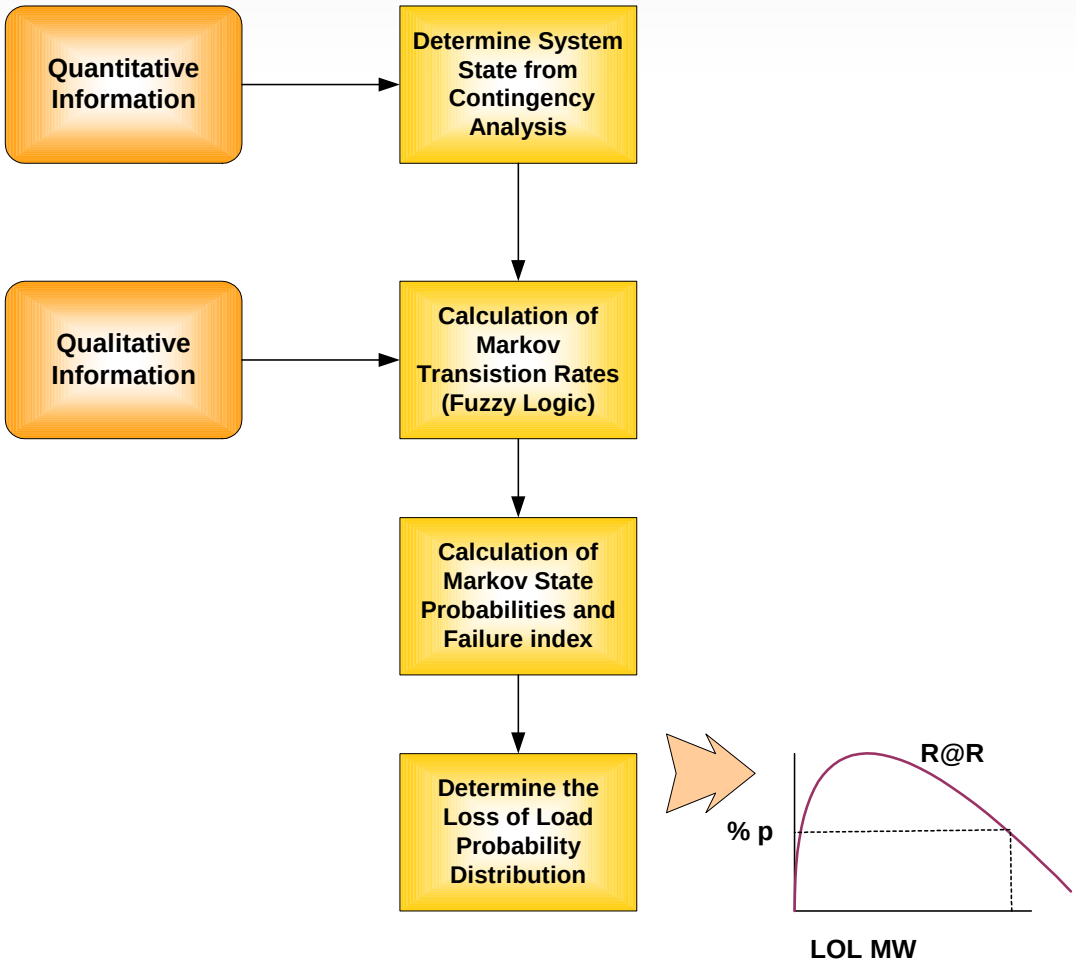
Power System States

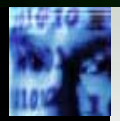
State	*Condition*	*Real Time Limit Violations*	*Contingency Limit Violations*	*Comment*
I A	Secure	No	No	
I B	Secure	No	Normal - Yes	Action required
II A	Insecure	Normal - Yes	Emergency – No	Action required
II B	Insecure	Normal - Yes	Emergency – Yes	Action required
III	Emergency	Emergency - Yes		Immediate response required
IV	Failed	Emergency - Yes		System failed (Load lost)

R@R Power System State Markov Model



Conceptual R@R Process

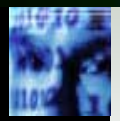







Conceptual Results of R@R

- Real Time Operations
  - The probability of system failure can be used as an index to measure system risk
- Planning
  - Probability of loss of load over a time horizon can be used for risk assessment






Potential Research

- Calculation of Markov model transition rates
  - Fuzzy logic
- Calculation of Loss of Load Probability
  - Aggregation of results of probabilistic contingency chains and MW loss/State produces the R@R probability density function
- Probabilistic contingency analysis
- Ralph Masiello; *ralph.masiello@kema.com*