Steady-State Power System Security Analysis with PowerWorld Simulator

S11: Distributed Computing

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Outline

- Motivation
- Implementation
- Distributable Calculations
- Configuration
- IT Concerns
- Future Directions

Introduction

- Distributed Computation is a set of add-ons that split large problems into smaller, independent problems.
- The independent problems can then be sent to multiple processors on the same machine or even to other computers on a network to spread the workload and dramatically reduce overall calculation time.

Motivation

- Historically, problem sets were smaller
  - Slow computers and little available memory
    - Limited case size significantly
    - Limited set of contingencies (generally only the worst)
  - Fewer regulations and penalties
  - Few data warehousing tools to process and store large amounts of data
  - End result: Small problems that took lots of time and only calculated a few power flows.

Motivation

- Problem sets are much larger now
  - Faster computers with lots of memory
    - Larger, more detailed models (even to the node-breaker level)
    - More detailed contingency lists
  - More regulations and audits with significant potential penalties
    - Contingency lists significantly grew (N-1-1, etc.) & number of ATC scenarios
  - End result: much larger calculations, with *many* more power flow solutions

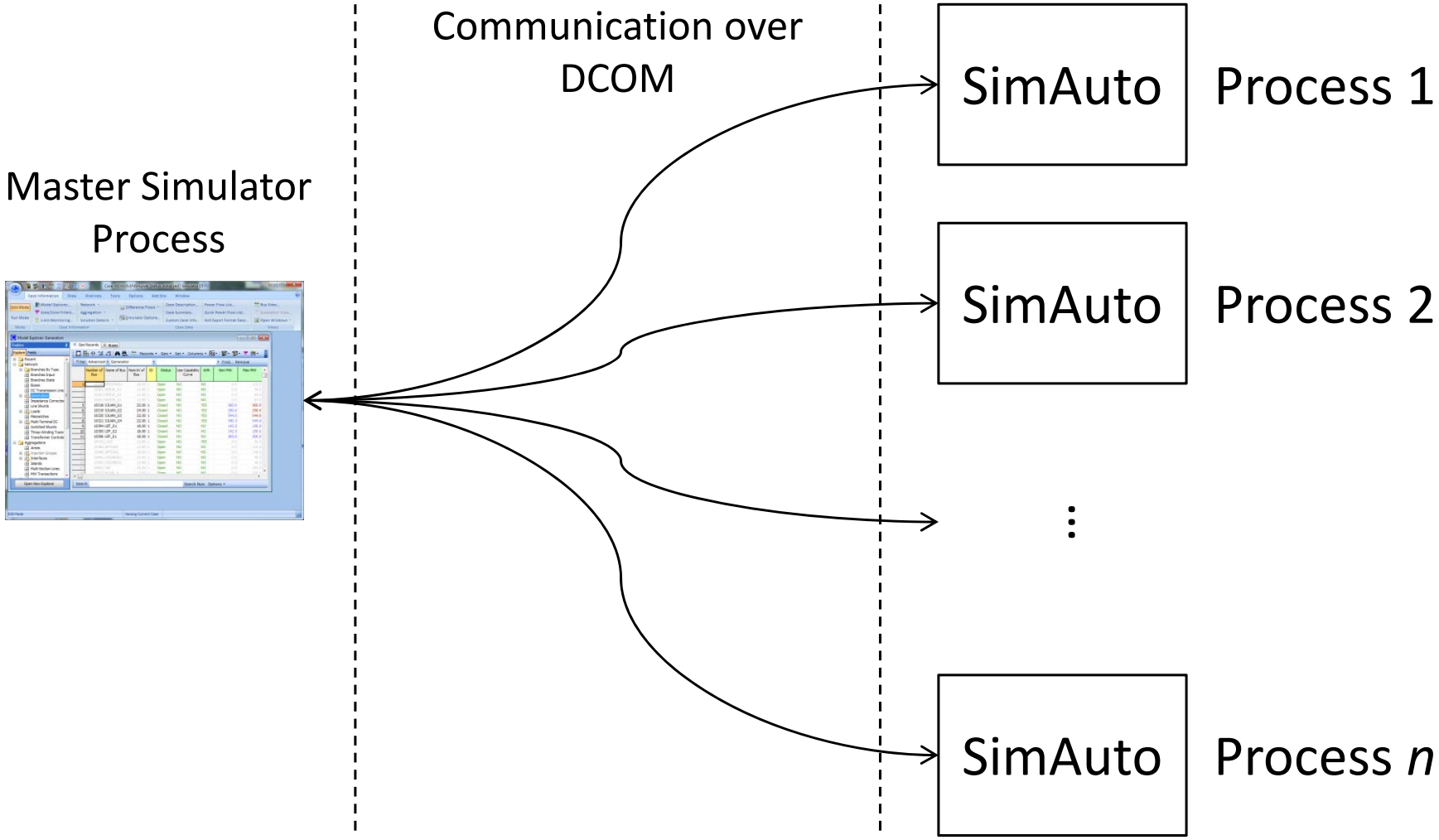
Motivation

- Ultimate problem
  - Processor speed hasn't kept up with problem set size
- Solution
  - We have many more cores/processors available to do the work
  - Split the problem set into multiple, smaller problems that can be solved independently.
    - While power flows are difficult to parallelize, contingencies and ATC scenarios are completely independent.

Implementation

- Use SimAuto and additional specialized COM (Component Object Model) programming interfaces for communication
- Use Microsoft Distributed COM to access computation resources on other machines

Implementation



Implementation

- How does Simulator distribute calculations?
  - Create a pool of SimAuto instances.
  - Send current case to each SimAuto in the pool.
  - Send current tool's settings to each SimAuto.
  - Break the calculation into small chunks (groups of contingencies, individual ATC scenarios, etc.).
  - Distribute chunks to each available SimAuto in the pool until there are no more chunks left.
    - After a chunk is completed, gather the results into a list.
    - Release the SimAuto instance back into the pool of available SimAutos
  - Take the results list and apply it to the current case

Distributable Calculations

- What makes a good distributable calculation?
  - Easily identifiable cleaving points
    - Contingency (steady state and transient stability)
    - ATC scenario
    - Bus injection (QV)
  - Independence of individual operations
    - SimAutos within pool do not communicate with each other
    - Too much network communication causes large overhead

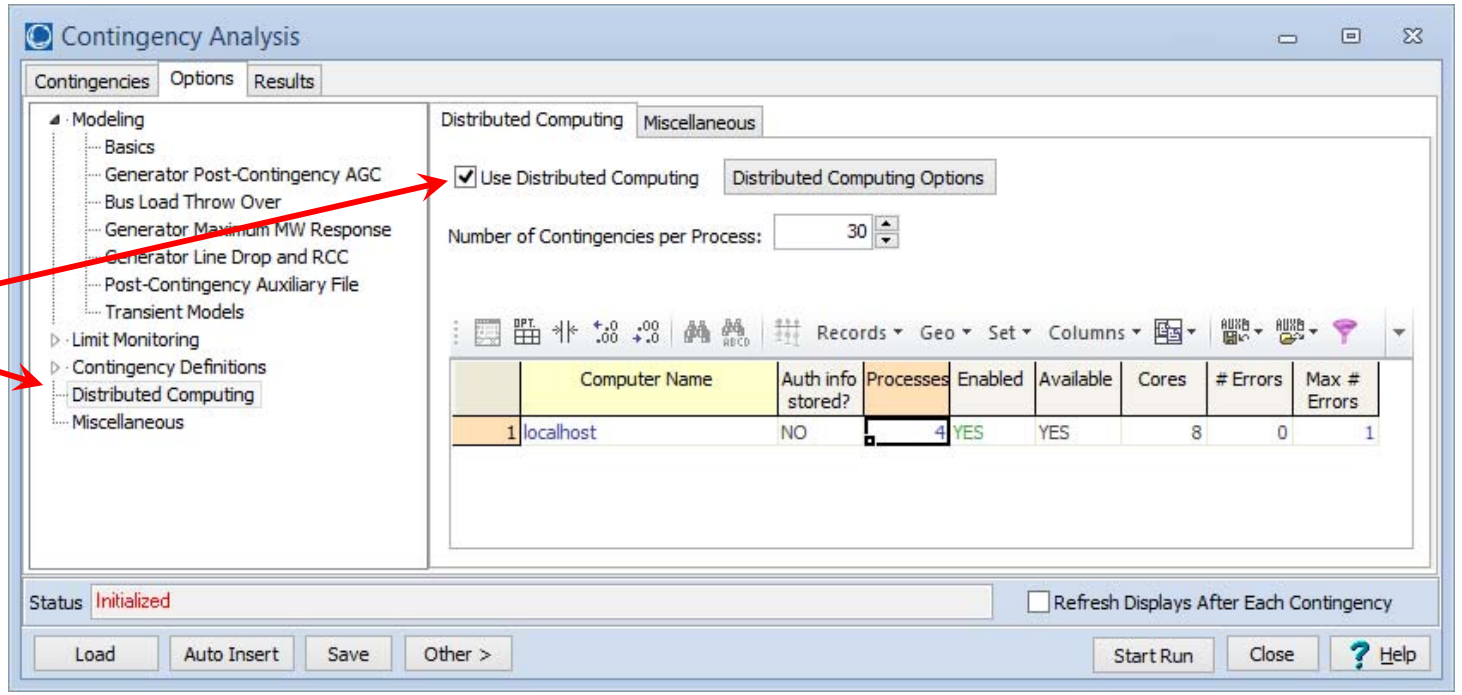
Distributable Calculations

- Completed Tools:
  - Contingency Analysis
  - ATC (multiple scenarios)
  - Transient Stability
- Soon to be undertaken:
  - QV Curves

Configuration

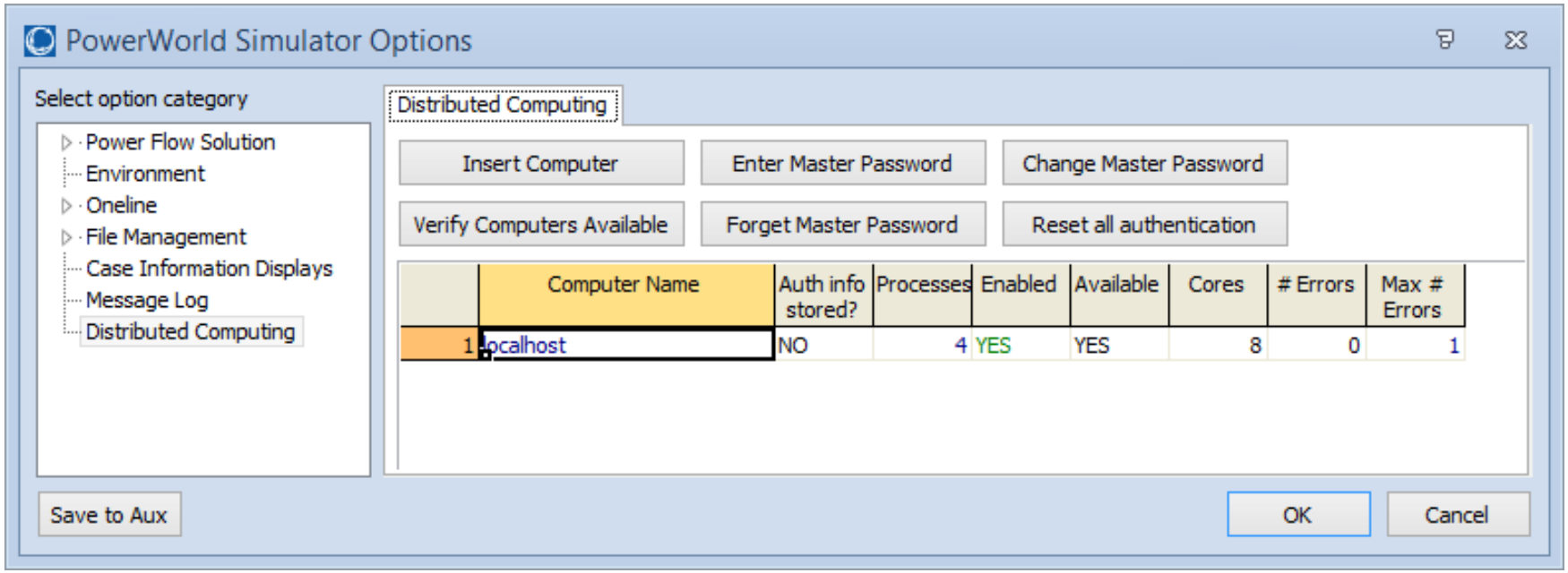
- Enable Distributed Computing through Contingency Analysis dialog or ATC dialog (after enabling Multiple Scenarios)

Select Distributed Computing Page from Options tab in Contingency Analysis



Configuration

- Clicking the “Distributed Computing Options” button opens the Distributed Computing page of PowerWorld Simulator Options



Configuration

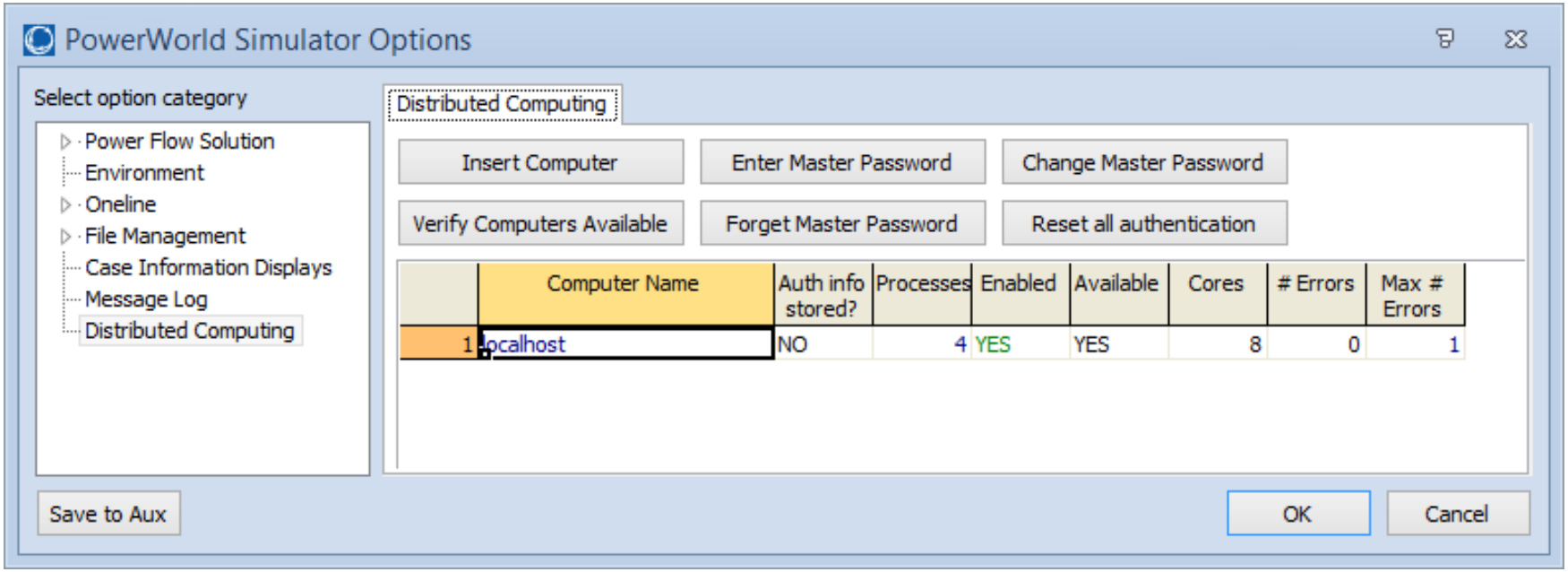
- Insert Computer: add a new computer from the local network to list of those available for Distributed Computing
- Verify Computers Available: checks each computer for availability and populates Enabled, Available, and Cores fields
- Enter Mater Password: decrypts the distributed machine login credentials

Configuration

- Forget Master Password: discard the previous master password. The user will not be able to perform a distributed analysis until the master password has been re-entered
- Change Master Password: re-encrypt all credentials with a new master password
- Reset all authentication: clear all authentication, including master password and all distributed machine login credentials

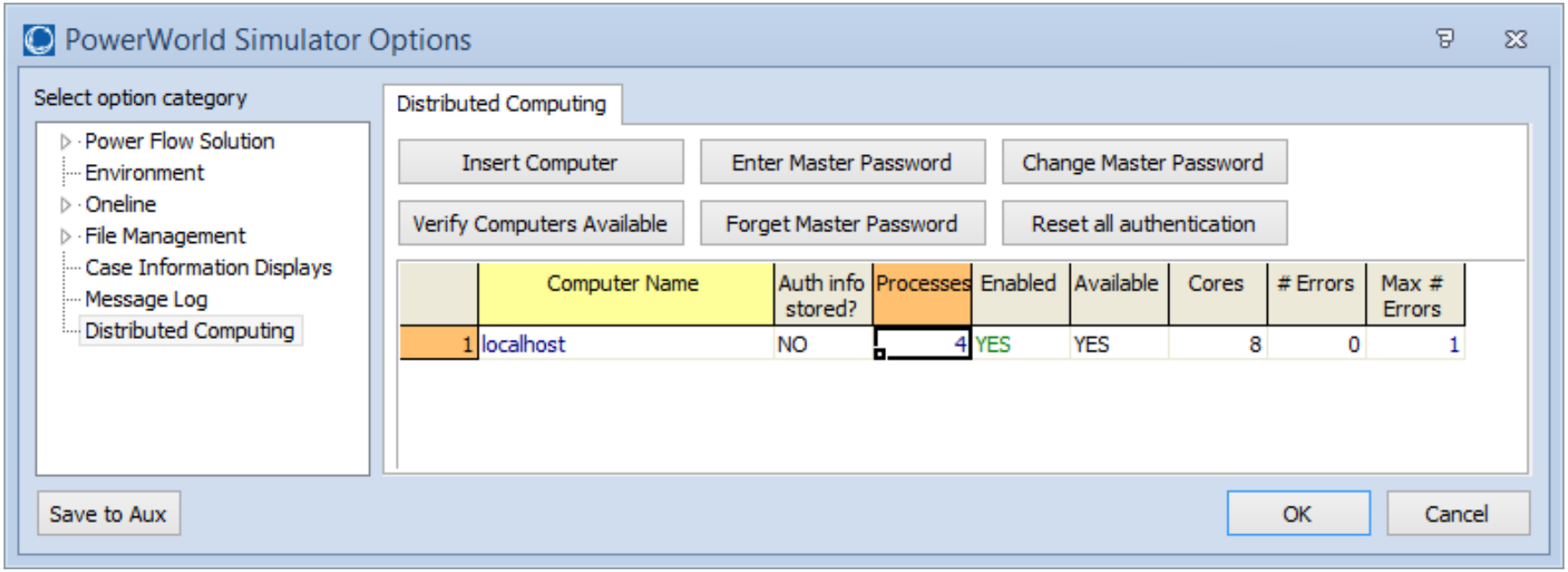
Single Multi-Core Computer

- Simplest operation is to use multiple cores on the local machine: no Windows or network security issues
- Choose Insert Computer, then enter the computer's Windows Name or "localhost"



Configuration

- Computer Name: name of the computer on the local network.
- Auth Info Stored? YES if login authentication information is stored for this computer.



Distributed Computer Fields

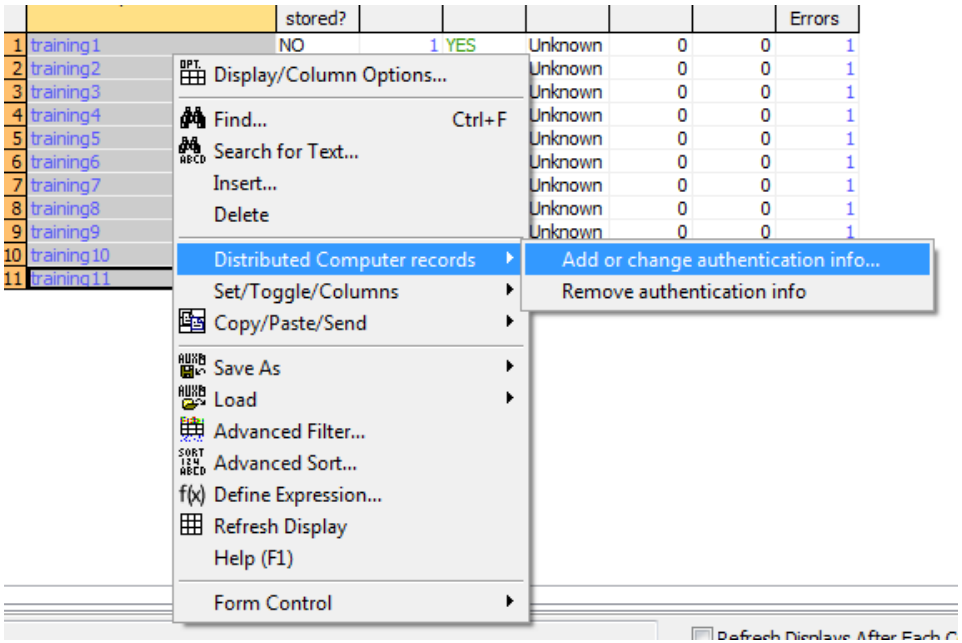
- Processes: the number of processes which will be started on this when performing distributed computer. For computers with multiple cores and/or multiple processors it may be advantageous to execute multiple processes.
- Enabled: Set to YES to use the computer.
- Available: set by Simulator after user clicks Verify Computers Available button
- Cores: number of cores available on the computer.
- # Errors: encountered when trying to use the computer for distributed computing.

Configuration

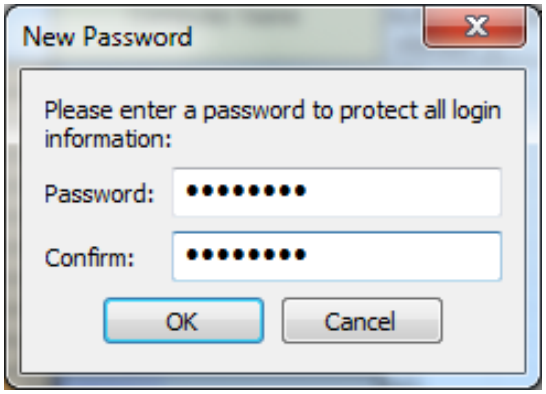
- Max # Errors: user-specified maximum number of errors which can be encountered with a computer before the distributed computing will stop attempting to use the computer for computation.
- Domain, Password, Username: login information that must be encrypted and decrypted through the Master Password. Use local menu options “Add or change authentication info” or “Remove authentication info”. These values may be saved and loaded from an AUX file in encrypted form. If authentication fails then Simulator will not use the computer for distributed computing.

Authenticate Distributed Computers

1. Choose “Add or change authentication info…” from local menu



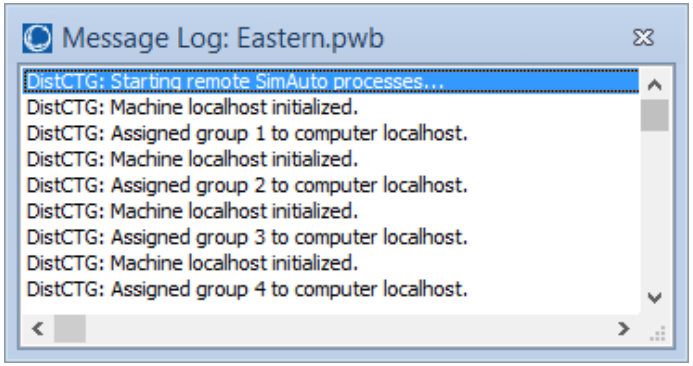
2. Enter Master Password (if not already done)

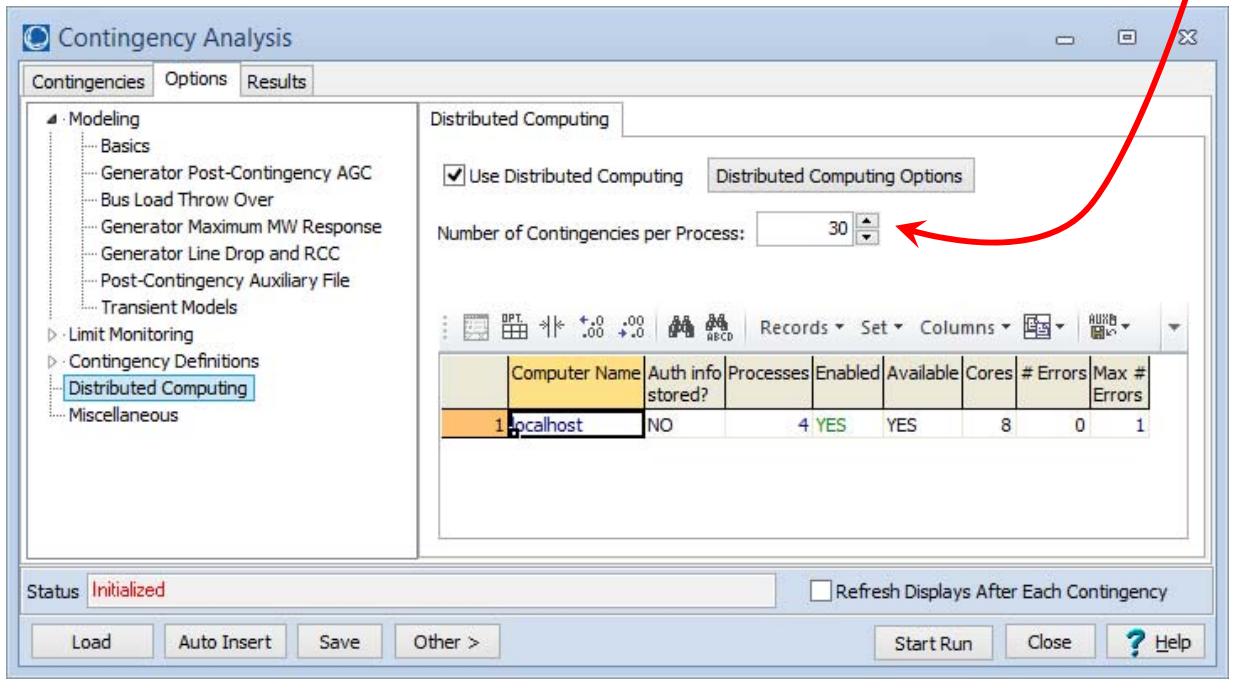


3. Enter Authentication for Individual Computer

Contingency Analysis Example

- Set the Number of Contingencies per Process: after a computer completes a group of this size, Simulator will send another group to that computer. This will continue until the contingency analysis results are completed.





IT Concerns with Network Resources

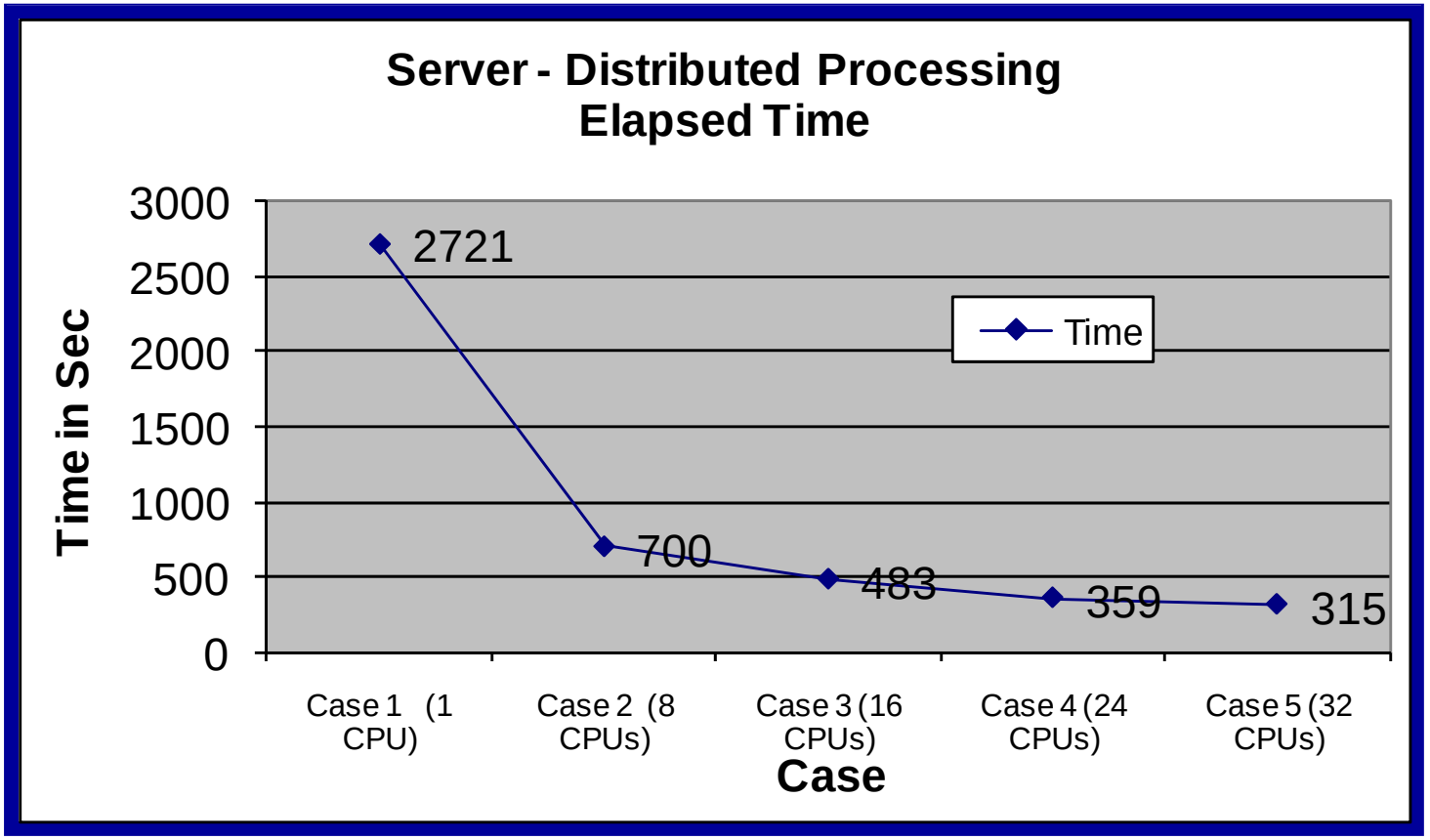
- Distributed automation has a big drawback: SECURITY
  - Microsoft DCOM has been known to have security issues
  - Login accounts must be adjusted or created to allow SimAuto to run on networked machines
  - Security policies may need to be updated

Benefits

- The upshot?
  - DCOM is a mature and robust technology, so new, large security issues are unlikely
  - The potential for massive performance improvements in total elapsed time
  - Put unused computers to work at night, on weekends, etc.

Contingency Analysis Benchmark

Source: Bonneville Power Administration, June 2010



Case 1: Single process (1 CPU)
Case 2: 8 Process on Dual Quad single machine (8 CPUs)
Case 3: 8 Process on 2 Dual Quad (16 CPUs)
Case 4: 8 Process on 3 Dual Quad (24 CPUs)
Case 5: 8 Process on 4 Dual Quad (32 CPUs)