PowerWorld Trainer:

Multi-User Operations Training Simulator

Trainers' Workshop Reception

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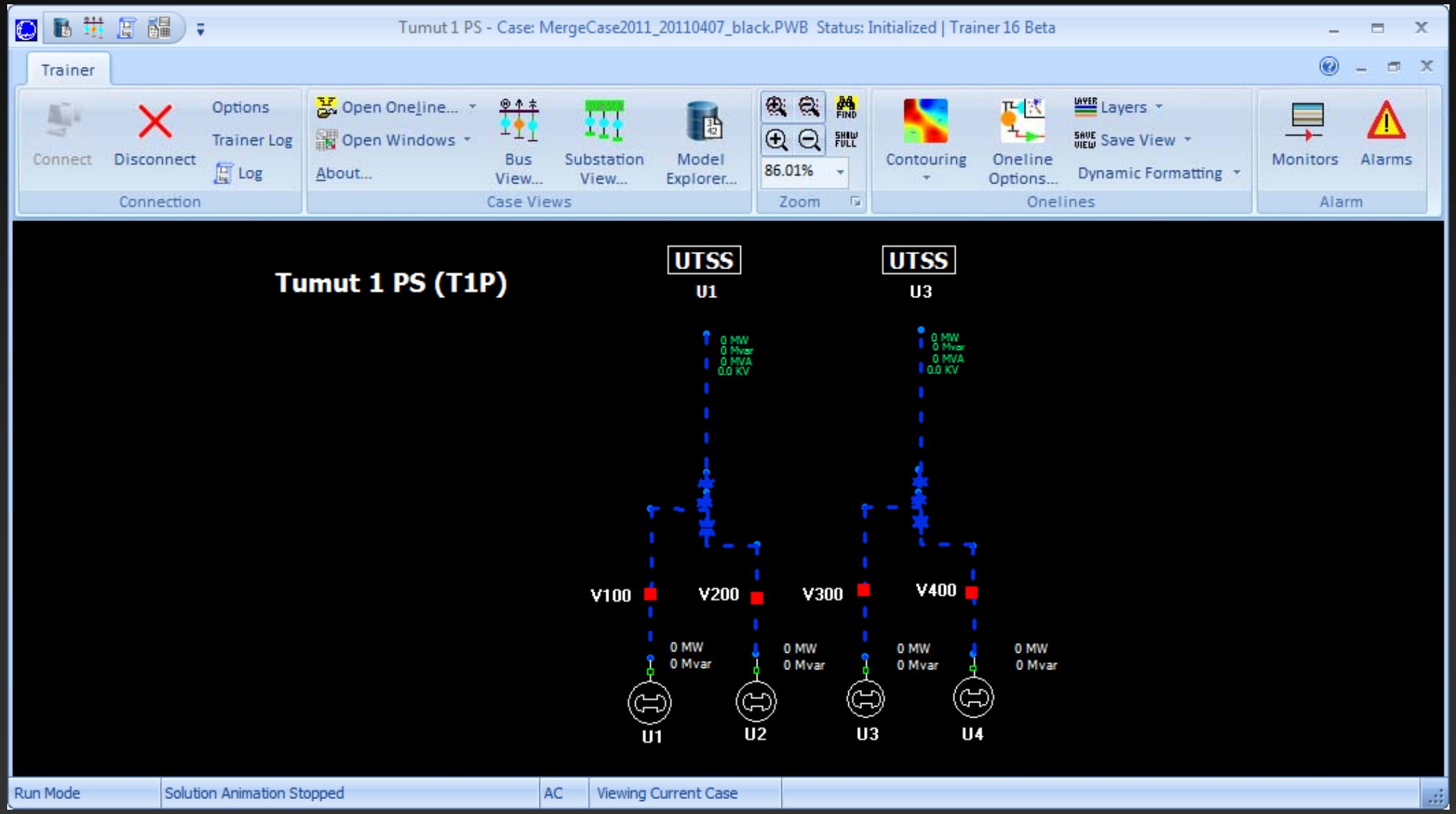
PowerWorld Products

- PowerWorld Simulator
  - Analysis and visualization
  - Power flow, contingency analysis, available transfer capability, voltage stability, transient stability, geomagnetically induced current, optimal power flow (LMP markets)
- PowerWorld Retriever
  - Real-time visualization for the control room
  - Integration with PowerWorld Simulator and analysis tools
- OPS-X: simulation training modules for NERC System Operator Certification requirement
- PowerWorld Trainer: New simulation platform for multi-user operations training

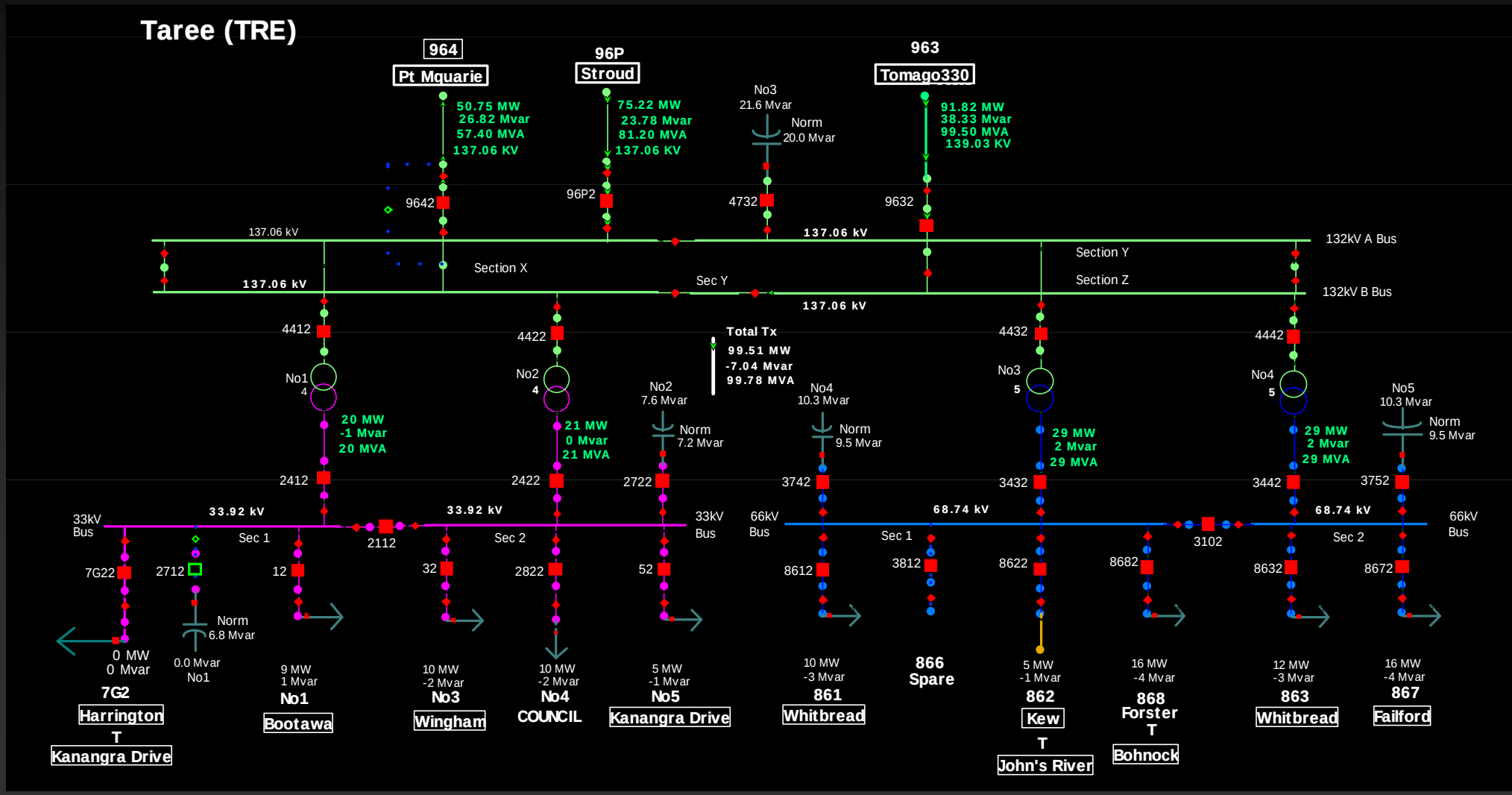
PowerWorld Trainer Highlights

- Uses PowerWorld's industry-leading user interface and visualization platform
- Easy to customize for company-specific training requirements. PowerWorld Trainer supports:
  - multiple one-line diagrams and graphical system representations
  - full breaker topology - use the actual EMS system model, not a planning equivalent
  - customizable monitors and alarms
  - conditional remedial action schemes (RAS)
  - multiple simultaneous participants: transmission operators, generation dispatchers, etc.
- Instructor may pre-program a sequence of events to which students must respond, or participate alongside operators

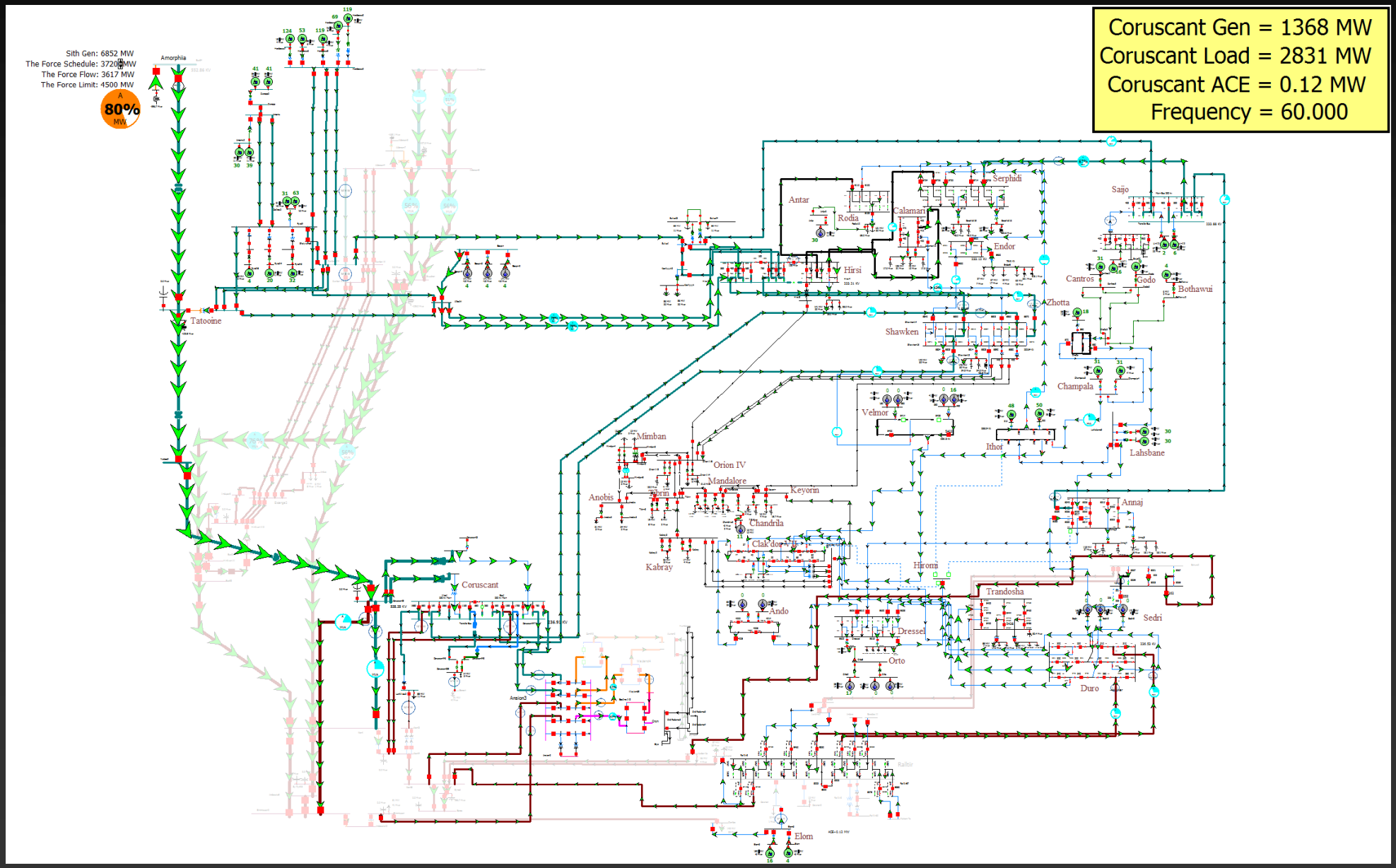
PowerWorld Trainer Client



Customizable Diagrams



System-Wide View

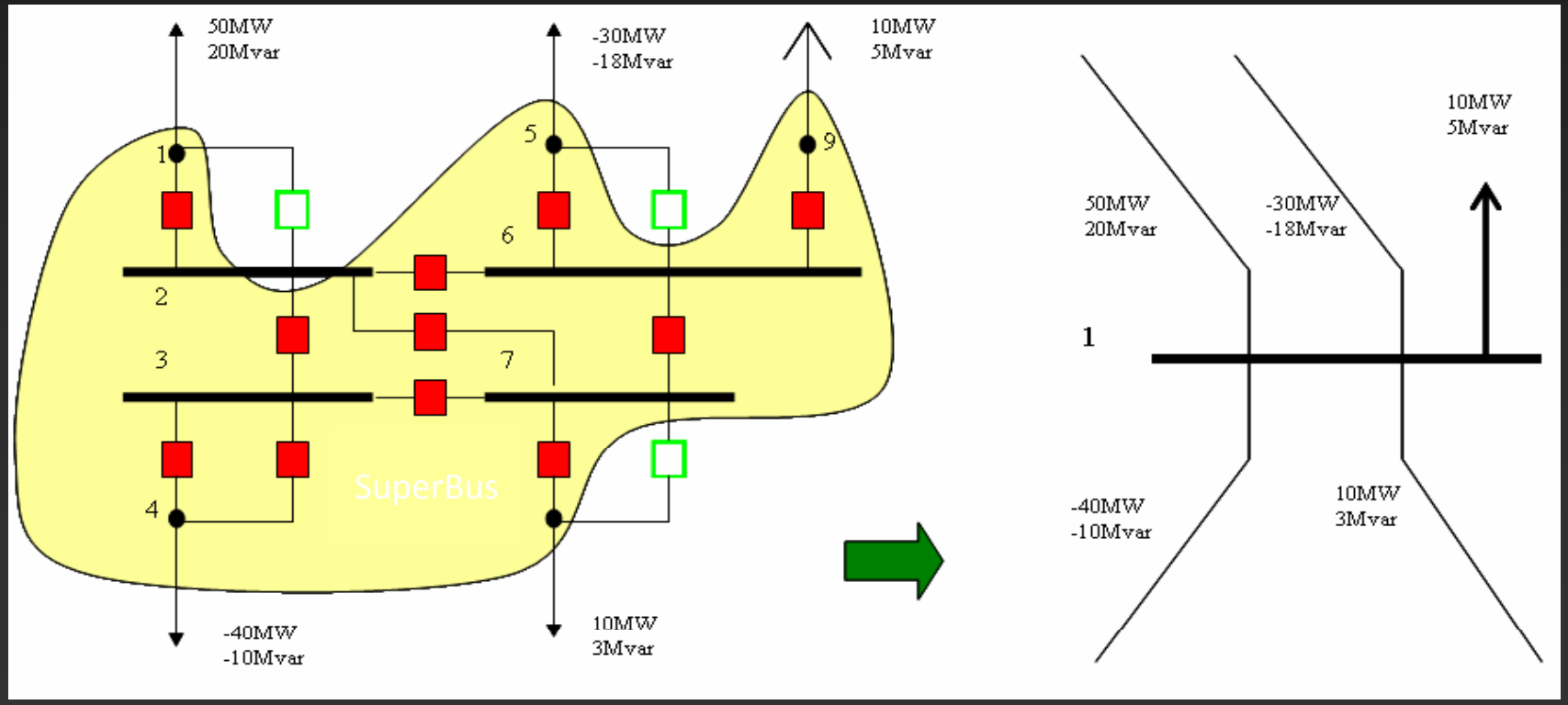


Integrated Topology Processing

EMS systems use a *Full-Topology Model*

Planners use a *Consolidated-Topology Model*

PowerWorld Trainer can use *Both*

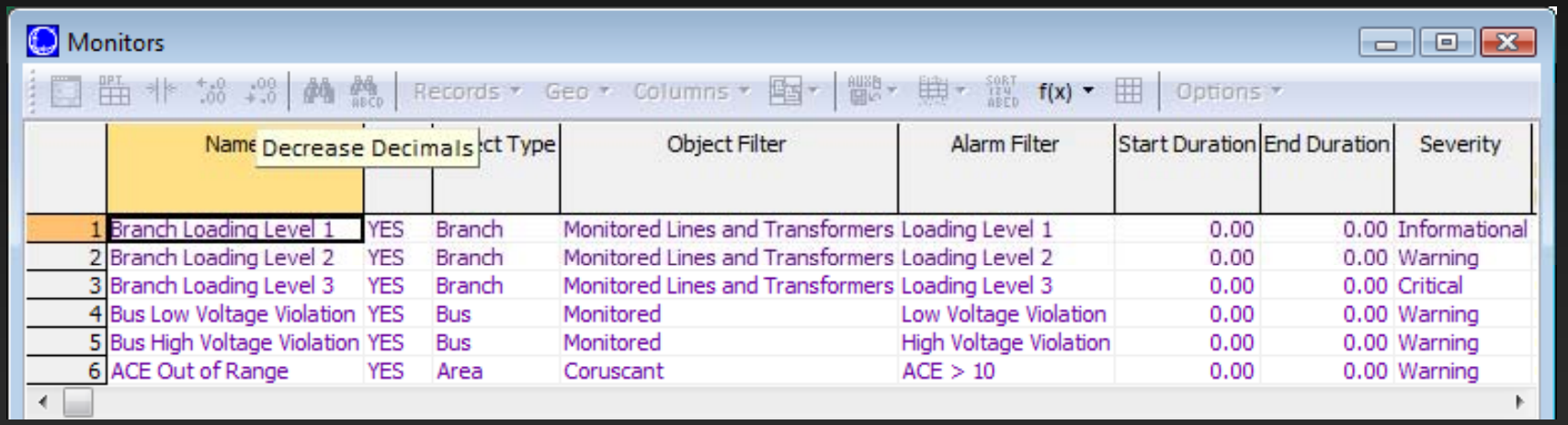


Monitors and Alarms

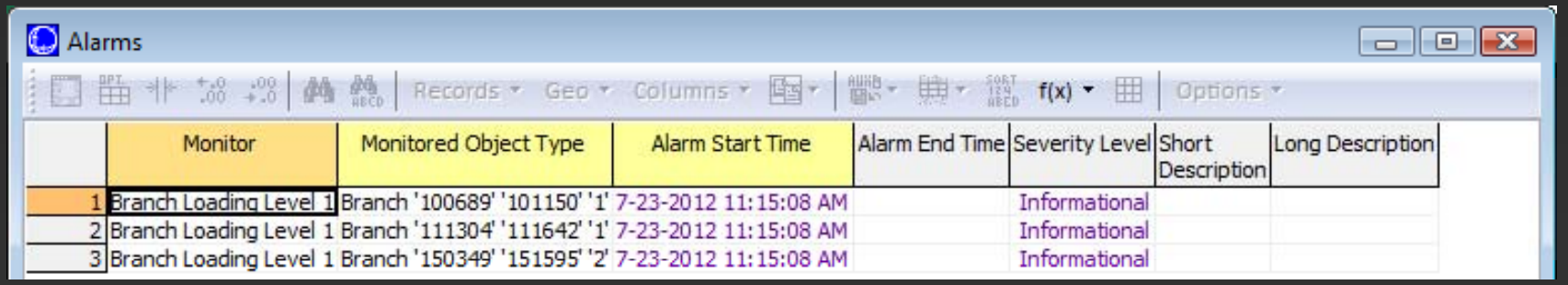
- Can be configured and sent from server
- Monitors work like filters
  - Users can specify a type of device to monitor and a condition on a particular field (e.g. Bus voltage > 1.08 pu)
  - To make the alarms more decipherable, it is also possible to create a description of the alarm based on various model fields (e.g. Bus Name, Label, Nominal kV)
- When the monitor condition is met, an alarm is generated

Monitors and Alarms

Monitors: show what is being monitored and the filters that define limits



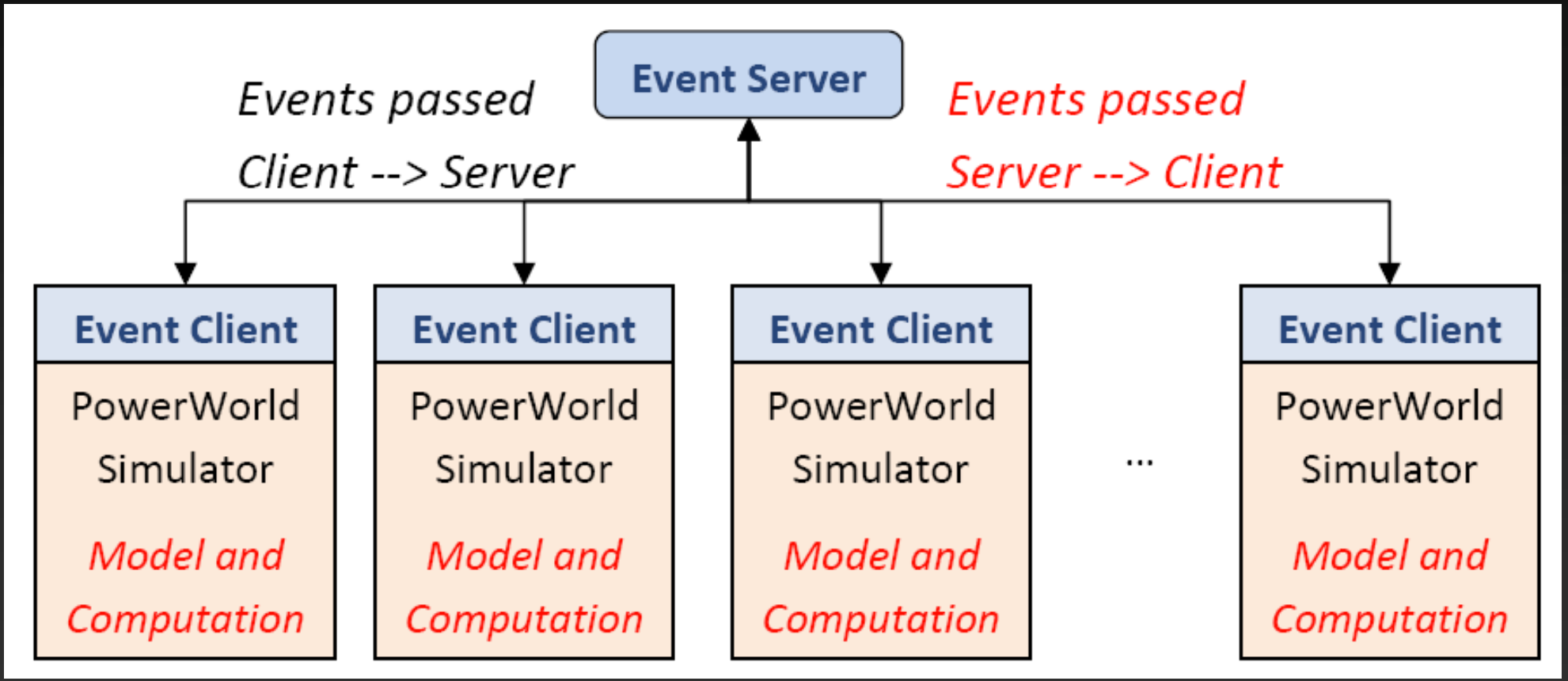
Alarms: show devices that violate those limits



How Trainer Works

- Architecture
  - Trainer Server
  - Trainer Client
- Using Trainer
  - Develop Training Content
  - Server Setup
  - Client Setup
- Operation
- Demo

Trainer Architecture

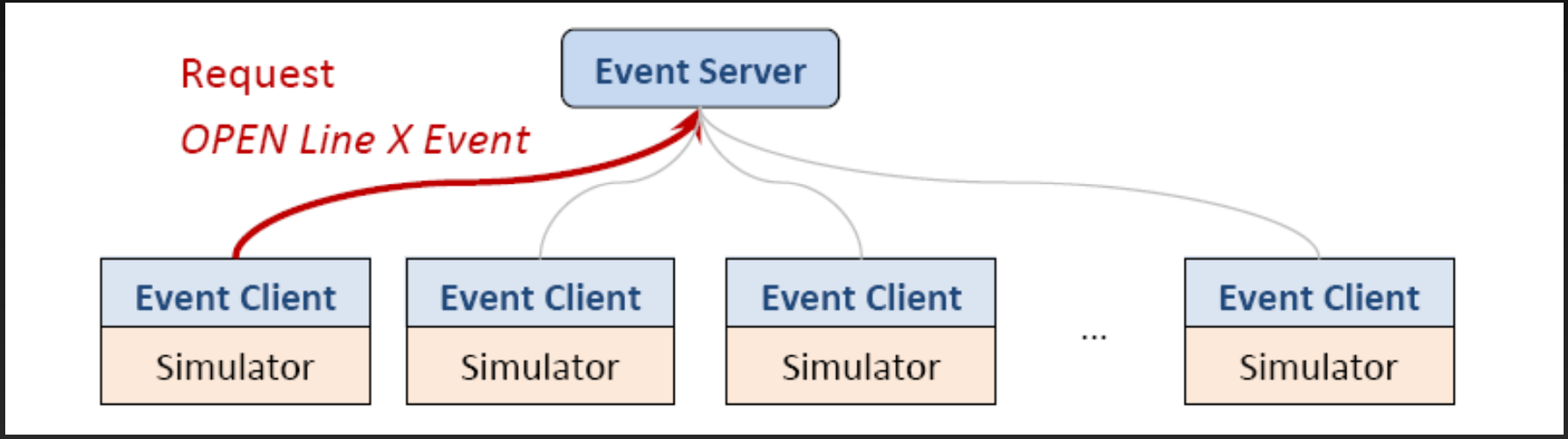


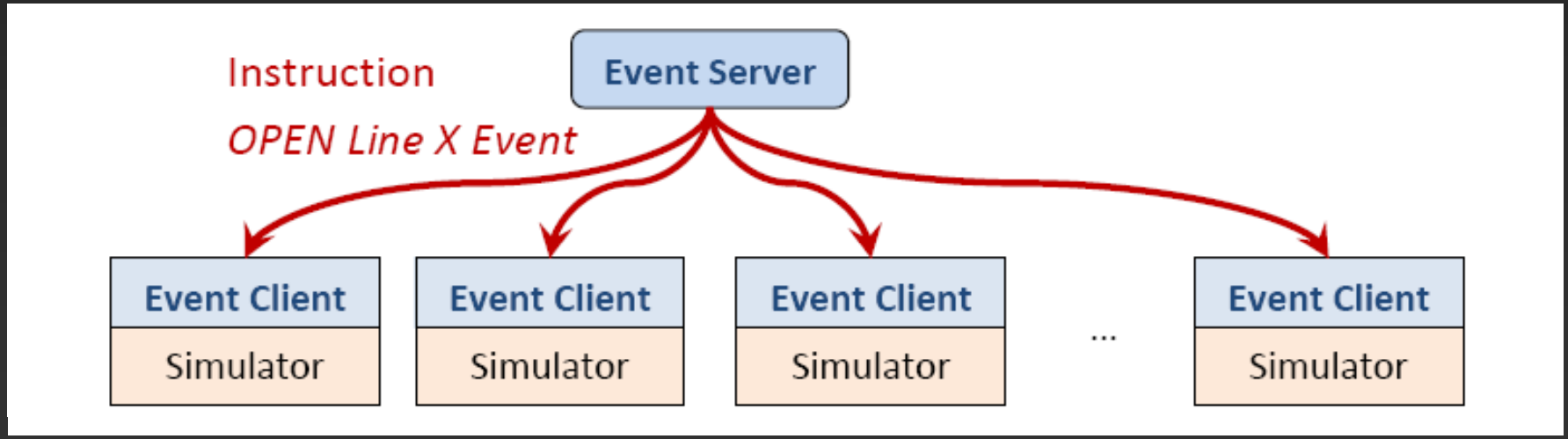
Traditional operator training platform does computation on the server and passes full system state; PowerWorld Trainer approach uses less network bandwidth

Trainer Architecture

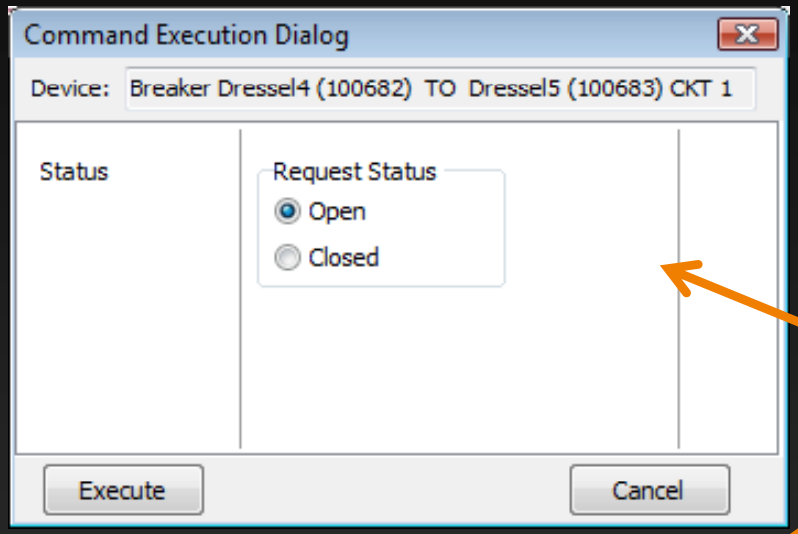
- Each client maintains its own model of the power system
- To avoid every client having a different state, the server manages
  - Starting point
  - Solution options
  - Changes that affect system state (e.g., opening lines, changing generator outputs, …)

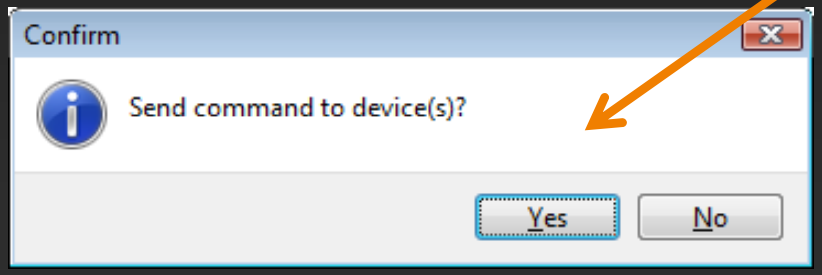
Event Processing





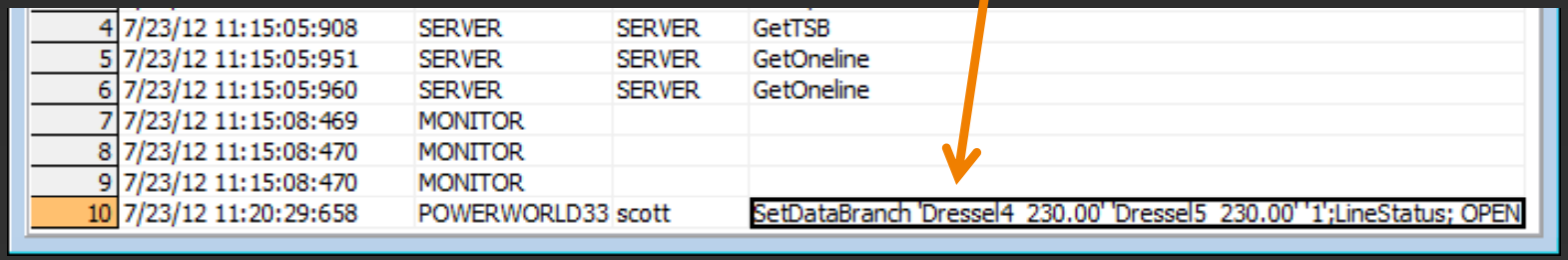
Event Processing





Commands are issued as in EMS environment

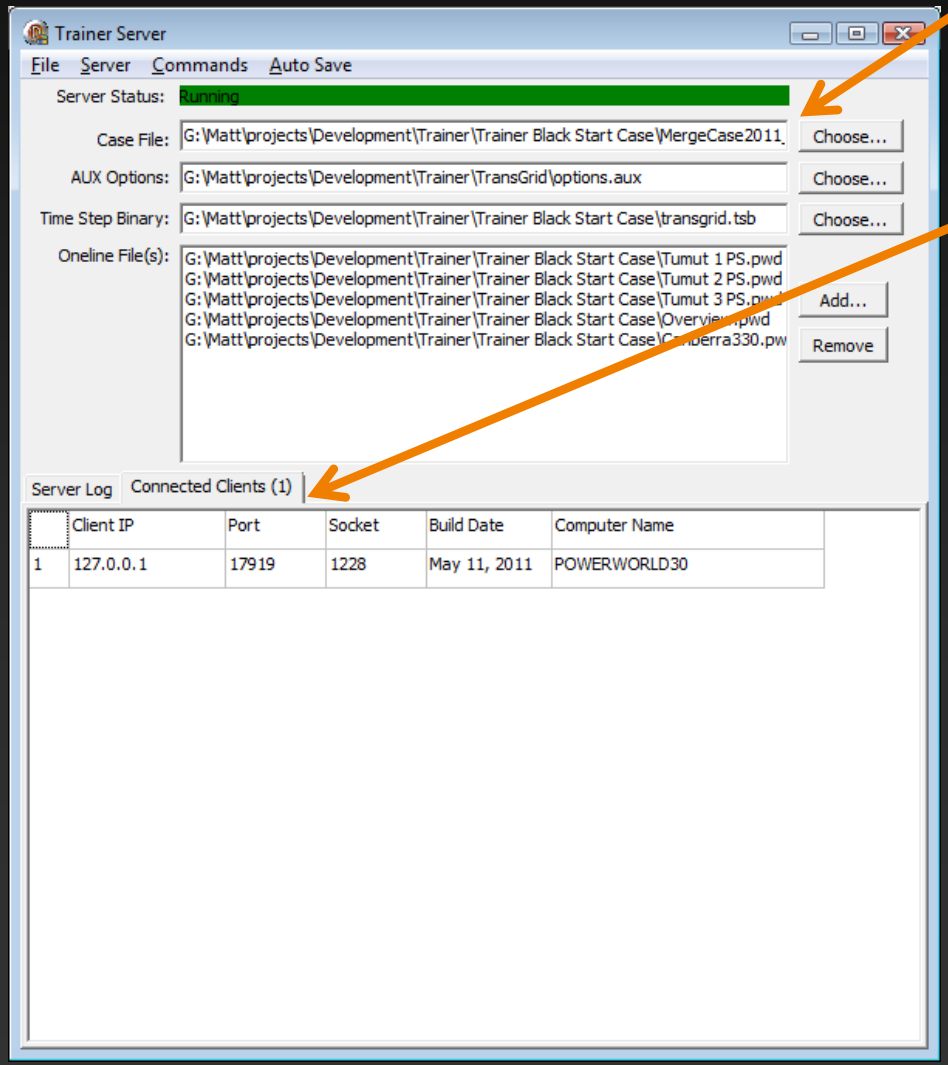
1. Click on device
2. Request action
3. Confirm action
4. Message broadcast to all clients in Trainer Log



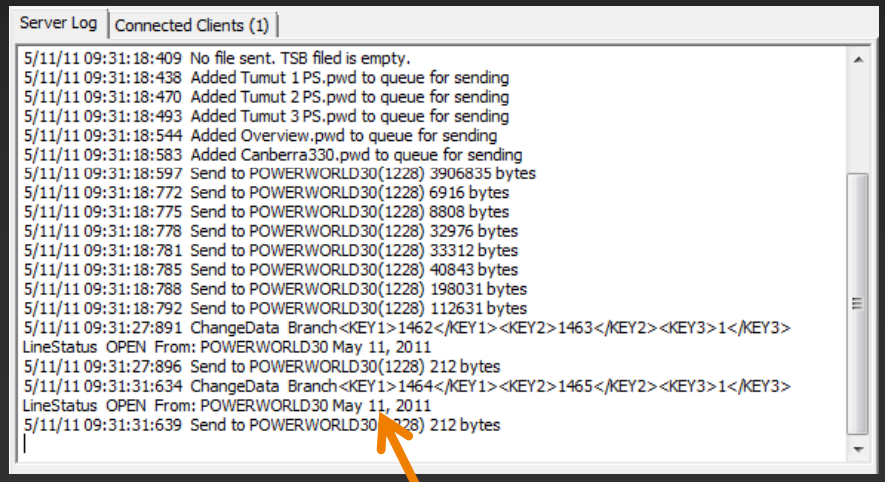
4	7/23/12 11:15:05:908	SERVER	SERVER	GetTSB
5	7/23/12 11:15:05:951	SERVER	SERVER	GetOneline
6	7/23/12 11:15:05:960	SERVER	SERVER	GetOneline
7	7/23/12 11:15:08:469	MONITOR		
8	7/23/12 11:15:08:470	MONITOR		
9	7/23/12 11:15:08:470	MONITOR		
10	7/23/12 11:20:29:658	POWERWORLD33	scott	SetDataBranch 'Dressel4 230.00' 'Dressel5 230.00' '1';LineStatus; OPEN

Trainer Server

Configure files to send to each Client



Connected Clients tab has a list of the Clients that are connected and information about each one (Build Date and Computer Name are not populated until GetBuildDate Command is sent)



Server Log contains a list of commands That have been sent and received

Trainer Server

- Designed to be as simple as possible
  - Server has no knowledge of system state
  - Every client is treated the same
- Primary function is to send model and solution options and forward commands
- Several options and commands have been added to support logging, recovery from errors, and scripted behavior

Trainer Client

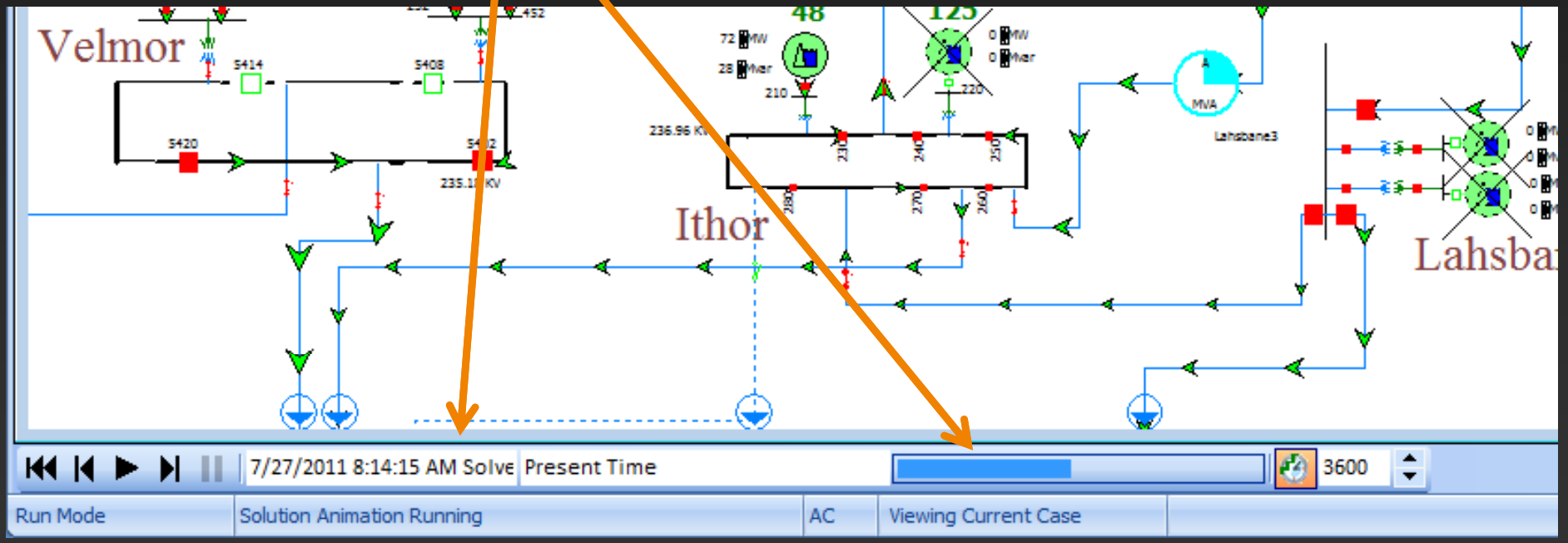
- The Trainer Client is a stripped-down version of PowerWorld Simulator
  - Only the Trainer ribbon is available, which contains mostly one-line diagram functions
  - Commands that can potentially change the state have been disabled
    - Cannot load aux files or change values through dialogs or the Model Explorer
  - All changes are made through a dialog that forwards the changes to all clients via the server

Developing Training Content

- Develop training scenarios or exercises in PowerWorld Simulator and/or Retriever
  - Models, cases (pwb): may use topology processing for node-breaker models
  - One-line diagrams (pwd)
    - Multiple one-lines may be used
    - Supports contouring, saved views, layers, dynamic formatting, emphasis filter, one-line links, and other features
  - Auxiliary files (aux): simulation options, contingencies, alarms (setup in Retriever Control Panel)
  - Time Step Simulation (tsb): schedule events to happen at a certain time during training simulation
- Instructor may also participate on a Trainer Client alongside trainees: manually force outages or sabotage the system

Time Step Simulation

- Footer shows current time and progress through simulation

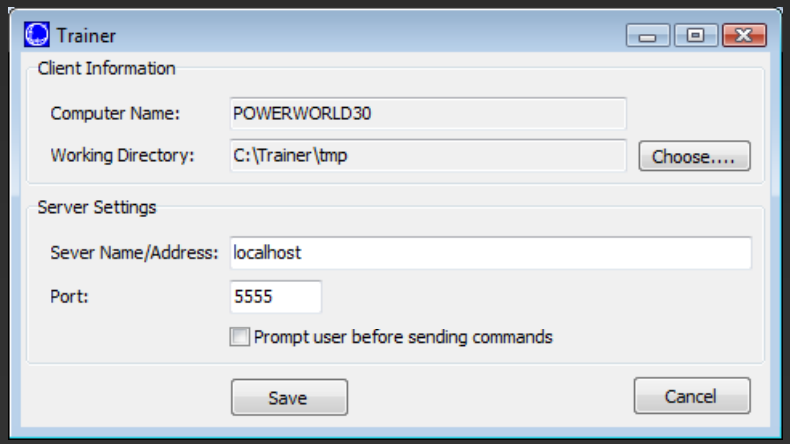


Server Setup

- Run Server program
- Choose files to send
  - At a minimum the case and options files should be sent
- Check server configuration options
- Start server, wait for clients to connect
- After all of the clients have connected
  - Send GetBuildDate command
  - If the build dates are the same, send the files; the "Send all files" commands sends all the selected files

Trainer Client Setup

- Start the Trainer program
- Configure the Trainer client options
  - Set the server address and port number to match the server configuration
  - Set the working directory (this is where the files from the server will be stored)



Server/Client Configuration

- Server
  - Manages starting point
  - Manages solution options
  - Manages changes that affect system state
- Client
  - Maintains own model of system
  - Only certain changes made through special dialogs (branch status, generator outputs, generator AVR, etc.)
  - Receives changes made by other clients through the server
  - Monitors and Alarms: Monitor a specific device and field and log (Alarm) when it meets this condition

Server Operation

- During the training simulation, the server may be used to:
  - Log events
  - Automatically save system states
  - Restore the simulation in the event of a blackout or failure

Client Operation

- Files are sent from the server to each client to establish a common training scenario
- When a participant interacts with the system (e.g. opens a circuit breaker)
  - a command is sent from the participant's client to the server
  - the server broadcasts the command to all clients, and
  - the power flow is solved on each client
- Commands are stored in a buffer queue so they will be applied in the proper order
- If there are multiple commands in the buffer queue, several may be applied together before the power flow is solved (to enhance program speed, as solving the power flow takes much more time than applying a command)