The Changing Needs of Non Real-Time Simulation EMTDC/PSCAD

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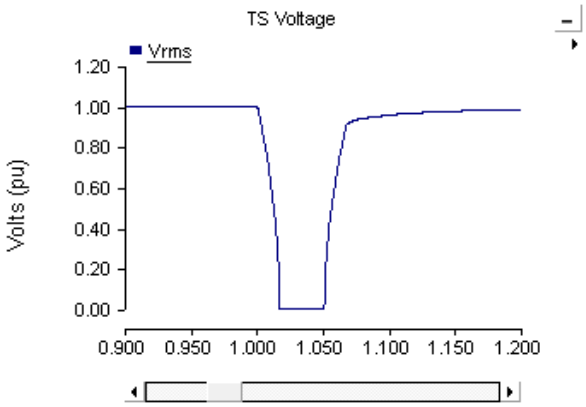
Classical Transient Stability Tools

- Applications:
  - Power flow, Transient Stability
  - Short Circuit Analysis
  - Small signal, PV/QV Stability Analysis

  } planning study tools

- Features:
  - Phasor based fundamental frequency analysis
  - Less detailed models/fast controls are assumed instantaneous
  - Larger time steps (half a cycle)
  - Large system models
- Examples: PSS/E, PSLF, PowerFactory…



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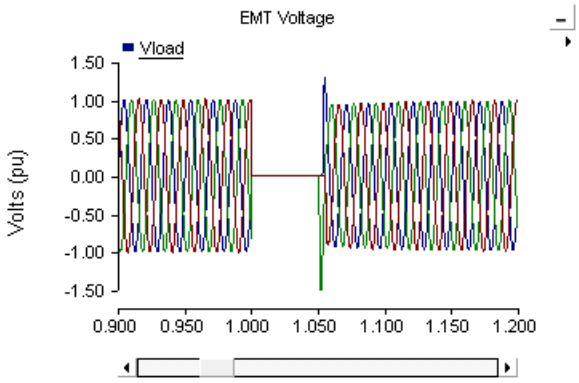
Classical EMT Tools

- Applications:
  - HVDC/FACTS Equipment Design
  - Transient Overvoltage Analysis (TOV)
  - Energization Studies, Lightning Studies
  - Harmonics and Power Quality
  - Transient Recovery Voltage Analysis (TRV)
  - SSR/SSCI, and other special studies



- Features:
  - Time domain differential equation solver
  - Detailed models (often using the “real” code from hardware)
  - Smaller time steps (typically 20-50 usec)
  - Small portion of the system is modeled (ie simple equivalents)
  - Examples: PSCAD/EMTDC, EMTP-RV, ATP

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Limitations

Transient Stability Tools

- High level control approximations due to use of large time steps, simplified models, phasor representation, poor/non-convergent weak system behavior (islanding), studies with complex interactions with many “modern” devices (HVDC, SVC, Statcom, Wind farms…).

EMT Analysis Tools

- Slow run-times, small systems with simplified system equivalents, setting of initial conditions, machine models, collection and entering of detailed data…
- **Confidentiality (EMTDC models often use the “real code”).**

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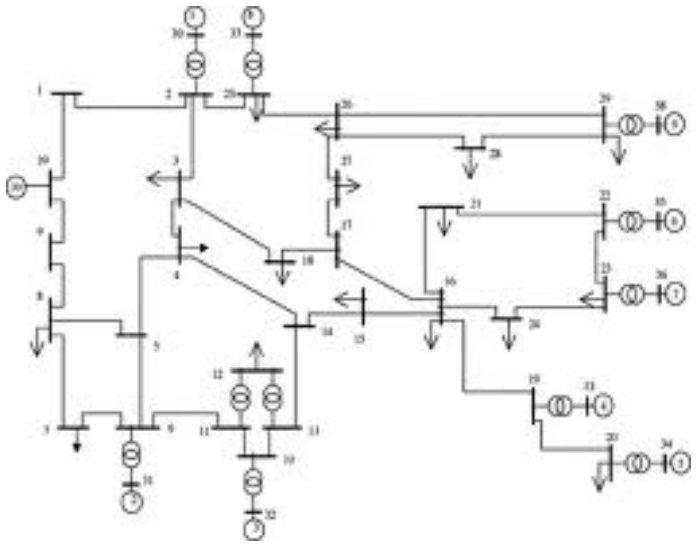
The Power System “20 years ago”

- Generation: synchronous generators
- Transmission: AC transmission lines/cables, shunt capacitors/reactors, transformers
- Classical distribution/loads
- Relatively strong systems
- A few complex high speed devices (HVDC etc...) which rely on high Short Circuit Ratio (SCR) and inertia.



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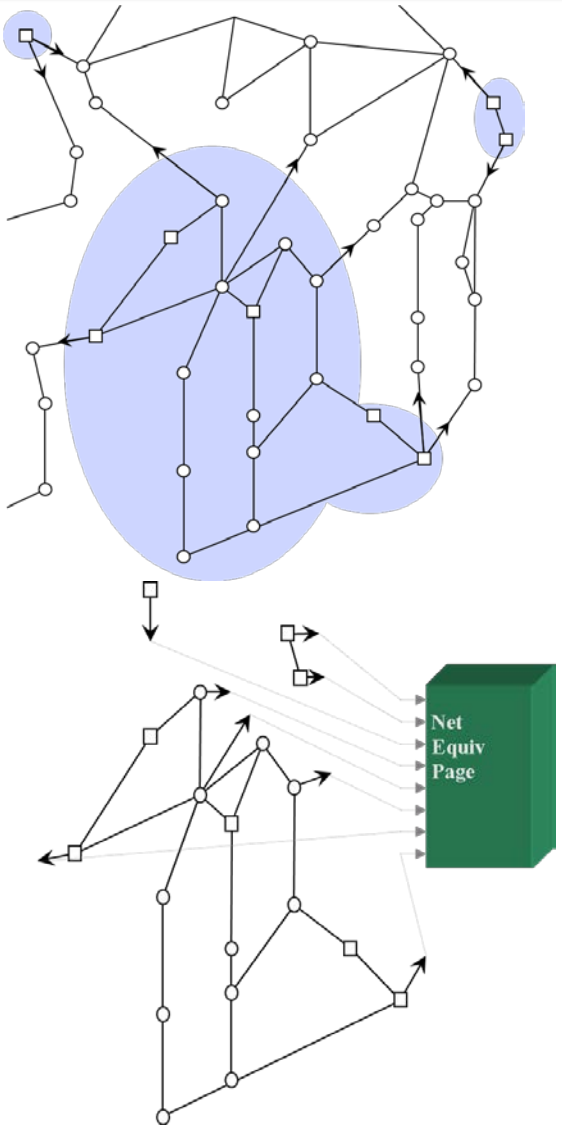
Today's Power System/Trends

- Many complex power electronic devices: Wind farms, HVDC/VSC, DC Multi-terminal, PV Inverters...
- Weak systems, low ESCR, reduced system inertia
- Increased loads, need for RAS schemes
- Series capacitors, SVCs and STATCOMs (instead of new lines)
- "Doing more with what you got"
- New research required for simulation tools!

E-TRAN (Integration of EMT and TSA)

- *E-TRAN (2005-2012):*
  - *Translates/autoroutes PSS/E data into PSCAD*
  - *Generates network equivalents*
  - *Auto-translation and initialization of machines, exciters, governors, stabilizers… dynamic models into EMT*
  - *All detailed models are in a database – correlated with each object in the TSA case*
  - *Initialization of complex models, HVDC, wind, taps, loads, shunts..*
- *Simulations of large/complex systems now possible*



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New Simulation Products

- *Parallel Processing of EMT Simulations*

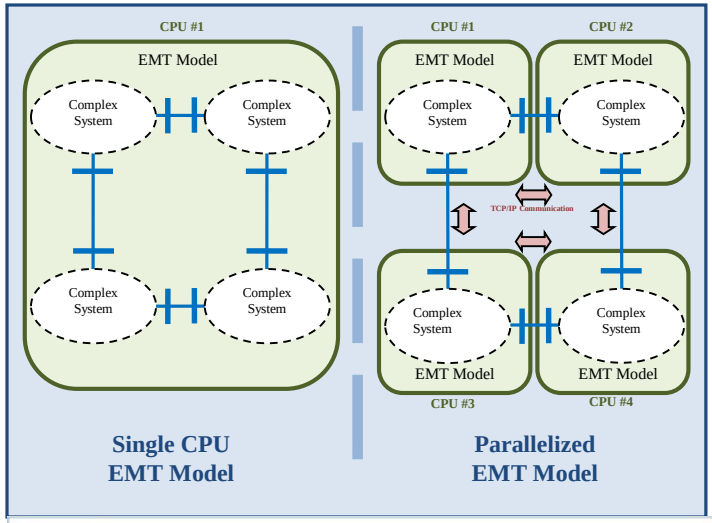
  - Break the EMT simulation into several cases and run them in parallel talking with each other with possibility for different time steps

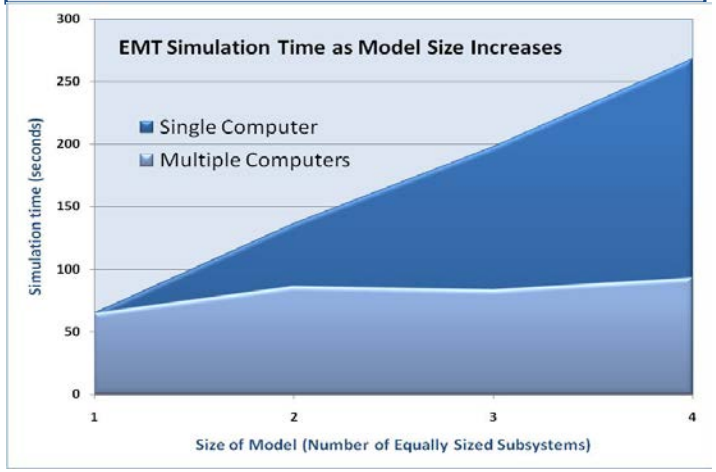
- *Hybrid Simulations*

  - EMT and Transient Stability simulations are run in parallel talking with each other on separate processors and different time steps

EMT Parallel Processing

- Traveling wave transmission line models have natural time delays.
- Simulations can be broken up at Bergeron transmission line boundaries.
- Results on 1 CPU or multiple CPUs are identical.
- Multiple cores on one computer, or multiple computers across a LAN can be used.
- Auto-launch of one process from another used to make parallel processing easy to use





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EMT Parallel Processing

Further time savings

- Use of different time steps (20 usec for PWM converters in wind farms, 50 usec for large systems)
- Reduction in memory usage

Black-boxing

- Wind farms (or any complex models) may be pre-compiled, released to customers as a full .exe
- Wind farm runs at its own time step (as tested by the manufacturer)
- Independent of program versions and compiler versions etc…

Confidentiality issues resolved

- Proprietary models are run on different machines

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Example – MISO-CanWEA DC Grid

Continental Transmission Super Highway - MISO, Canadian Government and CanWEA

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Hybrid Simulation

- Communication between the 2 programs (TSA and EMT) occurs at the larger of the time steps.
- Voltage magnitude and angle/frequency information from the TSA is sent to the EMT, where it is used to update equivalent voltage sources (on the diagonals of a system-equivalent that is auto-created based on the power flow admittance matrix).
- A DFT (discrete Fourier transform) is used to extract positive sequence PQ from the EMT, and transmit it to the TSA, where it is used to update a dynamic constant PQ load/generator model.
- The 2 programs run synchronously in time, allowing faults to be made on either side and affect the other.

Conclusions

- Hybrid Simulation of TSA and EMT tools
  - Running two types of simulations in parallel talking to each other:
    - For TSA Users:
      - Imbedding “real” system models (ie EMT models using real code) into simulations
    - For EMT Users:
      - Accurate “dynamic system equivalents” for mechanical oscillations etc...
  - PSSE output exporting and viewing interactively

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Conclusions

- EMT Parallel Processing
  - Splitting up large PSCAD cases onto multiple cpus or computers
  - Speed increase
- Overall Advantages
  - Confidentiality Concerns are met
    - Models from multiple manufacturers can be securely used in one simulation
    - “black-boxing” to avoid NDA concerns
    - Solves version/compiler problems
  - Case management/Ease of Use
    - Auto launching, plotting and case control from one central location…
- Modern Studies using Hybrid Simulation and Parallel Processing

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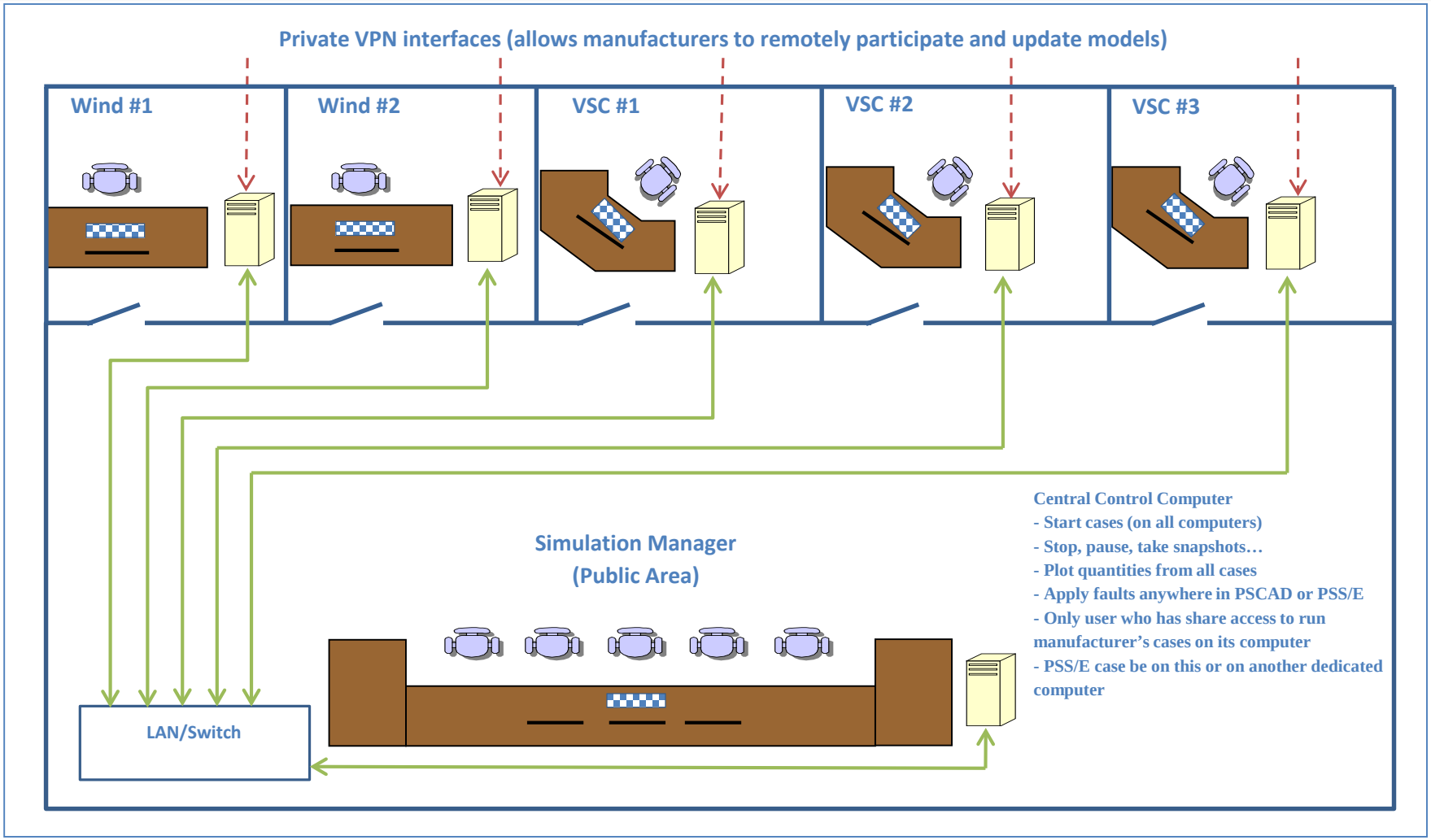
Multi-Vendor Simulation Setup



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RTDS Simulation Requirements for the Future

Knowing a lot about RTDS is becoming sexy at parties

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