VISUAL PLANT MODELING: THE COOL WAY TO DO IT

L3Harris MAPPs Inc. | Power Systems and Simulation

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Outline

Graphical Modeling and Runtime Environment
- Historical Perspective
- Today’s Environment
- Demonstration (Model Runtime)
- Graphical Models in Instructor Station
- Demonstration (Instructor Station)
- Conclusions
1980s

> Majority of plant modeling with FORTRAN

> Real problems faced by vendors and customers in 1980s

> Customers saw projects suffer from significant schedule delays
  – Acquired extremely complex software, often unreadable, depth of simulation not uniform and very difficult to maintain

> Vendors suffered from cost and schedule overruns
  – Schedules were so long → suffered from staff turnover
  – When a modeler left, code often considered hard to read → new modeler started over from scratch
  – No way of enforcing uniformity in depth of simulation or quality of coding—even though standard models available
  – Even if “standard” model was used, subsequent changes could seriously alter model’s performance

> Late 1980s: L3Harris (then part of CAE) started developing standardized, graphical approach to modeling

> Design rules (not guidelines) were established
Design Rules (Late-1980s)

1. Depth of simulation for any model had to be 100% independent of modeler
2. Details of plant model had to be 100% visible to anyone who looked at plant model
3. Model development and execution had to be completely graphical
4. Graphical models had to be 100% compatible with any other models generated manually
5. Developing, integrating and testing graphical models had to be at least 50% faster
6. Resulting product had to look and be overwhelmingly superior to anything else on market
1991-1992

Launched ROSE® (Real-time Object-based Simulation and runtime Environment) in 1991 at SCS Conference (New Orleans, LA)

- “You guys are crazy”
- Included ability to configure and run Homogeneous 2-phase Hydraulic, Electrical and I&C models in a single modeling tool
- Added Non-homogeneous 2-phase Hydraulic and Containment models later (1999, 2001)

Early Adopters of ROSE®

- First overseas sale awarded in 1991: Pyeongtaek LNG terminal (S. Korea)
- First major nuclear simulator upgrade awarded in 1991: San Onofre 2,3 PWR plant simulator (USA)
- First full-scale fossil simulators awarded in 1991: Moneypoint 2 (coal-fired) and Poolbeg 3 (oil and gas-fired) (Ireland)
- First full-scale nuclear simulator model replacement awarded in 1992: South Texas Project PWR (USA)
1991-1992

> Early Recognition
  – SCS Distinguished Professional Achievement Award given to Les White (then Director of Software Engineering) in Reno, NV (1992)
  – For significant achievement/contribution of singular value that ROSE® made to simulation industry

> Foundation for Success
  – Business line experienced significant growth
  – Yesterday’s ROSE® become today’s Orchid® Modeling Environment
  – Commitment to and investments in innovation never stopped
  – Customers on 5 continents (BWR, PWR, PHWR, GCR, MSR, LNG, Coal, O&G, GT, CCGT)
Typical Nuclear Plant Simulator Modeled with Two Tools

**Orchid®**

*Core Builder*

> Visual Core Model Development → Comet Plus™: full 3-dimensional, 2 energy group, neutronics model using Nodal Expansion Method; design and offline calculations

**Orchid®**

*Modeling Environment*

> Graphical Drag-Drop-Connect → Non-homogenous, 2-phase models a.k.a. ANTHEM™ (SGs, Cooling Systems), Room models (Containment, Reactor Buildings), Homogeneous, 2-phase models (Primary Auxiliaries, BOP), Electrical and I&C models, and interfaces to external systems

**FIRST PRINCIPLES, HIGH-FIDELITY PLANT MODELING WITH ORCHID®**
Graphical Models for the Whole Simulator Lifecycle

Development

Testing/Validation

Runtime/Maintenance

Today’s Focus
Orchid® Models Stay in Synch with Plant Data

Document Management System

Plant Documents *synchronized* with Simulation Models

Simulation Models *synchronized* with Plant Documents

Plant System Models (Orchid®)

Build, Integrate, Test

Runtime

Fully Integrated, Interactive Visual Simulation of Whole Plant

Used for Verification & Validation + Operator Training
Model Design, Development, Testing

- Mature multi-discipline object libraries
- Development environment for all model types [except neutronics]
- Libraries/objects can be modified and maintained by end-users
- Documentation for each object and plant system generated on-the-fly

Drag & Drop

Connect

Calibrate
Distributed Development and Testing

> Designed for collaborative development
> Purpose-built configuration control features
  – Versioning of all configuration items (schematics, libraries, files, simulator configurations)
  – Configuration baselines and baseline locking
  – Change tracking
  – Check-in/Check-out source control
> Multiple users can work on and test versions of the same sources concurrently
  – At company or remotely (VPN, cloud)
Document Management and Bug Tracking

> Document Management System (DMS)
  – OpenKM provided for DMS, integrated with Orchid® Modeling Environment
  – Provides direct access to documents in DMS from Orchid® Modeling Environment
  – P&IDs, equipment specifications, plant operating procedures, etc.

> Deficiencies Tracking
  – Mantis Bug Tracker (MantisBT) for change requests (CRs), integrated with Orchid® Modeling Environment
  – Configuration Management feature enforces assigned CRs to be linked with work/tasks
  – Orchid® Modeling Environment work/task information automatically pushed to MantisBT for associated CR
Important Version Control Feature

> Compare Feature
  – From previous version (e.g. validated) to current (e.g. in work) version, never get lost
  – Visual comparison for different versions of workspaces, configurations, libraries, schematics and files
> Single environment for all model types incl.
  – Single phase and homogenous two-phase thermal-hydraulics
  – Non-homogenous, non-equilibrium thermal-hydraulics (ANTHEM™)
  – Instrumentation and control
  – Electrical generation, distribution and logic
  – Nuclear Containment
  – Connection to conventional models, external systems and other applications
Model Runtime Viewing and Manipulation (2)

- Visual dynamics (e.g. colors, shapes, etc.) based on system/component statuses
- Engineering readouts (e.g. pressure, temperature, current, voltage, etc.)
  - All simulator variables can be monitored
  - Resizable/Floating Data Logger Windows
  - Constants, calibrations, instructor controls or any other simulator variable can also be changed on-the-fly
- User defined real-time plotting
ANTHEM™ within Orchid® Modeling Environment

> ANTHEM™: Advanced Thermal-Hydraulic Model - graphically configured and tested in Orchid® Modeling Environment for any plant configuration

> Used for Nuclear Steam Supply Systems

> Two-phase, non-equilibrium, non-homogeneous (drift flux) model

> Accurately simulates
  - Normal and abnormal plant conditions
  - Major transients such as steam line breaks, loss of feedwater, tube leaks, load rejection and turbine trips
  - Draining, filling and venting, as well as nuclear plant mid-loop operations

> Features
  - Extensive nodalization
  - Multi-nodal fuel model
  - Extensive heat transfer package
  - Semi implicit numerical scheme
  - Large installed base

> Salts included; experience with high-temperature gas-cooled plants
Seamless Plant Navigation

> Not OK to remember system schematic names and fish for them
> Not OK for systems to be connected by computer scientists
> All interfaces and connections must be transparent to users
> Must be simple to navigate from one system to the next
  – Regardless of model class
> Important “connectors” in Orchid® Modeling Environment

> Off-page connectors (“offcons”) allow all systems to be connected graphically (process, electrical, I&C)

> Additional interface objects to facilitate connections between process models (ANTHEM™, homogenous hydraulic models and Containment)
Demonstration

> Integrated Plant Models in Orchid® Modeling Environment
  – 2-loop CE PWR
Graphical Models Accessible in Instructor Station

> Orchid® Modeling Environment runtime graphics also available from Orchid® Instructor Station
VIDEO IN SOURCE PRESENTATION
Conclusions

> Launched in 1991 as ROSE® - now Orchid® Modeling Environment

> Broad user base (simulation + control system design) – Power, Naval, Space

> Continued investment in unified simulation and development environment for more than 30 years

> L3Harris power plant simulators (full scope and incremental upgrades) since 1991 built with Orchid® Modeling Environment

> Programming knowledge not needed → skills needed: understanding processes/systems

> Most extensive object (plant components) libraries

> Highly intuitive, integrated and navigable plant systems

> Easy-to-use and easy-to-modify environment for end-users