GPS System Simulation Methodology

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Talk Outline

Background
GPS Methodology Overview
Graphical User Interface
Current models
Application to Space Nuclear Power/Propulsion
Interfacing requirements

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History

- SALT (system analysis language translator) - Early 80's
  - PL/I code for IBM mainframes
  - Moved to multiple platforms and languages (C, C++)
  - Batch oriented - translate, compile, run
  - Used model and property libraries
  - Optimizations and system analysis

Applied to
- Open-cycle and liquid-metal MHD systems
- Fuel cells
- Ocean thermal energy conversion
- Municipal solid waste processing
- Fusion
- Breeder reactors
- Geothermal and solar energy systems

Next Generation Implementation - GPS

- Designed for modern workstation environments
- Developed in C++, moved to C for greater portability
- Steady-state & dynamic model libraries concept of SALT, but accessed as class objects
- Complete, extensible, object-oriented control language with numerous procedures for optimizations, equations solving, system constraints, parametric analysis
- Language interpreted, but uses compiled, fully optimized models and math procedures ==>
  - Fast prototyping cycles
  - On-the-fly creation of interaction with simulations
  - Simulation systems can be interrupted, queried and changed, then resumed
Simulation/Modeling Approach

GPS Operators

- 86 built-in operators
- I/O functions (fopen, printf, scanf, sprintf)
- Math functions (atan2, pow, exp, max, ln, log10)
- Numerical procedures (vary, cons, icons, mini, diff)
- Looping and flow control
  
  cond [...] if
  cond [...] [...] ifelse
  start inc bound [...] for
  count [...] repeat
  [...] loop
  [cond] [...] while
**Miscellaneous Operators**

- Allocate new model class instance - `cdef` 
  `/pump1 {pump : /param1 12.0 /param2 0.495} cdef`
- Set a debug level (0 thru 5) - `debug`
- Run gps simulation from an input file - `run` 
  "input.fil" run
- Interrupt simulation to permit queries/interactions 
  `sintrp` (followed by `resume` to continue)

**GPS Steady-State Power System Models**

**Basic component models**
- gas - gas flow initiator
- sp - gas flow splitter
- mx - gas flow mixer
- ht - gas flow heater/cooler
- hx - gas flow heat exchanger
- cp - compressor
- gt - gas turbine
- pump - pump
- dt - diffuser
- nz - nozzle
- power - calculate system powers

**Basic thermionic models**
- reac - reactor model
- ti - thermionic converter
- rad - thermal radiator
- sp - power flow splitter
- res - electrical resistor
- bc - boost converter
- bus - electrical bus
- mass - mass calculations

**More sophisticated models**
- therm - thermal flow initiator
- hprad - heat pipe radiator
- tds - thermionic diode subsystem
- shx - simple, multinode heat exchanger
- nhx - multinode, general purpose HT model
Phillips Lab Simulation Strategy
NP-TIM-92 1139 NEP: Systems Modeling
Advantages as Integrating Environment

- Consistent user interface to models
- Diverse models can be combined for use in arbitrarily complex systems
- Suite of GPS system analysis capabilities (sweeps, optimizations) and numerical methods/properties available to models
- Interface definitions external to models =>
  - can adapt models developed independent of GPS
  - can use proprietary models available only as object code
  - models used with GPS can still be run in native mode
Interfacing Considerations

- Component models can be Fortran, C, or other Sun languages which generate linkable object code.
- Standalone codes must be structured as subroutines with argument list of variables/parameters that must be known to GPS system.
- Use of Fortran common blocks prevents (presently) having multiple instances of that model in a system.
- Because models may be cycled through numerous convergence iterations with perturbed input flows.

Models must be true functions of their inputs.
Models must be reasonably robust.
I/O routines should be moved outside computation routines.

Converting a standalone code

- Two step process:
  Convert code to one or more subroutines.
  Create a interface definition file (IDEF).
- GPS uses IDEF to generate small C code to handle interfaces.
- Model can still be run independently of gps (standalone) by writing a main program to call subroutine.
Interface Specification File Format

Interface specifications external to models

- User-prepared ASCII file used by GPS preprocessor to generate C stub code to handle gsp interfacing
  - Model name
  - Variable types and initial values (arguments + gsp I/O)
  - Entry procedures (name, arguments if Fortran routine, in and out flow variables)
  - Print variables (used as default gsp output)

Example Conversion

Fortran Standalone code - TDS

- 8400 lines of Fortran code (includes TECMDL)
- Required 32 line interface definition file
- Conversion completed in < 2 hrs.
- Same model now runs standalone (called from main) or in gps environment
- Both open (once through) and closed systems have been run in gps
- Have successfully run problems with 250,000 nonlinear constraints in nested loops