Réseau de transport d'électricité

Numerical Libraries: RTE experience and perspective

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Outline

- Motivation
- Experience
  - ✓Time Domain Simulation
  - ✓Optimization
- Perspective

Motivation: RTE (French TSO)

- Our Missions: operating, maintaining and developing the high and extra high voltage network.
  - ✓ Guaranteeing the reliability and proper operation of the power network at the minimal cost

- RTE makes decisions, using simulation and optimization software based on power system network modeling. We want:
  - ✓ To have a full knowledge on how the system is modeled
  - ✓ To understand how the associated mathematical equations are solved.
    - Utilization of "as generic as possible" solvers *(no dedicated tricks for power sytems)*

⇒ RTE is developing its own software since decades

- In the past, we developed everything including low level solvers:
  - ✓ sparse linear solver *(critical for most of our applications)*

Experience in Time Domain Simulation

- We are the developers of EUROSTAG jointly with Tractebel Engineering

- The PEGASE project, www.fp7-pegase.eu, (European Project). Review of all numerical methods to speed up the simulation of very large system (Pan European Grid): around 125 000 state variables.
  - ✓ for sparse linear solvers: we tested most of the existing numerical libraries:
    - Direct and Iterative Methods, Sequential or Parallel implementation
    - we found that KLU was the best method, it seems that our system is too small (only 125000 sv) to be solved efficiently with parallel sparse linear solvers
  - ✓ KLU is now used in the new release of EUROSTAG instead of our home made historical LU solver.
- In this project, we also develop a prototype using a generic DAE solver (SUNDIALS/IDA).
  - ✓ The results were very promising and we are starting a collaboration with LLNL.
  - ✓ Main advantage: accuracy (management of switching)

Experience in Optimization

- Mixed Integer Linear programming (MILP): DCOPF / UC
  - ✓ We still have a home made solver in our operational tools but we benchmark it against commercial solvers: CPLEX, FICO Xpress.
    - The home made solution gives good results
  - ✓ "Open source" solutions are not yet competitive and commercial solvers are quite expensive (deployment in a data center: 40 servers)
- Non Linear Programming (NLP): ACOPF
  - ✓ We still have a home made solver: Interior point Method in some of our applications,
  - ✓ But we are using more and more KNITRO (ZIENA):
    - For Mixed Integer Non Linear Programming for large systems: we found that a MPEC formulation with KNITRO is currently the only viable alternative
  - ✓ We investigated ideas around Automatic Differentiation:
    - we tested intensively ADOL-C in a collaboration with the developers (*Jacobian Ok but Hessian too computational expensive)*
    - AMPL reaches incredible performances in AD for the HESSIAN
    - We have now operational applications using AMPL

Perspective

- Promote «open» solutions:
  - ✓ Clear separation between modeler and solver
    - Standard interface between modeler and solver
  - ✓ "Open" modeling
    - Possibility to see all the equations *(non hidden tricks modifying the problem to solve it)*
    - MODELICA, AMPL, …
  - ✓ as generic as possible solvers
    - not dedicated methods:
    - Utilization of the best solvers from applied mathematics
- Utilization of HPC: (typically 1000 servers with 16 cores)
  - ✓ barriers due to licensing policies of some commercial products