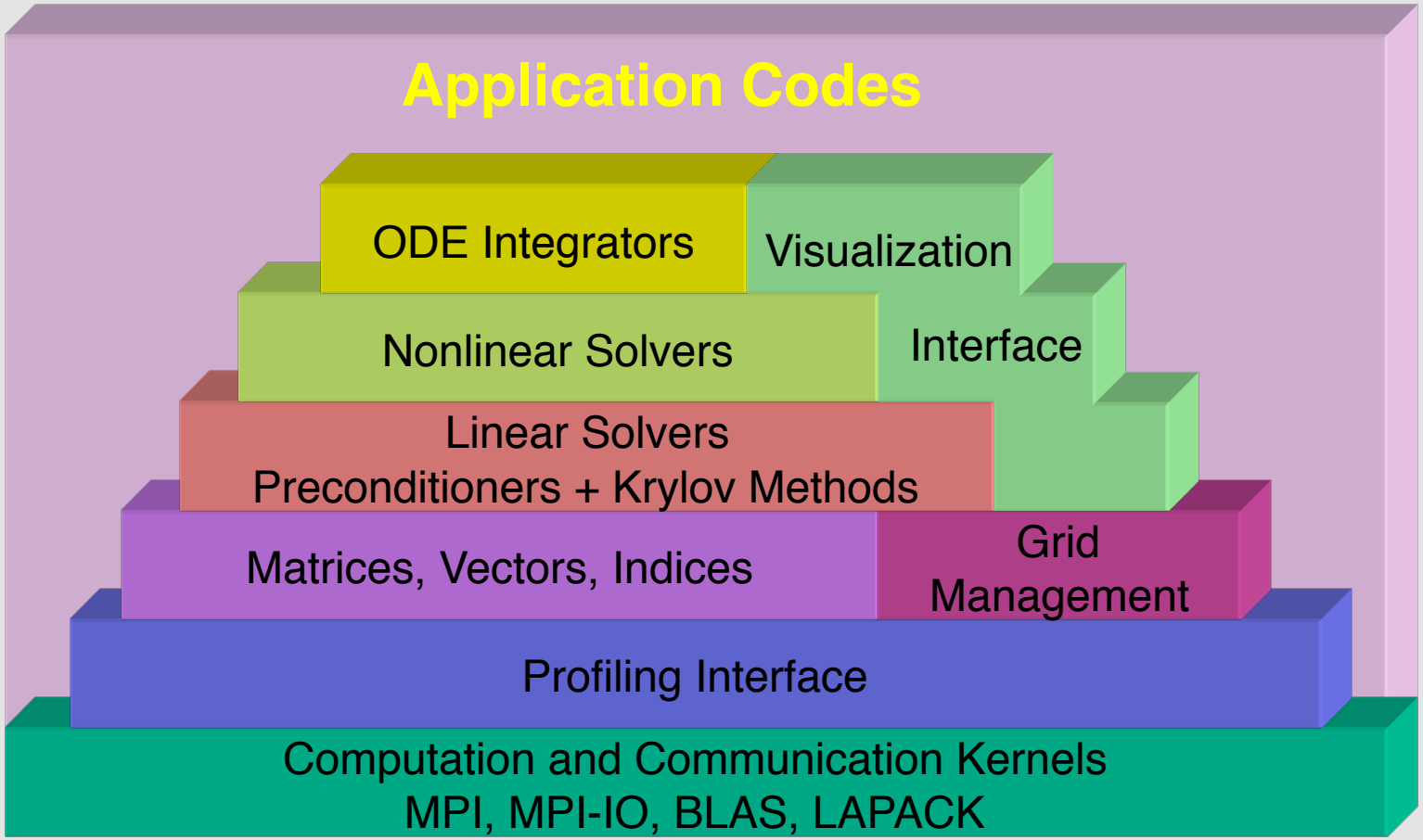
Introduction to PETSc

Scalable ODE and DAE Solvers: TS

Fall, 2010

Level of Abstraction

Portable Extensible Toolkit for Scientific computation



PETSc Structure

Scalable ODE and DAE Solvers (TS)

- Application code interface
- Choosing the solver
- Setting algorithmic options
- Viewing the solver
- Determining and monitoring convergence
- Matrix-free solvers
- User-defined customizations

Time-Dependent Problems:

$Ut = F(U,t), \quad U(t0)$: given

User provides:

- Code to evaluate *F(U,t)*
- Code to evaluate Jacobian of *F(U,t)* (optional)
  - or use sparse finite difference approximation

Scalable ODE and DAE Solvers (TS)

- Explicit methods
  - Euler, Runge-Kutta
- Implicit methods
  - Backward Euler, Crank-Nicolson, etc
- Differential algebraic equations (petsc-dev):

  $F(t,U,dU) = 0,\ U(t0) = U0$
- Interface to Sundials's CVODE
  - https://computation.llnl.gov/casc/sundials
  - Configure with '--download-sundials'
  - Run application with '-ts_type sundials'
- Solving steady-state problems with pseudo-timestepping
- Can customize all phases of solution process

TS: Basic Usage

```
TSCreate(comm,&ts);
TSSetProblemType(ts,TS_NONLINEAR);
TSSetType(ts,TSBEULER);
TSSetRHSFunction(ts,RHSFunc,&userctx);
TSSetRHSJacobian(ts,J,Jpre,TSDefaultComputeJacobian,&uerctx);
TSSetInitialTimeStep(ts,t0,dt);
TSSetSolution(ts,u);
TSSetDuration(ts,time_steps_max,time_total_max);
TSSetFromOptions(ts);

TSStep(ts,&steps,&ftime);

TSDestroy(ts);
```

Time step options ----------

- -ts_max_steps <1>: Maximum number of time steps (TSSetDuration)
- -ts_max_time <1>: Time to run to (TSSetDuration)
- -ts_init_time <0>: Initial time (TSSetInitialTime)
- -ts_dt <0.0001>: Initial time step (TSSetInitialTimeStep)
- -ts_monitor <stdout>: Monitor timestep size (TSMonitorDefault)
- -ts_monitor_draw: <FALSE> Monitor timestep size graphically (TSMonitorLG)
- -ts_monitor_solution: <FALSE> Monitor solution graphically (TSMonitorSolution)
- -ts_type <beuler>: TS method (one of)
  euler beuler cn pseudo gl ssp theta alpha, sundials rk (TSSetType)

And many more options...

Example:
~petsc/src/ts/examples/tutorials/ex7.c