DDDAS Workshop

WG 1

Ed Seidel and Alok Chaturvedi

- Not finished answering questions!
- Introductions
  - Applications amazingly diverse!
    - Physical systems: astro, chem
    - Engineering: cfd, phones, power, imaging
    - Environmental systems: marine, ecology
    - Biological systems
    - Economic systems: business
    - Social/Political/Historical: archeology ...
  - Compute classes
    - pc's: small amount of comp
    - clusters: moderate, many jobs
    - supercomputers: model reduction critical

Application Examples

- Turbulence
- Modeling biological system – small to large scale protein
- Environmental fluid mechanics, porous media flow
- Problem solving environment
- Imaged based analysis
- Near real time critical events assessment
- Spatial optimization model
- Global change
- Anomalous behaviors
- Multiple hypotheses
- Automated shop floor to high level decision
- Chemical reaction modeling
- Inverting chemical networks to big chemical networks
- Computational electromagnetics
- Distributed software integration
- Remote instrumentation
- Sense making
- Non time-contiguous data
- Model, data, and simulation integration
- Agent based model of household vis-s-vis landscape
- Revenue modeling
- Supply chain and logistics

Classes of applications

- Many diverse disciplines, but:
  - Model predicts future, data stream coming in, adjust model, repeat quite common
- Self organization of:
  - Application component
  - Measurement system
- Tiered
- Plurality of models
- “Get human out of loop”, “Human needs to check”, “human part of loop”…expert systems important
- More work on this…

Data

- All groups very worried about data!
  - how to distill all info to something on which decisions can be made
  - data streams, changing with time!
  - viz (human in loop), algorithms (computer in loop)
  - state estimator: how to do this?
    - reduction, noise, multiple states, etc
    - what is interface between data and computation?
  - error tracking, confidence in fitting to models of real data, need to be more rigorous

What do apps groups struggle with? What is needed?

- Data!
  - standards not clear, not clear if we should focus discussion on this
  - streams, size of data: but is it really too big?
  - Metadata not discussed, but important
- Algorithms
  - how to find all modes in multimode system? need to find correct state
  - cannot solve scale of problem: need model reductions
- Surely some common tools will develop, but not clear what they will be
- Policies and support at centers for DDDAS

- Dynamic validation!! Both data and models
  - Strongly and weakly constrained systems
  - General framework for validation needed
    - Specifics may all be different depending on app
    - Framework for making decisions
    - There is a lot of development already…need to understand how well it could apply
    - How to assimilate data
- These are all forms of inverse problems
  - How does dddas make this different?
- Metamodels, model management

Next steps

- Answer questions more clearly
- Try to give feedback to other groups
- Are there questions the other groups want to pose to apps?
- We would like to have a workshop on tools and techniques for DDDAS apps

What Opportunities & Challenges in enabling DDDAS?

- Creating vs using dddas
  - Adaptive dddas
- Challenges: what does not work well
  - Current tools…
    - need a tool to refine coarseness
  - Data too simple for the models, or data too complex for the models, observability/identifiability…ties to measurement groups
  - Do our models allow us to identify key features
  - Model discovery: how to get the right model from a plurality to be active? Impedance (mis)match between data and model
    - There are more useful models than current: how to identify
    - How to construct appropriate models that don't exist
  - Application software, steering interfaces, guidance, toolkits for writing new codes, forces scientists to think about these issues as codes are designed
  - Identifying users, providing interfaces for them

New Apps

- Traffic routing and environment
- Still design experiments by hand for small amounts of data…scale up, can computer suggest experiment: e.g., bio
- Operation of wholesale power markets
- Education & training
  - Computer models what student knows, challenge student, refine model
- Anywhere that new data streams are created…opportunity: every possible discipline
- Sentient world sims:
- Solid earth systems: e.g., earthscope

What are Current Research & Technologies in our projects?

- Grids and related technologies
  - Middleware…dddas special requirements, often discipline specific
- Adaptive computation, changing algorithm based on data
- “service oriented architectures”
  - Services, agents, etc: use of this
- Model autocalibration…tuning to real data
- Toolkits for dddas apps are being used
- Debuggers, profilers, etc all need to work in this environment
- New Research issues: tightly constrained systems, estimating parameters, search applications and combining identifiability

Example apps to benefit from DDDAS?

Challenges: multilevel, multimodal models, composition of complex apps, model coupling

- On demand scaling
- ROM's: tuning them for different scales
- Algorithms that adapt according to data:
  - Gauge conditions…analogies to others
- Middleware to support these issues
- Model equivalence as scales and models change

Challenges: data management, interfaces to data/experiment

- Synergies between different data sources, model data, experiments…the metadata issue
- Some systems are not controllable, some are…different issues
  - Controllable: optimal design of experiment
- Challenges in location and time of data and model output
- Data so large, can't be stored…how to discard, and how to reconstruct discarded data? This point was missed this AM

Challenges: computation, memory, I/O requirements

- Yes, including knowing how they develop and change during a dddas process
  - Predicting what will be needed soon
  - Understanding bandwidth between systems based on model coupling
  - Model adaption based on resource availability
  - Access to on-demand computing needs to be provided
- Heterogeneity of grids
  - Driving middleware apps
- QoS issues

Needed Modeling Technology Advancements, Systems Support?

- Toolkits for creating new apps
- Event driven support at system and scheduling software level
- Semantic composition of dddas apps
- Workflow, etc
- Theory issues to be addressed to deal with all this
  - Recent events show this: tsunami, hurricanes, WTC

Dynamic Data Management

General points

- Interdisciplinary needs, international, interagency cooperation
  - Discuss central and generic nature of dddas; table would be first step…just collecting info
  - Applications require cooperation of other parts of nsf and other agencies: make this point. E.g., can't do medical w/o dddas
  - Cooperation within nsf divisions: engineering, mps, etc
  - Some agencies (e.g. Navy) require formal correctness tools, strong operational support
  - Requirements/spec steps important
- Strong executive summary
- High level points and recommendations needed
- Workshops…

Dynamic Application Selection

Dynamic Configuration Management

DDDAS - Why now?

DDDAS - Broader Impact