Twinkle, Twinkle Data the Real Star
How I Wonder Where You Are
(And how good are you and where you should go?)

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(sheesh)

In cooperation with Anthony Vodacek, Guan Qin, Robert Lodder,
and Mauricio Kritz in particular
plus all of the *workshop* speakers and participants

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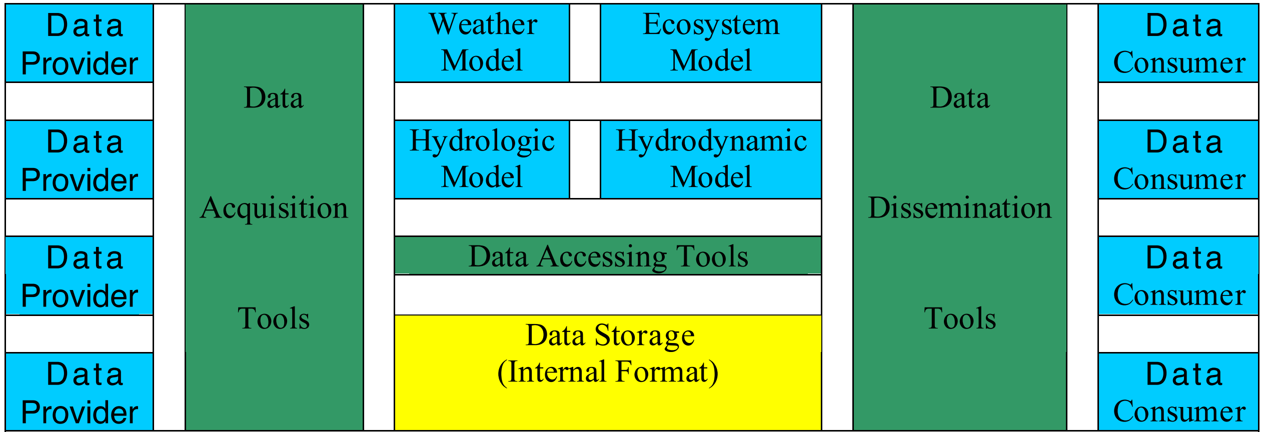
Typical DDDAS



Schematic showing connection of components via data tools, models, and sensors.

DDDAS Entails the Ability to

- dynamically incorporate data into an executing application and involves the ability of the application to dynamically steer the measurement process.
  - Such capabilities promise more accurate analysis and prediction, more effective measurements, more precise controls, and more reliable outcomes.
  - Incorporation of dynamic inputs offers the promise of computational models that more accurately describe real-world complex systems.
    - Enables the development of applications that intelligently adapt to evolving conditions and that infer new knowledge in ways that are not predetermined by initialization parameters or static data.

Data Center

- Data acquisition tools process the incoming data
  - Retrieval: from sensors or force sensors to produce
  - Extraction of useful data from large inputs
  - Conversion to a common set of internal formats
  - Quality control is especially important since it allows rejection of data, recollection while it is still inexpensive, and determination of relative errors
  - Store data if it is needed again later
  - Notify applications that need the data for running processes or continue simulations that need new data
- Security has to be maintained throughout the entire process.

Multidisciplinary Research at Multiple Sites and Different Employers

- Data sets are typically owned by a particular site, who stores it in some format, and keeps it…
  - public on a web site: Access is easy unless there are unacceptable legal restrictions placed on the data's use.
  - private: Access is problematic to the rest of the partners.
  - pay per view: expensive and not practical for most academics unless a government agency pays the expenses over a long time with unlimited viewing.
  - in between: Access may be inconsistent. Worst of all possibilities and most common. Legal limbo.

Most Important Parts of Cooperative Modeling

- Access to the data.
  - Ability to access the data over long periods of time, even if the incoming and outgoing formats change over time.
- Adapt to personnel changes over time.
  - Team must get along instead of constant battles.
    - Death to jihadist big egotists who claim credit for everything and stab in the back their colleagues.
- Adapt to changing computational methods, models, and locations/types of computers.

Data Formats

- In the U.S., NASA keeps a data center just for water quality and analysis of estuaries.
  - There are ~1000 contributors (nightly). There are ~1000 formats.
  - NASA converts all incoming data to a common format for storage. It can deliver the data back to users in any of the ~1000 formats.
- In many academic data collections, the formats change with every new graduate student.
- Interoperability is essential.

Computing Platforms of Interest to Us

- Laptops
- PC's
- Clusters and SMPs
  - Small, large, and Amazon-scale forests of boxes
- Hybrids
  - GP GPUs (i.e., with 32 and 64 bit IEEE arithmetic)
  - Roadrunner-like atrocities

Data Sources of Interest to Us

- MODIS
- NOOA and NASA
- U.S. Forest Service
- World meteorological organization
- ???

General Purpose Data

- Climate, atmospheric, ocean, weather, …
- Chemical species, temperature, solar absorbtion, …
- Size and/or quantity
- Movement (or flow) rates and directions
- Quality of data
- ???

Sensor Types of Interest to Us

- Imaging
  - Satellite, airplane, on ground, in or under water
  - (Hyperspectral) spectrometer
    - Various infrared waves (short–long and targeted ones)
  - Visible, ultraviolet, …
- Chemical measurements
  - From satellite, air, water, ground, …
- Physical and biological measurements
  - Tree trunk diameter, …
- Rovers with sensors
- Integrated sensing and processing (ISP)
- Nanosensors

Sensor Placement and Quantity of Interest to Us

- Optimize number and location of sensors
  - Too many cause stability problems, too few cayse accuracy problems
  - Dynamic quantity and locations
- Allow sensors to move through changes in the environment (e.g., tree growth)

Sensor Communications

- Via satellite from a planet
- Wired or wireless
  - IP style: WiFi and IPOR (over radio)
  - Specialized transmission (from Mars)
  - Radar
- Cell phone
- Sneakernet
- Hybrid: network of the sensors that communicate with some other method to the world

Powering the Sensors

- Standard electrical methods
  - Nearby power station
  - Solar
  - Water
- Flow of some media
  - For nanobugs underground?

How Do We Construct a *Virtual* Data Center for Cooperative Research?

- Internal data storage
  - U.S. has one metadata format: Federal geographic data committee (FGDC.gov)
  - LBA's format
  - NASA format
  - HDF
- Getting access
  - Brazil: Amazonal
  - U.S.: Soil moisture, water quality

How Do We Construct a *Virtual* Data Center for Cooperative Research?

- Statistics
  - What to do with missing or awful data
  - Ecology: pattern based modeling (confirm model and data to control errors)
  - "Data without knowing the error in it is worthless."
  - How to measure and store information about things
- Data clearinghouse concept
  - Combine with metadata to find data reliably

How Do We Construct a *Virtual* Data Center for Cooperative Research?

- Geographic simplification
  - Start with *one* area, e.g., Amazonal region
  - Maybe two areas, but not more until at least one works

Summary of Speaker Sensor Types

Raw Notes

Types of Sensors (by speaker)

- Darema
  - Too many to count with 60 application areas funded through grant agencies
- Vodacek
  - Imaging spectrometer (airplane): visual and SWIR+MWIR+LWIR
  - Satellite Worldview-2, 8 spectral bands, 800 MB/picture, 500 GB/orbit
- Almiron
  - Small ISP with wireless communication

Types of Sensors (by speaker)

- Mandel
  - visual and SWIR+MWIR+LWIR and on ground temperature+chemical species and weather stations
- Costas
  - Measurements taken by hand (tree circumference) and satellite data and climate data (real-time)
- Qin
  - In well sensors cable connected and nanobugs

Types of Sensors (by speaker)

- Barbosa
  - MRIW imaging spectrometer and hyperspectral imager, currently in situ, but will be automated.
  - Radar images
  - Buoys with sensors and communication to INPE through satellites with hourly data - data public
- da Silva Dias
  - Airplane and ground photos, chemical (aerosol, CO_2, CO, $PM_{2.5}$, NO, NO_2, O_3) sensors
  - LWR+SRR
  - Africa ⟷ South America interaction
  - Photochemistry (ozone)

Types of Sensors (by speaker)

- Dias
  - Current meters in situ
- Yamasoe
  - PAR sensors on 65m towers above canopy with sensors at 47m
- Efendiev
  - Well sensors (measure pressure and the total flow of oil/gas) and satellite imaging, soil moisture sensors

Types of Sensors (by speaker)

- Campos
  - Satellite images and sensors on buoys, wharfs, etc. and standard ROMS style data collectors
- Kritz
  - Satellite images, canopy level sensors
- Lodder
  - Hyperspectral sensors, IR, and Mars style rover and SSSI with ISP

Types of Sensors (by speaker)

- Carbonel
  - Wind driven forcing function - buoys or satellite data should be suffcient
- Douglas
  - Summary of all speakers' types (hopefully)