Dynamic Data Driven Application Systems
(Symbiotic Measurement & Simulation Systems)
“A new paradigm for application simulations and
a new paradigm for measurement systems”

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Dynamic Data Driven Application Systems, are:

- New paradigm for application simulations, where
  - the applications can accept and respond dynamically to new data injected at execution time,
  and reversely
- New measurement methods, where
  - the application systems will have the ability to dynamically control the measurement processes
- The synergistic and symbiotic feedback control-loop between simulations and measurements can open new domains in the capabilities of simulations with high potential pay-off
- Will create applications with new and enhanced analysis and prediction capabilities
- Will create a new methodology for more efficient and effective measurement process.
- Great potential to transform the way science and engineering are done, and induce a major impact on manufacturing, commerce, transportation, hazard prediction/management, and medicine

Darema
New Paradigm

OLD
(serialized and static)

NEW
(Dynamic Data-Driven Simulation Systems)

Challenges:
Application Simulations Development
Algorithms
Computing Systems Support
Examples of Applications benefiting from the new paradigm

- **Engineering (Design and Control)**
  - aircraft design
  - oil exploration
  - semiconductor mfg
  - computing systems hardware and software design
    (performance engineering)

- **Crisis Management**
  - transportation systems (planning, accident response)
  - weather, hurricanes/tornadoes, floods
  - fire propagation

- **Medical**
  - customized radiation treatment, x-rays, NMR, surgery, etc
  - epidemics

- **Manufacturing/Business/Finance**
  - Supply Chain (Production Planning and Control)
  - Financial Trading (Stock Mkt, Portfolio Analysis)
Examples of Technology Challenges

- **Application development**
  - interfaces of applications with measurement systems
  - dynamically select appropriate application components
  - ability to switch to different algorithms/components depending on streamed data

- **Algorithms**
  - tolerant to perturbations of dynamic input data
  - handling data uncertainties

- **Systems supporting such dynamic environments**
  - performance engineering technology
  - application development and run-time support
Enabling DDDAS

Dynamic Data-Driven Application Systems
  — Symbiotic Measurement & Simulation Systems

Dynamic Compilers & Application Composition

Performance Engineering

Darema
Enabling DDDAS

Performance Engineering

Dynamic Compilers & Application Composition

Dynamic Data-Driven Application Systems
  Symbiotic Measurement & Simulation Systems

Darema
Distributed Systems Software/Hardware Architectural Framework

- Distributed Applications
  - Visualization
  - Collaboration Environments
  - Scalable I/O
  - Authentication/Authorization
  - Data Management
  - Archiving/Retrieval Services
  - Dependability Services
  - Other Services...

- Distributed Systems Management
  - Distributed, Heterogeneous, Dynamic, Adaptive Computing Platforms and Networks

- Performance Engineered Design Technology
  - Languages
  - Compilers
  - Libraries
  - Tools

- Application
  - API & Runtime Services
  - Global Management
  - Computing Engine
  - Components Technology

- Memory Technology
- CPU Technology
- Device Technology
- ...

Darema
Multiple views of the system
The applications’ view
Multiple views of the system
The Operating Systems’ view
Enabling DDDAS

Dynamic Data-Driven Application Systems
- Symbiotic Measurement & Simulation Systems

Dynamic Compilers & Application Composition

Performance Engineering

Darema
New Technology for an integrated feedback and control compiling system

Dynamic Analysis Situation

Launch Application (s)

Application Model

Application Program

Application Intermediate Representation

Dynamically Link & Execute

Distributed Programming Model

Compiler Front-End

Compiler Back-End

Architecture Models

Application Components

Distributed Computing Resources

Adaptable computing Systems Infrastructure

Distributed Platform

MPP

NOW

SP
Enabling DDDAS

Dynamic Compilers & Application Composition

Dynamic Data-Driven Application Systems
  -- Symbiotic Measurement & Simulation Systems

Performance Engineering

Darema
Relevant Agency Efforts

- NSF
  - NGS: The Next Generation Software Program
    - Funds Research on Performance Engineering, and Dynamic Compilation and Application Composition Technologies for Adaptive Runtime Support
  - SES: Scalable Enterprise Systems
  - ITR: Information Technology Research
  - In addition aiming to develop a DDDAS Program:
    - “Symbiotic, integrated simulations and measurements”
      - leap-ahead initiative
      - will provide a focus for new exciting work in applications areas, algorithms and in systems’ areas
- Also DARPA, NASA, DoE interested in these programs
What about Industry

• Industry has history of both
  – forging new research and technology directions and
  – adapting and productizing technology which has demonstrated promise

• Need to strengthen the joint academe/industry research collaborations
  – joint projects / early stages

• Technology transfer
  – establish path for tech transfer from academic research to industry
  – joint projects, students, sabbaticals (academe <----- industry)

• Initiatives from the Federal Agencies / PITAC Report

• Cross-agency co-ordination

• Effort analogous to one that pushed the frontiers for VLSI, Networking, and Parallel and Scalable computing

• DDDAS impact akin to the impact of computers in the 50’s
http://www.cise.nsf.gov/eia/dddas