A Service-Oriented Approach of Integration of Computer-Aided Engineering Systems in Distributed Computing Environments

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SKIF-Aurora SUSU Supercomputer Specifications

- Ranking TOP50 CIS list: 3rd
- Ranking TOP500: 87 (June 2011)
- 117 Teraflops
- 8832 computing cores
- RAM: 9 TByte
- Disk space: Intel SSD 108 TByte

Communication networks:
- System network: 3D torus, 60 Gbit/s
- InfiniBand QDR, 40 Gbit/s
- Gigabit Ethernet
Distributed Problem-Oriented Environments
Distributed Problem-Oriented Environments

Goal:

• The principal objective is to develop a technology allowing to take into account the specifics of the problem-oriented subject areas while providing the recourses of distributed computing environments.

• This technology aimed to create “intelligent” middleware providing users with easy, transparent and secure access to distributed computing resources and allowing them to solve specific classes of applied problems.
A Problem-Oriented Environment

User

Define Parameters of Simulation

Model

Get Results of Simulation

Run the Simulation

Development

Application programmer

Grid
The Basic Definitions: Job

- **Job** defines the process of model simulation

- **Job** is a set of *Tasks* organized as a workflow aimed at achieving of a useful result.
The Basic Definitions: Tasks

- **Task** represents a solution for some part of a job

- **Task** describes the process of transformation of input parameters into output parameters

![Diagram showing the process of transformation with symbols for Template, Converter, Script, DesignModeler Service, Geometry, Input parameters, Transformation, and Output parameters.]
“Simulating Flow in a Static Mixer” Job and Tasks example

Creation or correction of a geometric model

Creation or correction of a mesh

Creation or correction of problem definition

Problem Simulation in CFX-Solver

Visualization in CFX-Post

Values of the optimization criteria are not satisfactory

The accuracy of the calculation is not satisfactory

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The Basic Definitions: Resources

- **Resource** is a hardware and software required to perform a *Task*

  - **Target system**
  - **Hardware resources**
  - **Software resources**
  - **Licenses resources**

- **CFX-Solver**
Distributed Virtual Test Bed
Distributed Virtual Test Bed (DiVTB) includes:

- an **interface** for a CAE-problem statement;
- a **driver** (a set of software tools enabling the use of grid resources for virtual experiment);
- a set of **grid services** (a set of supercomputers in a distributed computing environment, with the installed software components)
Distributed Virtual Test Bed

Features:

- Providing a safe and transparent web-access to the resources of a distributed computing environment
- User do not need to know about the distributed nature of the computing environment
- User do not need desktop application to perform simulation
CAEBEans System
CAEBeans Constructor
CAEBEans Portal
CAEBEnas Server

Diagram:

- `unicore.WSResource`
- `CAEBEnas Portal`
- `CAEBEnas Constructor`
- `WS-Client`
- `Instance`
- `Projects`
- `Executor`
- `WorkStorage`
- `ResultStorage`
- `CAEBEnas Broker`
- `UNICORE/X Site`

Relationships:

- `use` relationship between `unicore.WSResource` and `CAEBEnas Server`
- `use` relationship between `CAEBEnas Constructor` and `Projects`
- `use` relationship between `WS-Client` and `Projects`
- `use` relationship between `Executor` and `UNICORE/X Site`
- `use` relationship between `Executor` and `ResultStorage`
CAEBBeans Broker

- CAEBBeans Server
  - Core
  - Estimator
  - Collector
  - Scheduler
  - Catalog
  - Brokered Workflow
  - unicare.WSResource
  - Registry
  - Target System Factory
CAEBEans Resources

- **CAE-Resources** – UNCORE/X Site with several special applications
Example: LS-Dyna CAE-Resource

<!-- LS-Dyna application -->

<idb:Application>
  <jsdl:ApplicationName>LS-Dyna</jsdl:ApplicationName>
  <jsdl:ApplicationVersion>1.0</jsdl:ApplicationVersion>
  <idb:ScriptTemplate>
    <idb:Description>
      Template for LS-Dyna Simulation Invocation.
      Fields:
      SOURCE                  source file name
      DOUBLE_PRECISION        double precision or not (y/n) (*)
      PROCESSORS             number of cores (*)
      MEMORY                 total memory (*)
      MEMORY2                memory per core (*)

      (*) - optional field, default value is provided.
    </idb:Description>
    <idb:Invocation name=""/>
    <idb:Body>![CDATA["ls-dyna.sh" +S<SOURCE> +DP<DOUBLE_PRECISION> +NP<PROCESSORS> +M<MEMORY> M2<MEMORY2>]]></idb:Body>
  </idb:ScriptTemplate>
</idb:Application>
DiVTB for practical engineering problems solution
DiVTB for common CAE-systems

- We developed DiVTB to solve problems by using common CAE systems
  - ANSYS CFX,
  - ANSYS Mechanical,
  - ABAQUS,
  - DEFORM,
  - LS-DYNA.
Vortex Flow Meter DiVTB

Fig. 1 - a sketch of a flow part

Pressure distribution in flow tube of vortex flow meter
Customer: JSC Chelyabinsk Tube-Rolling Plant

Purpose of study: simulation of tube deformation during hardening during production on tube rolling plants

Result:
- rejection rate reduced by 10%

Temperature distribution during water sprayer pipe cooling
Simulation of Deformation of Flat Knitted Products Structure

Customer: Kyshtym knitwear Ltd.

Purpose of study: development of new methods of clothes design that take into account properties of the tissue

Result:
- automation of design process
- time to design new models reduced
- product range growth
- volume of output increased by 20%
Deformation and Destruction of Fabric Bulletproof Vest by a Bullet Strike

Customer: UAB “FORT Technology”

Purpose of study: development of new body armor design

Result:
- profit margins increased from 10% to 30% due to reduction of field experiments and use of virtual prototyping
- bulletproof vests are on arms of special units of the Russian Federation and foreign countries (Germany, France, Israel, Poland, Czech Republic, etc.)
What’s next?

- Development of billing services for DiVTB
- Development of CAEBeans Constructor Web-application
- Development of scheduling algorithms for CAEBeans Broker
- Development of remote 3D-visualization services
- Integration of authorization and authentication with UNICORE services
- Integration with UNICORE workflow system
- Integration with multi-criteria optimization systems
Questions?

http://supercomputer.susu.ac.ru/en/