Application of SynfiniWay Grid Platform
for iterative LS-DYNA studies

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ABSTRACT

Whether end-users need to access local or remote systems, to use a batch system or to run jobs interactively, they will always raise the same questions: "Which system can I run my job on?" and "How do I get data to the machine where my job will execute?" Users should only need to know what applications they want to run and where the inputs for these applications are located. To answer these needs, Fujitsu markets a middleware product called SynfiniWay which hides all issues related to CPU location, and allows execution of complex applications via workflows.

The conclusion of this paper is that the SynfiniWay middleware can solve LS-DYNA iterative problems: the search for an optimal mesh size or successive LS-DYNA calculations with modified initial conditions. SynfiniWay provides an infrastructure to execute these studies automatically and transparently on remote computers (grid computing).

INTRODUCTION

The way organizations work today has changed a lot compared to some years ago. Organizations are often made of different sites having each their own compute resources and their own network security rules. Product development processes are often shared between these sites making collaborative work even more difficult. Finally, users develop more and more complex chain of tasks and they are asked to increase their knowledge in their specific engineering fields, and preferably to decrease their time spent on Infrastructure Technology (IT) activities

Today these organizations raised the following questions. How to simplify the access to all computers and storage areas and make collaborative work possible? How to offer to the users a single entry point to the global IT? How to automate the complex workflows users create in order to better utilize the computers?

To answer all these questions Fujitsu markets the SynfiniWay middleware product which was developed for one unique goal: hide the complexity of IT to give access to complex solvers (such as LS-DYNA) through a few mouse clicks.

For this paper Fujitsu Systems Europe (FSE) and CRIL Technology, distributor of LS-DYNA in France, have set up a complete SynfiniWay infrastructure in order to automatically solve two LS-DYNA cases. The infrastructure consists of three sites; CRIL Technology and FSE in Toulouse, and Paris (Fujitsu Technical Computing Facility - FTCF), linked together with SynfiniWay.

Two examples of SynfiniWay usage are shown here. The first example is an ALE model of the perforation of a shell container filled with water. The velocity versus time of the impacting sphere is computed with various values of the angle of the impact velocity. The second one uses a simple academic model of a free air burst. While this model may be very big needing large resources (obtained from the FTCF in Paris), it is easy from it to compare pressure levels to experimental data for different mesh densities.

The SynfiniWay middleware product

SynfiniWay Grid Platform is a sophisticated middleware layer that presents a global view of an organization's computer resources: servers, clusters, storage and applications. When using SynfiniWay, an organization will benefit from improved end-user productivity and more effective usage of their existing IT resources.

End users benefit because they no longer need to have extensive low level knowledge of computer systems to get their work done. Repetitive and unproductive tasks, such as interfacing to batch systems and transferring data between the various systems in an IT environment are managed directly by SynfiniWay leaving users free to work on more productive tasks.

Through virtualization of IT resources into a global virtual pool of services, SynfiniWay provides users with a uniform view of all resources from their desktop. Improved resource usage is obtained through the sharing of the global resource pool across SynfiniWay users, allowing the workload on over-utilized systems to be spread across under-utilized systems. Since global resources are used more effectively an organization will benefit from increased return on investment for their existing IT resources.
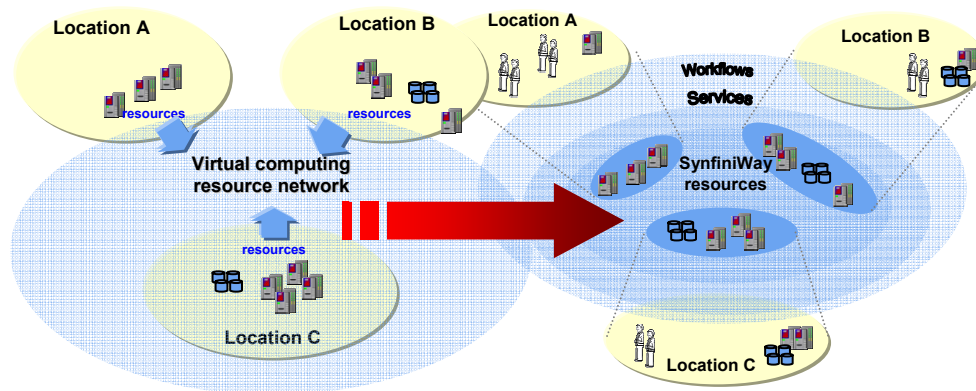
Virtualization of resources

Making grid work for you

SynfiniWay provides the mechanisms to successfully use and manage resources spread across a number of server systems regardless of their geographical location. With in-built secure connection support, organizations can be confident that even when using public networks their data is still safe and secure. With it's easy to use client interface, users will be running productive work in a matter of minutes.

Within any organization demands for compute resources change, so when your resource needs change so does the SynfiniWay grid. Server systems can be dynamically added to the grid without interruption of end-users workflows. This capability makes it easy to accommodate On-demand computing resource requests. Extra resource capacity can be employed via an ASP style usage model which can be realized using additional in-house resources or through an external ASP provider.

The simplest single view of networked resources

SynfiniWay implements a Grid oriented environment within which users obtain a uniform view of local and distributed resources. It is built on three fundamental concepts: the encapsulation of applications as services, the linking of service tasks in a workflow and the transparent implicit movement of data.

The concept of services enables complex and intricate applications, which may be located throughout a wide area network, to be accessed via a single client desktop interface. Workflows enable related service tasks to be linked together to form a single manageable unit of work. Each workflow service task can be executed anywhere in the grid where the service is available. The inherent data transfer facility automatically moves data to any specified location within the SynfiniWay grid.
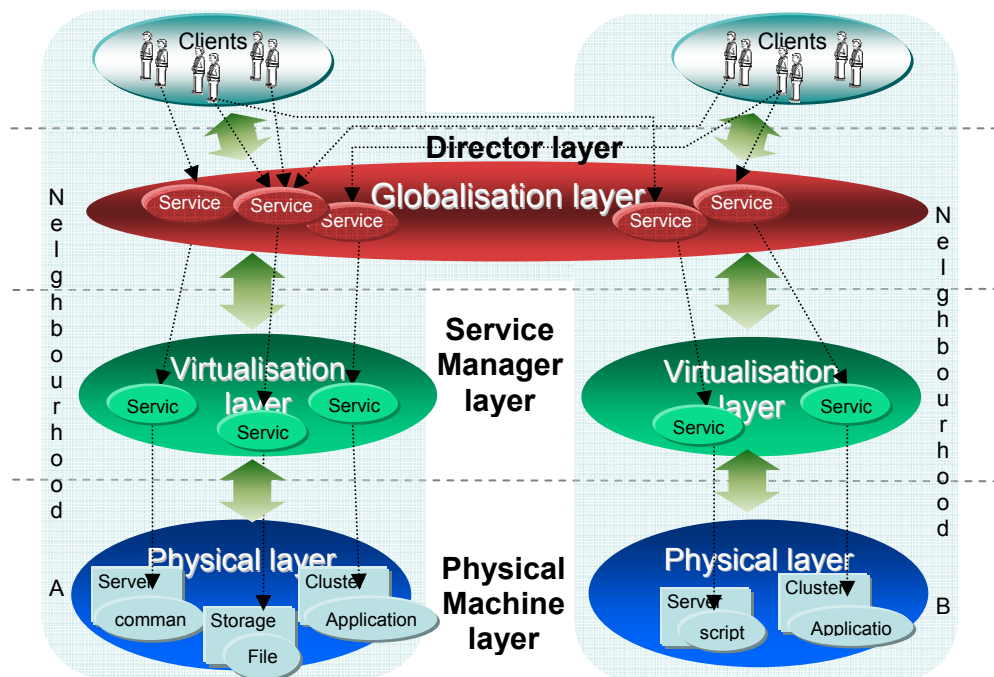
Encapsulation of applications as services

1 Set up of the SynfiniWay infrastructure

1.1   Definition of the main SynfiniWay components

Server systems

Director

- ▪ Manages user connections, user projects and data transfer request
- ▪ Provides user workspace (storage of projects, workflows and data)
- ▪ Workflow scheduling and management
- ▪ Discover available Service Managers and maintains a list of published services

Service Manager

- ▪ One required per cluster or server where services need to be used

-
- Defines the services available from this host
- Can export directories for access by users
- Interfaces to system services
- Can be dynamically added

Acquaintance Manager
- Links multiple neighbourhoods together
- Transparent propagation of service discovery mechanism
- Handles connection to all other neighbourhoods (can use unencrypted or SSL encrypted links)

Client
- Runs on the users local system (Windows, Linux, SUN Solaris, IRIX)
- Single sign-on with Graphical interface (connects to a Director)
- Interface for creation of workflows (editor)
- Interface to run, monitor, and manage workflows (users)
- Access to the user workspace
- Interface to any shared storage areas

Community
The global set of resources under the control of SynfiniWay (server systems, storage areas, clients)
Consists of one or more neighbourhoods

Neighbourhood
A distinct set of server systems with local network connection between each other
Includes at least one Service Manager

1.2   Deployment of SynfiniWay between CRIL Technology and Fujitsu

The SynfiniWay infrastructure provides to Fujitsu and CRIL Technology engineers (in Toulouse) an easy and transparent access to LS-DYNA and LS-INGRID (pre processor) installed on a Fujitsu Primepower SMP system located in Paris, in the Fujitsu Technical Computing Facility (FTCF).
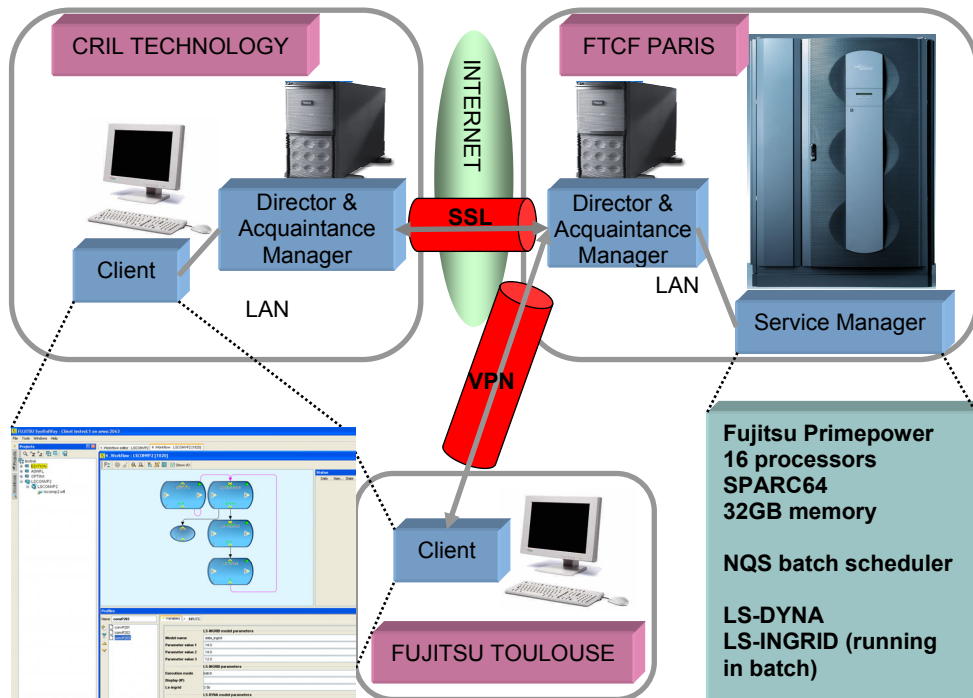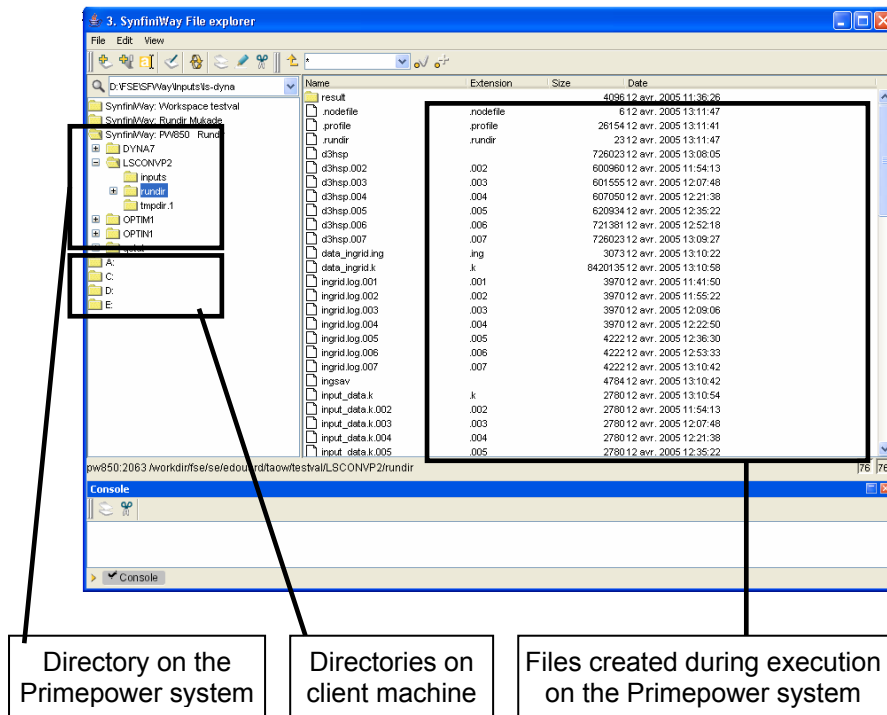
SynfiniWay infrastructure between Toulouse and Paris

Requests from the Client installed in Fujitsu Toulouse office goes to the Director based at the FTCF. A Virtual Private Network (VPN) guarantees the security during file transfer. Requests from the Client installed in CRIL Technology office connects to the Director based on the same LAN before being redirected to the Director based at the FTCF. In fact, it was initially planned to use local computers at CRIL Technology to run LS-INGRID and in such a case an extra Director is needed. An SSL encryption guarantees the security between the two Director components.

Both Clients access the same functionalities which are:
- o A global view of the working area located on the Fujitsu Primepower system from the global SynfiniWay file explorer

Directory on the Primepower system | Directories on client machine | Files created during execution on the Primepower system

Global view of the working area located on the Primepower system

- o LS-DYNA and LS-INGRID applications published as services by the Service Manager component installed on the Primepower system

These services can be usable through the workflow functionality of SynfiniWay, independently (single task) or one after each other (workflow of two tasks).

2 Iterative studies

2.1 Perforation of a shell container

2.1.1 Description

The model represents a 700 mm long and 430 mm diameter steel container filled with water, and surrounded by air. A 17 mm diameter sphere with a 2000 m/s initial speed impacts the container with an angle α from 10 to 45°. The container and the bullet are meshed with thin shell elements, the ALE material (water and air) use multi material solid element formulation. An eroding contact is defined between the bullet and the container. ALE penalty coupling is used between the shell elements and ALE elements.
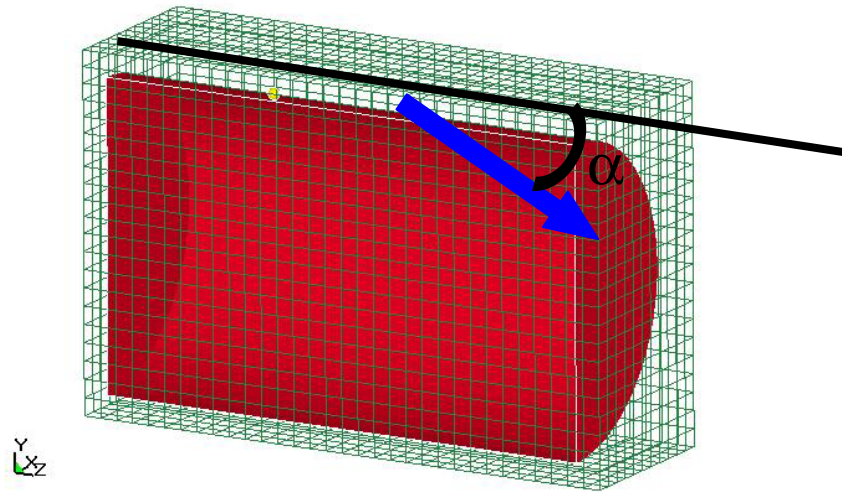
Example of coarse model

The goal of the study is to compute the velocity of the sphere for various angles α (see above figure) of the initial velocity. A loop is done using SynfiniWay: α takes a new value (the value at the previous iteration minus an increment value) if the sphere has not rebounded on the surface of the container. If it has rebounded, the mesh of the container is too coarse to correctly treat the contact and it is refined, α staying constant, until the sphere does not rebound.

2.1.2 Workflow diagram

The following diagram represents the iteration loop implemented in SynfiniWay, where ITER is the iteration number. When the job starts (ITER = 1) the set of parameters defined in the profile of the workflow is sent to the **LS-INGRID TASK** in order to generate the LS-DYNA input file. The LS-DYNA input file is then sent to the **LS-DYNA TASK** for execution. After LS-DYNA has finished ITER is incremented and the *rbdout* file (*rigid body data* file) is sent to the **CONVERGENCE TASK**. The file is parsed to get the two velocity components V_y and V_z of the sphere.

The component V_y gives information about the trajectory of the sphere. If V_y is > 0 the sphere has rebounded because the mesh of the container is too coarse. The value of the angle remains the same and the parameter which defines the size of the mesh of the container is multiplied by a scaling factor less than 1. Mesh modifications and LS-DYNA runs are performed until V_y becomes < 0. When V_y is < 0 the sphere has gone through the container and the angle of the impact can be decreased. The iterative study is stopped when the maximum of loops or the minimum angle initially set have been reached.
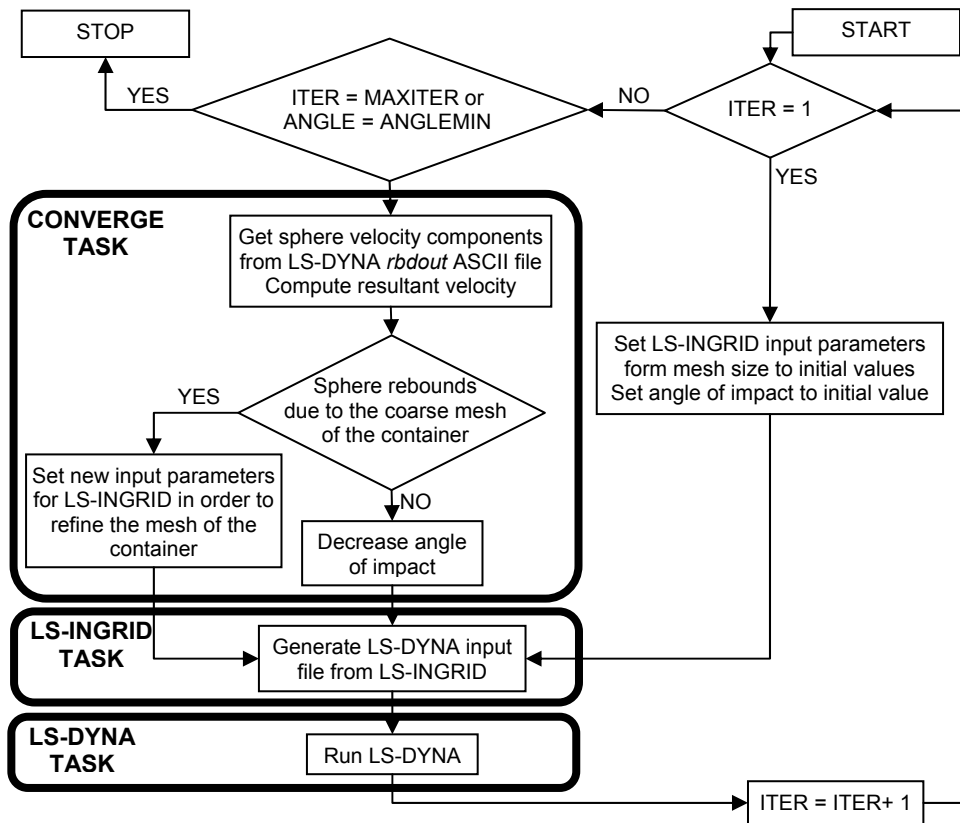
2.1.3 Workflow parameters

The workflow is created from the SynfiniWay workflow editor. Once it is created the workflow is published to the users. The parameters needed to start the workflow have to be set in the workflow profile before execution.

Workflow profile

In addition to the parameters, the user has to give the absolute path to the LS-INGRID input file located on the local workstation, in the INPUTS tab (see above picture). Once this is done, the run button can be clicked to start the iterative analysis.

2.2   Academic model of free air burst

2.2.1 Description

The system considered is a single 100 g sphere of TNT ignited from the centre. Due to symmetries, only one eighth of the sphere is represented using an ALE multi material formulation. The TNT sphere is defined using the ∗INITIAL_VOLUME_FRACTION_GEOMETRY keyword in a simple air cube grid (750x750x750 mm). The TNT behaviour is defined using HIGH_EXPLOSIVE_BURN material law and a JWL equation of state. Air is associated with an ideal gas behaviour using a NULL material law and a LINEAR_POLYNOMIAL equation of state.

To characterise the effect of the explosion, numerous fixed trace particles are defined in the model. The pressure signal (mainly pick value and impulsion) compute for each trace particle is compare to experimental data obtained by interpolation of abacus extract from Reference Manual TM5-1300 "Structures to resist the effect of accidental explosion".
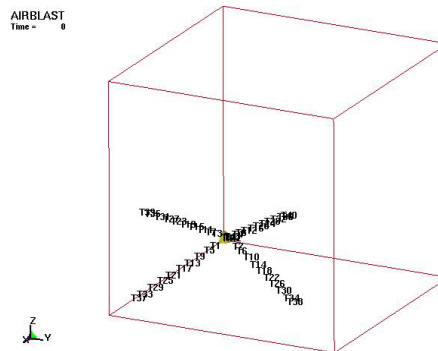
Trace particle location
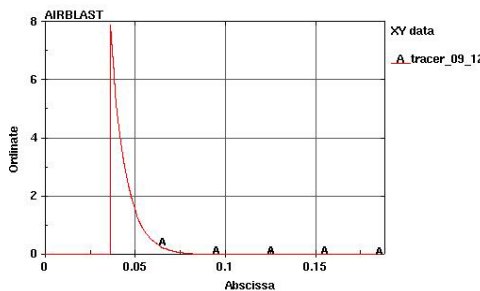
| **Example of TM5-1300 « experimental » pressure profile for particle 09** | **Example of corresponding TM5-1300 « experimental » impulsion profile for particle 09** |
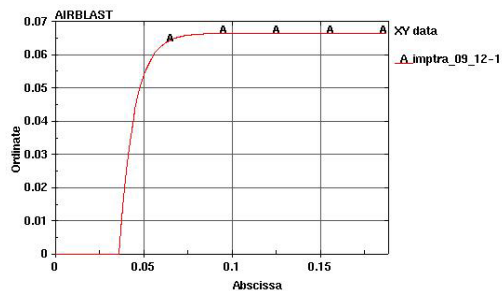
The goal of the study is to determine which mesh size is appropriate to get acceptable results. A loop is done using SynfiniWay: the ALE mesh is refined

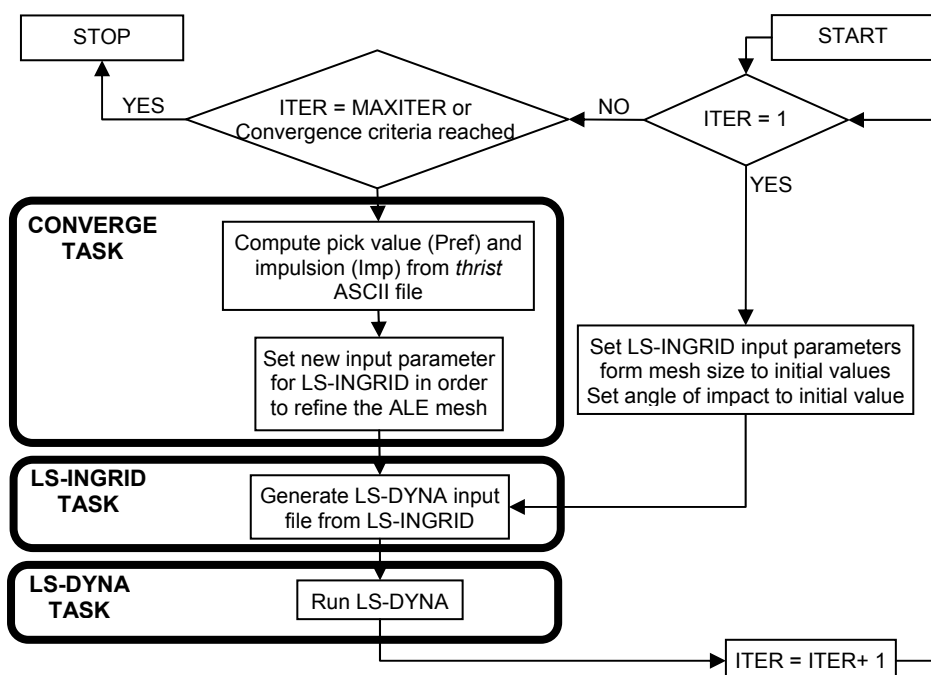until the error between pick values and impulsions obtained by simulation, and given by TM5-1300, fail under a predefine user criterion.

2.2.2 Workflow diagram

As before, ITER is the iteration number. The job starts (ITER = 1) with the set of parameters defined in the profile of the workflow. After LS-DYNA has finished, ITER is incremented and the *thrist* file (*tracer particle history information* file) is parsed to get the pick value (P_{ref}) and the impulsion (Imp). If P_{ref} and Imp have reached the experimental data with a tolerance specified by the user, the workflow is stopped. If not, the ALE mesh is refined and the workflow continues.

The iterative study also stops if ITER has reached a maximum number of loops authorized by the user.

```
STOP                                              START

        YES    ITER = MAXITER or      NO    ITER = 1
               Convergence criteria reached
                                                    YES

CONVERGE   Compute pick value (Pref) and
TASK       impulsion (Imp) from thrist
           ASCII file
                                          Set LS-INGRID input parameters
           Set new input parameter        form mesh size to initial values
           for LS-INGRID in order          Set angle of impact to initial value
           to refine the ALE mesh

LS-INGRID   Generate LS-DYNA input
TASK        file from LS-INGRID

LS-DYNA     Run LS-DYNA
TASK
                                              ITER = ITER+ 1
```

2.2.3 Workflow parameters

As before, the parameters needed for the three tasks are the set in the profile of the workflow.

Workflow profile

Before clicking on the run button, the user has to specify the absolute path to the LS-INGRID located on his workstation, in the INPUTS tab (see above picture).

3 Conclusions

The workflow functionality of the SynfiniWay middleware product has shown its capability to solve the two following iterative problems:

1. Run LS-DYNA to compute the perforation of a shell container for various angles of the impacting sphere. The iterative scheme also included an automatic mesh refinement when the size of the mesh of the container was not fine enough to obtain a correct contact behaviour

2. Run LS-DYNA to compute a free air burst to find out the optimal size of the ALE mesh to match experimental values (P_{ref}, the maximum of pressure and Imp, the impulsion of the free air burst)

The definitions of the LS-DYNA cases were done in Toulouse whereas the SMP server, a Fujitsu Primepower system, used to solve the large ALE problems was located in Paris. SynfiniWay has proved its capability to let users transparently access remote computers and complex workflows.

The combination of LS-DYNA and SynfiniWay allowed, for the free air burst study, to evaluate the evolution of the error due to the size of the ALE mesh, and to find the optimal mesh size for a desired accuracy compared to experimental results. Such pre study can be performed to find the best balance between expected accuracy and global IT and software resources.