

# WebParFE: a Web Interface for the High-Performance Parallel Finite Element Solver ParFE

Sumit Paranjape, Martin Kaufmann, Peter Arbenz  
Computer Science Department, ETH Zurich, Switzerland

December 8, 2009

## Abstract

ParFE is a fully-parallel micro finite element ( $\mu$ FE) solver for the modeling of human bone microstructures. We have developed an interface that will make available ParFE on the High Performance Computing (HPC) facility at the Swiss National Supercomputer Centre (CSCS) to a dedicated group of people. The interface has the form of a portal that can be accessed through a web browser. The portal provides a simple and secure means to submit and manage ParFE jobs without having to connect to the HPC facility in CSCS using a secure shell (ssh) connection.

## 1 Introduction

The goal of the ParFE project is to develop massively parallel solvers for finite element (FE) problems arising from bone modeling [1]. The computationally intensive phase is the solution of the linear system.

$$Ku = f \tag{1}$$

arising from the FE discretization of the linear elasticity equations.  $K$  is a sparse symmetric positive definite matrix referred to as the **stiffness matrix**,  $u$  is the vector of unknown displacements and  $f$  is the vector of applied external forces. Although the equation and their discretization techniques are well known, several issues arise while modeling the human bone microstructure. First, the application must be able to read large mesh files from disk, distribute the workload equally on all available processors and compute the desired solution and write it back to disk. Then, an optimal solution technique must be determined. The approach followed by the developers of ParFE consists in applying the conjugate gradient method [2] complemented by a powerful smoothed aggregation-based multilevel preconditioner [3].

ParFE is open source software written in C++. It is based on several high-performance libraries for scientific computing, namely MPI [4], HDF5 [5], Trilinos [6], and ParMETIS [7].

ParFE has been tested for scalability on the CRAY XT3 server - `palu`, located at the Swiss National Supercomputing Centre (CSCS), containing 1100 AMD Opteron single-core processors that run at 2.6 GHz and are equipped with 2GB of memory. More information about `palu` and other HPC facilities at CSCS can be found at [8]. Numerical results have

shown excellent weak and strong scalability for both artificial and realistic human bone problems [9].

The motivation for developing a web interface for ParFE is given in Section 2. In that section we also discuss some of the implementation details of the web application. Section 3 serves as a guide for using the web application.

## 2 Web Interface for ParFE

Conventionally, users execute ParFE directly on a high performance cluster by connecting to it via a ssh connection. The motivation for developing WebParFE is to substitute the ssh interface with a simpler web interface that will enable the users to submit and manage jobs on a high performance cluster with minimal effort. We have a dedicated user account at the CSCS that will execute ParFE on a HPC cluster on behalf of the users who have registered themselves through the website. This will make the modeling of large scale bone structures easy for a dedicated group of people. Time and memory space are charged to the dedicated user account. The interface has the form of a portal that can be accessed through a web browser. The portal can be accessed using the URL:

<https://webgui.cscs.ch/>

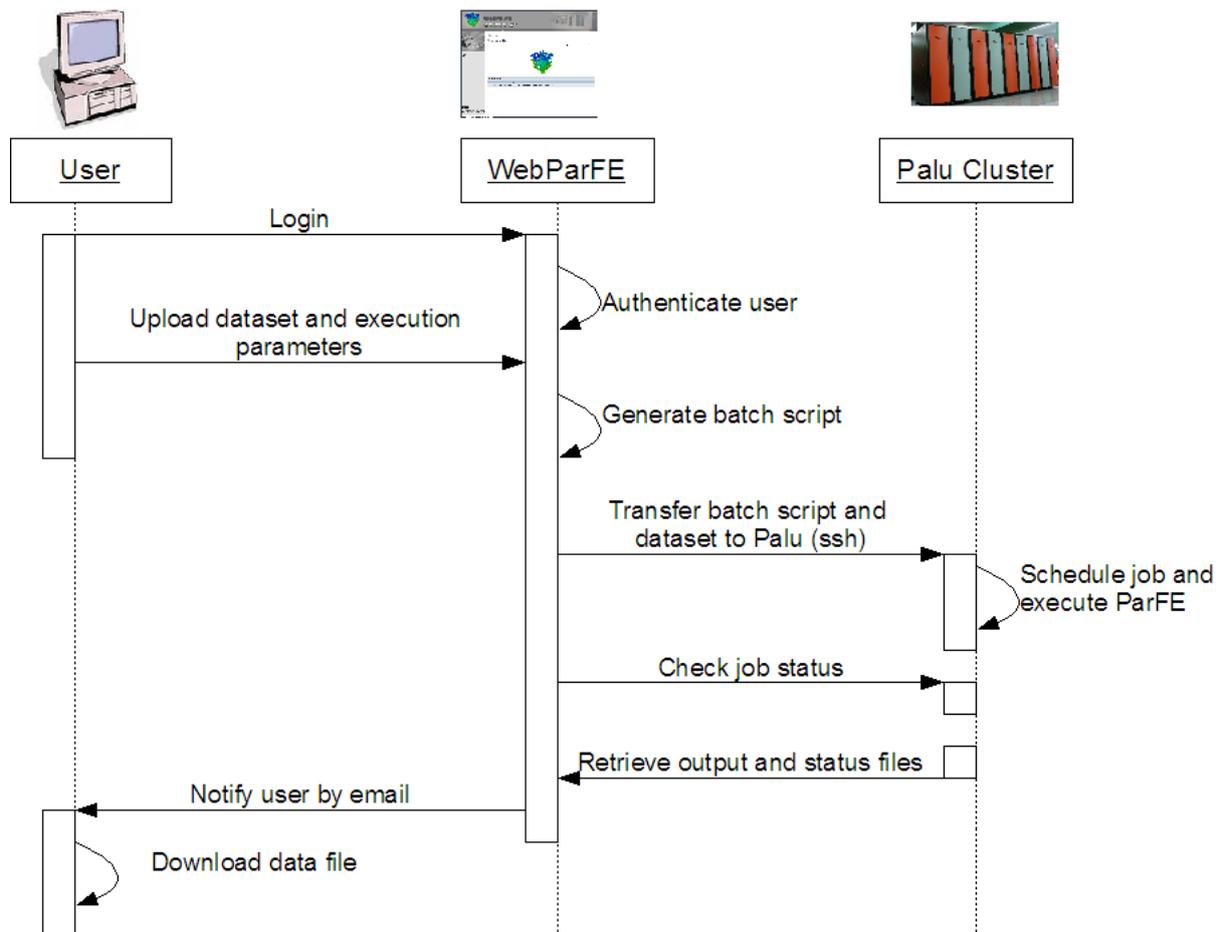


Figure 1: WebParFE: Sequence diagram

In order to use the web application, the user must register a username on the website clearly stating his/her affiliation. A typical scenario for submitting a job through the web interface can be described as follows: The web portal authenticates users through username and password. It only accepts actions of the user according to his/her permissions set by the administrator. The web interface accepts parameters that it will forward to ParFE jobs e.g., the number of processors needed, and the file that contain input data for one or several jobs. The web application will then generate a `batch script file` using this information. The `batch script file` and the input data file are then transferred to our account at CSCS which will submit the batch job to the `Palu` cluster on behalf of the user. The user does not have to bother about the actual start of a ParFE job. Jobs that are submitted to the HPC facility at CSCS are scheduled through a queuing system. It may take some time (minutes to days) until a job is scheduled and executed on the HPC facility. WebParFE checks the status of the job at regular time intervals and notifies the user through an email message after the job is completed. The user can then login to the portal and download the output files and the status file containing all the messages generated during runtime. In general, the size of the output file prevents it from being sent as an email attachment. After submitting a job, the user can log into to the portal at any time and check the job status.

## 2.1 Architecture

As a basic requirement, large numbers of people should be able to access WebParFE by any commonly used web browser without additional software. Therefore, a client-server architecture has been chosen to implement the web interface with the clients using their web browser to display information which is retrieved from a central web server.

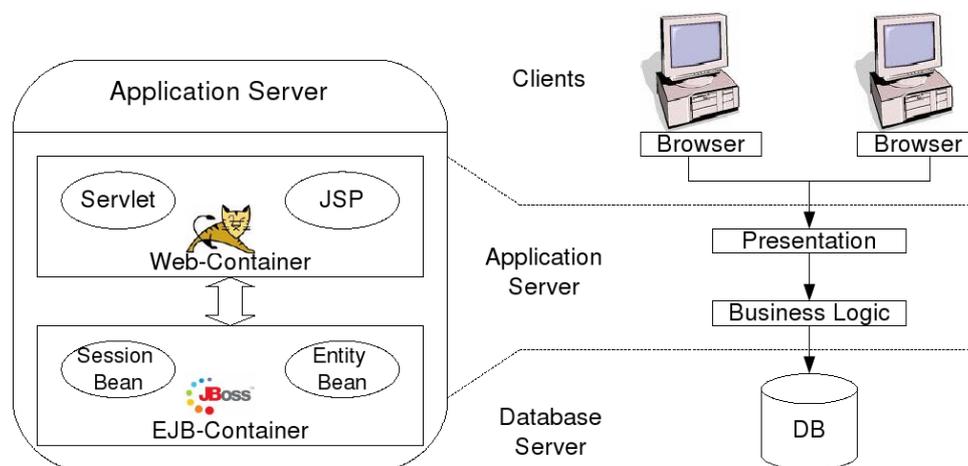


Figure 2: Architecture for web interface

For the presentation layer, the Apache Struts Framework [10] is used in order to simplify common tasks like transporting data from the business logic to the JSP view or mapping a URL to the corresponding view. The business logic is implemented using Enterprise JavaBeans (EJBs). The Enterprise JavaBeans have to be deployed on an Enterprise Application server, Jboss [11] in the present case. The WebParFE website has been derived

from PubZone [12] developed at the Computer Science Department at ETH.

## 2.2 Graphical User Interface

The user interface consists of four parts as represented in Fig. 3

1. The *main menu* contains logically separated sections.
2. Each main section is separated into one or several sub sections which are displayed in the *sub-menu* bar.
3. If a sub-menu section is selected, the *content* changes according to the current selection.
4. Optionally, there can be *tabs* on the top of the page to provide further sections.

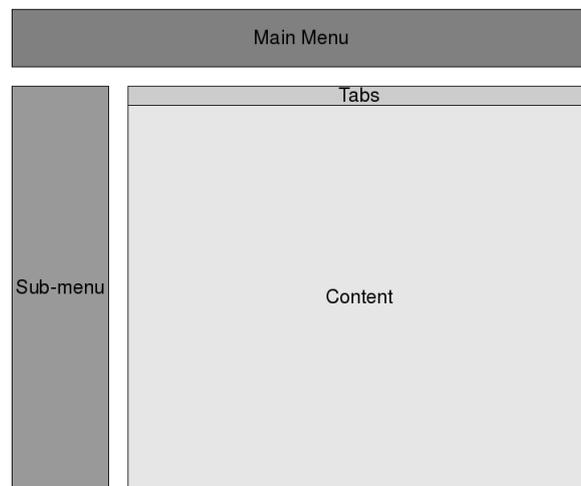


Figure 3: Screen layout

The access privileges are verified for each page in order to prevent an user to access a restricted page. The GUI is implemented in a modern table-less layout using CSS stylesheets. Thus, it is possible to have a simple print functionality without the need for a dedicated print button.

## 3 Using WebParFE

WebParFE is hosted on a server at Swiss National Supercomputing Centre (CSCS), hence the user is obliged to accept the security certificate furnished by CSCS in order to access the web application. Mozilla Firefox users may have to include the security certificate in the list of trusted sources. Internet Explorer users may get the following message:

There is a problem with this website's security certificate  
The user can safely click on

Continue to this website (not recommended)

to navigate to the homepage of WebParFE.

## 3.1 WebParFE homepage

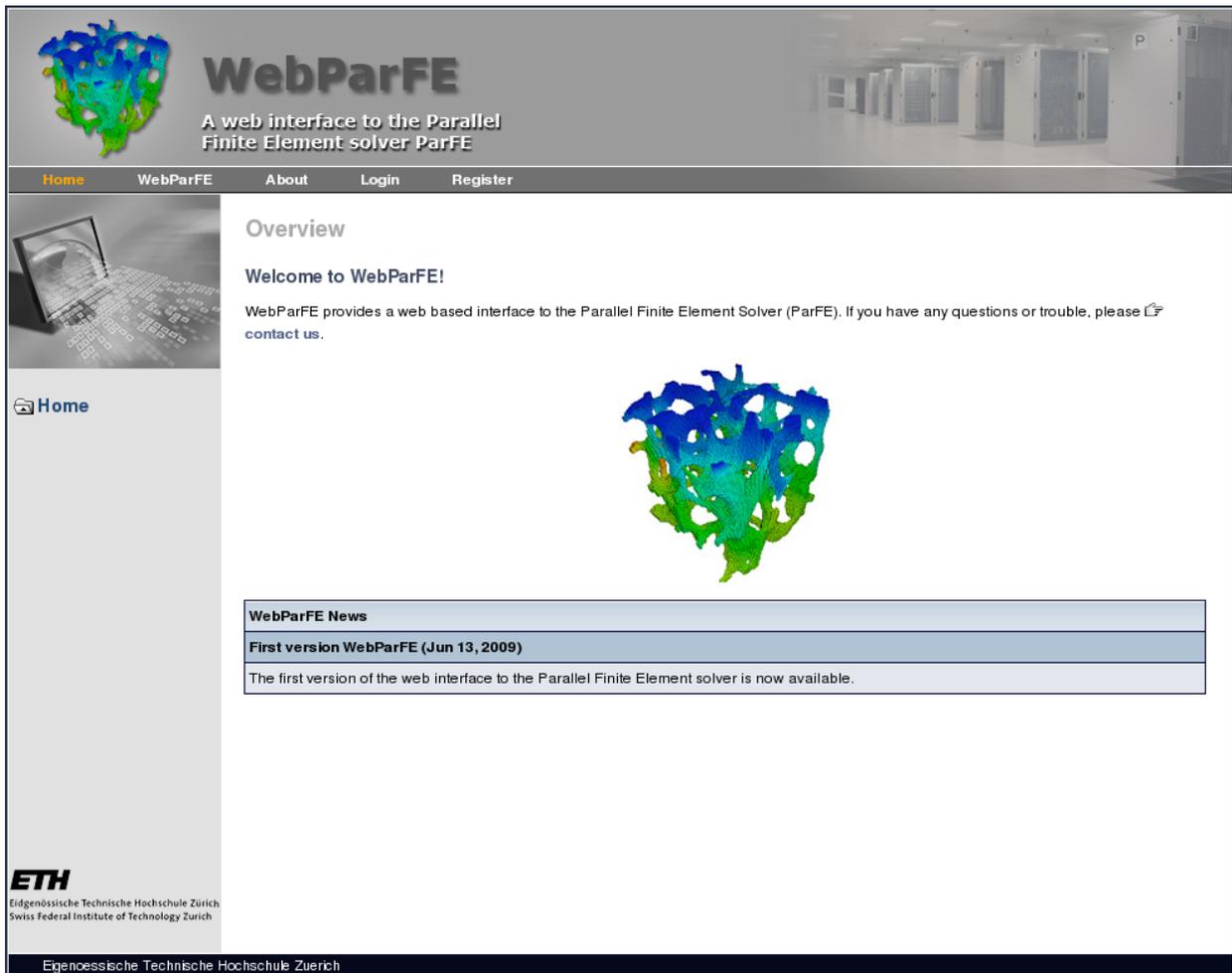


Figure 4: WebParFE homepage

The main tabs and the corresponding functions in the WebParFE homepage (Fig. 4) are as follows:

1. **Home:** Navigate to WebParFE homepage
2. **WebParFE:** Information related to submitted jobs.
3. **About:** Brief information about the web application and contact details.
4. **Login:** Login using username and password in order to submit ParFE jobs.
5. **Registration:** Register your username in order to be able to use the web application. An initial password will be sent to you by email.

## 3.2 User Home

After login, using username and password, the user navigates to the screen depicted in Fig. 5.

**WebParFE**  
Parallel Finite Element solver  
Parallel Finite Element solver ParFE

Home WebParFE My Account About Logout

Overview You are logged in as **Sumit Paranjape**

My WebParFE WebParFE News

**Welcome, Sumit Paranjape!**  
You have successfully logged in to WebParFE.  
On this page you see a summary of your submitted jobs.

Show item 1 to 7 of 7

Show	JobID	Time	Status
	44265.20783	Aug 24, 2009. 13:55:09	
	60742.14136	Aug 14, 2009. 11:33:37	
	34058.36533	Aug 14, 2009. 11:26:25	
	62625.99886	Aug 14, 2009. 11:03:17	
	19465.89603	Aug 13, 2009. 17:09:06	
	24441.95792	Aug 13, 2009. 14:51:04	
	31427.32523	Aug 10, 2009. 13:58:41	

You have 7 jobs in the database.

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Figure 5: User Home

1. Home: Navigate to user Home.
2. WebParFE: Submit a new job or get information related to submitted jobs.
3. My Account: Change password and other user information.
4. About: Brief information about the web application and contact details.
5. Logout: Logout from the web application.

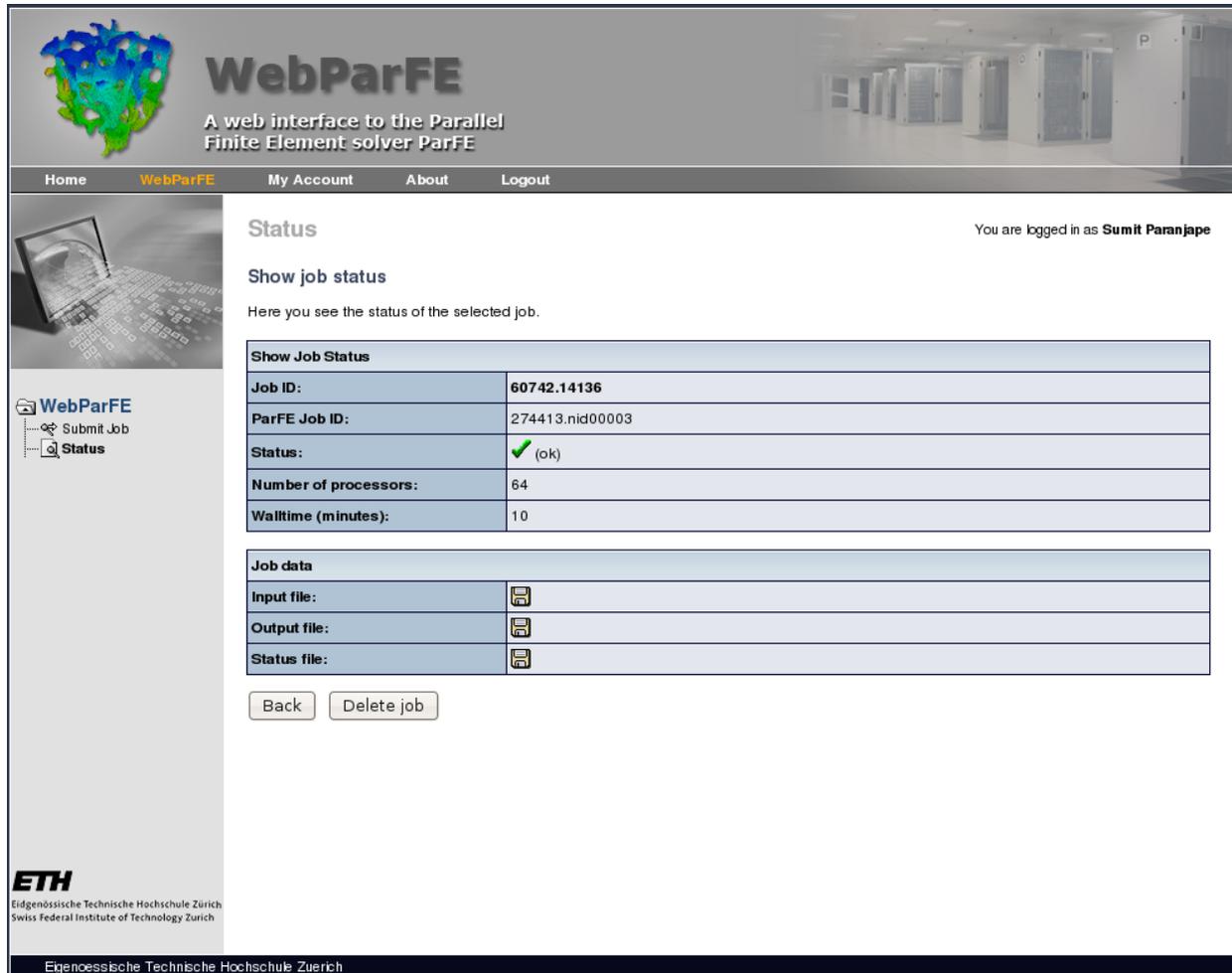
In addition to the above tabs, the user homepage gives a brief overview of jobs submitted in the past. The JobID is a unique ID assigned to every job submitted by the user. This JobID can be used to query the status of a submitted job in the WebParFE tab. A job can have any of the states indicated in Table 1.

### 3.3 Job status

Detailed information of a particular job (Fig. 6) and also the output (if available ) can be accessed by clicking the Show button against the corresponding JobID in user homepage (Fig. 5).

	Job is submitted and will be transferred to CSCS
	Job is pending in queue
	Job has completed
	Job has been interrupted due to some error

Table 1: Job status



**WebParFE**  
A web interface to the Parallel Finite Element solver ParFE

Home WebParFE My Account About Logout

Status You are logged in as **Sumit Paranjape**

Show job status

Here you see the status of the selected job.

Show Job Status	
Job ID:	60742.14136
ParFE Job ID:	274413.nid00003
Status:	 (ok)
Number of processors:	64
Walltime (minutes):	10

Job data	
Input file:	
Output file:	
Status file:	

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Figure 6: Job Status

The Output file and the Status file can be downloaded from this page by clicking the Save icon against these file names.

### 3.4 Job submission

A new job can be submitted through the WebParFE tab on the user homepage (Fig. 5). In the first step the user has to specify the absolute path on the local machine to the input data file in the hdf5 file format [5]. In the second step the user has to enter additional parameters namely, number of processors to be used and the approximate wall time required to complete the job, refer to Fig. 7

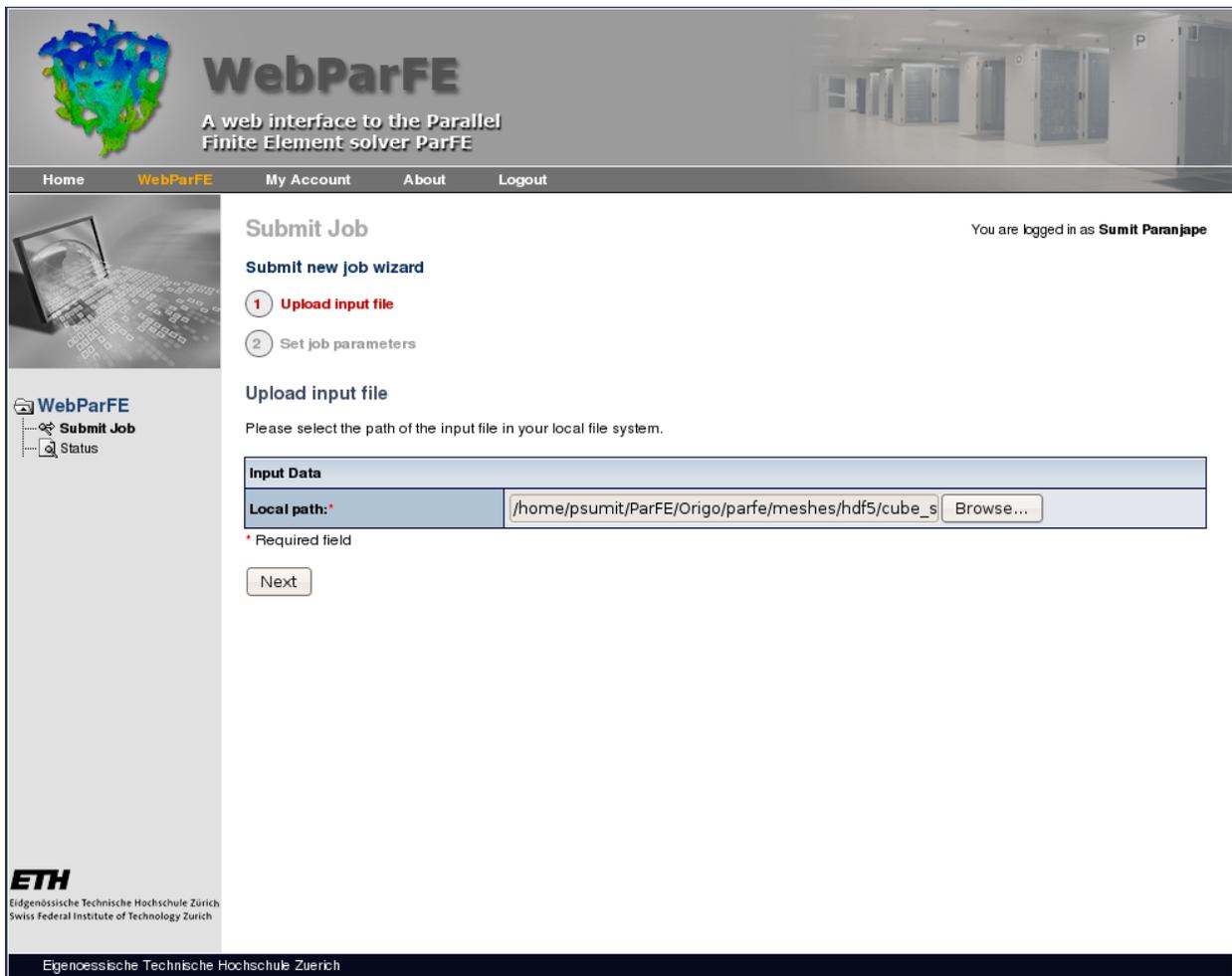


Figure 7: Submit Job

## 4 Acknowledgment

We would like to acknowledge the help of the CSCS support team for installing the web application on their local server.

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