



FORTISSIMO

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The Fortissimo White Paper

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Executive Summary

This White Paper comprises a presentation of the vision and objectives of Fortissimo, the challenges that these presented and the achievements that resulted. It also comprises a discussion of the end-user-driven experiments carried out, an in-depth discussion of the business aspects of a Cloud of HPC resources from the perspective of all potential participants in the value chain, a set of recommendations to support the exploitation of viable business opportunities, a discussion of impacts, both realised and potential and overall conclusions from the project

The vision of Fortissimo is to enable European manufacturing industries to benefit from the efficiency and competitive advantages inherent in the use of simulation, as practised, successfully and for some time now, by numerous high-tech industries. The importance of advanced simulation to increased competitiveness for both large and small companies is well established. The mechanism adopted by Fortissimo to realise this vision is the provision of simulation services running on a Cloud of HPC resources, accessed through the Fortissimo Marketplace.

The achievements of Fortissimo comprise:

- The implementation of a prototype “one-stop shop”, the Fortissimo Marketplace, where end-users new to HPC can get expert advice on opportunities to improve their competitiveness through the use of HPC-enabled modelling and simulation combined with access to the expertise necessary to exploit those opportunities and where more experienced users of HPC can have easy access to HPC services;
- The establishment of Fortissimo Marketplace Limited, the legal entity to carry out the business of the Fortissimo Marketplace;
- The development of business models to address the long-term sustainability and viability of the Fortissimo Marketplace;
- A wide awareness of the potential benefits of the on-demand HPC simulation across European manufacturing. The creation of this awareness has been based around the 44 success stories resulting from the 53 end-user driven experiments;
- The commercially relevant new services resulting directly from the experiments.

These outcomes have significant potential to improve the competitive position of European manufacturing industry and to create new business opportunities for the diverse actors in the on-demand HPC value chain including infrastructure providers, service providers, ISVs, HPC experts, application domain specialists and end-users.

The Fortissimo Marketplace now exists as a usable ecosystem supporting interactions between all players in the value chain. A legal entity has been established to carry out the business of the Marketplace. A confidential business plan has been developed to support and develop that business. That business plan sets out how the activities of the Marketplace will develop. The challenge now facing the Fortissimo Marketplace (and the legal entity which conducts its business) is to compete in a challenging market where there are already several growing players. Flexibility, opportunism and the right approach to promotion and sales will be essential components in the tactical and strategic approaches to the establishment and development of the business of the Fortissimo Marketplace.

Table of Contents

1	Introduction.....	5
2	Vision and Objectives	5
3	Challenges.....	5
4	The Fortissimo Approach.....	6
5	Achievements.....	6
5.1	Development of the Fortissimo Marketplace.....	6
5.2	The Major Outcomes of Fortissimo.....	7
6	The Experiments	7
7	Business cases for the Fortissimo Marketplace	8
7.1	Business case for an HPC Centre.....	8
7.2	Business case for an end-user of Cloud-based HPC services;.....	9
7.3	Business Case for a Potential ‘Solution as-a-service’ Service Provider.....	9
7.4	Business cases for ISVs and code owners and providers	9
7.4.1	Output of the Fortissimo ISV Forums.....	10
7.5	Business case for an Expert	10
8	Marketplace Status and the Way Forward.....	10
9	Impact.....	11
9.1	The Marketplace.....	11
9.2	The Experiments.....	11
9.3	Dissemination.....	11
9.4	Business models	12
10	Conclusions and Overall Recommendations	12

1 Introduction

This White Paper presents the vision and objectives of Fortissimo. It describes the challenges that these presented and how they were overcome. It discusses the end-user-driven experiments which were carried out to define and develop the Fortissimo Marketplace for advanced, on-demand HPC simulation using a Cloud of resources. It discusses the business aspects of on-demand HPC from the perspective of all potential participants in the value chain. It presents a set of recommendations to support the exploitation of viable business opportunities, a discussion of impacts, both realised and potential, and overall conclusions from the project.

The target audience for this White Paper comprises all potential participants in the value chain, namely end-users, domain and HPC experts, ISVs, code owners and HPC Centres. The target audience also includes industrial decision makers, associations, other stakeholders and politicians.

2 Vision and Objectives

The vision of Fortissimo is to enable European manufacturing industries to benefit from the efficiency and competitive advantages inherent in the use of modelling and simulation, as practised successfully for some time now, by numerous high-tech industries. The importance of advanced simulation to increased competitiveness for both large and small companies is well established. The mechanism adopted by Fortissimo to realise this vision is the provision of simulation services running on a Cloud of HPC resources, accessed through the Fortissimo Marketplace. Towards the realisation of this vision, Fortissimo has addressed the following goals:

- Making advanced simulation accessible to industrial users, particularly SMEs, through the creation of a “one-stop shop”, the Fortissimo Marketplace, where hardware, expertise, applications and visualisation and other tools are easily available and affordable on a pay-per-use basis;
- Creating and demonstrating a sustainable commercial ecosystem where actors at all levels in the value chain can realise sufficient commercial benefit to enable that commercial ecosystem to persist independently of EU funding, providing services to manufacturing industry, particularly SMEs.

The focus in Fortissimo has been on business-relevant application experiments to develop, test, refine and demonstrate this “one-stop-shop” and to confirm its economic viability to all participants in the value chain. A key objective has been to overcome the barriers to the development and exploitation of on-demand HPC-enabled simulation services. This has been done through the development, testing, evaluation and demonstration of on-demand HPC-enabled simulations, complemented by the creation of a working infrastructure, the Fortissimo Marketplace.

3 Challenges

The challenges facing Fortissimo, the development of the Fortissimo Marketplace and its use by potential beneficiaries have been manifold and include:

- **Flexible and affordable accessibility of HPC resources:** HPC systems are not, in general, accessible by companies, particularly SMEs, on affordable, flexible, pay-per-use terms. The creation of an environment where such systems can be made widely available in an affordable pay-per-use way is an essential development;

- **Lack of awareness of the capabilities of simulation:** Many small organisations, which could benefit from advanced simulation, are not aware of its capabilities and benefits;
- **Lack of domain expertise in small companies or departments of larger organisations:** Many organisations, even those aware of the capabilities of advanced simulation, lack the necessary in-house expertise to exploit those capabilities to improve their competitiveness and profitability;
- **Lack of HPC expertise in small companies or departments of larger organisations:** There is a general lack of HPC expertise in small companies and even in many departments of larger organisations;
- **Licensing issues:** The adaptation of licensing models to enable pay-per-use of applications and resultant services needed to be addressed;
- **Ease of use:** increasing the ease with which HPC can be used in the manufacturing sector through the availability of ready-to-go applications and on-demand access to HPC systems;
- **Combining skills and resources:** this is essential for the effective use of HPC resources which include software, licensing, domain and HPC expertise and compute cycles.

4 The Fortissimo Approach

The Fortissimo approach has been straightforward and pragmatic:

- A prototype on-demand HPC access point, the Fortissimo Marketplace, has been set up, giving access to existing HPC hardware resources owned by the Fortissimo partners;
- The “one-stop-shop” concept has been tested and evaluated using 53 business relevant experiments involving all levels of the value chain. These experiments have formed the basis for an extensive dissemination and awareness activity based on success stories derived from the experiments;
- The comprehensive dissemination activity has created awareness of the capabilities and potential of on-demand HPC-enabled simulation to all potential participants in the value chain and has stimulated the market for the provision of the necessary infrastructure, software, services and expertise as well as creating awareness amongst potential end-users.

5 Achievements

Fortissimo has contributed to overcoming the barriers of access to HPC-based advanced simulation by providing the benefits of Cloud (low cost of entry, elasticity and pay-per-use models), combined with the necessary expertise (application domain and HPC) and open-source and licensed software.

5.1 Development of the Fortissimo Marketplace

To address the challenge of developing an infrastructure fit for purpose, Fortissimo has been driven by end-user requirements where business-relevant application experiments have been used to test and demonstrate both the infrastructure and the concept of the “one-stop pay-per-use shop”. Furthermore, the participants in the experiments have represented all actors across the value chain to ensure its viability in real commercial use. These actors comprise end-users; ISVs, simulation service providers, HPC and domain experts, and HPC centres.

To achieve its objective of enabling European manufacturing industries to benefit from the efficiency and competitive advantages inherent in the use of advanced simulation, Fortissimo has addressed the following tasks:

- To establish a prototype European Marketplace for on-demand HPC-enabled simulation services offering European manufacturers, particularly SMEs, access to a pay-per-use one-stop shop for simulation and modelling applications;
- To run a total of 53 end-user driven application experiments that showcase the innovative use of modelling and simulation using the HPC-Cloud services and infrastructure;
- To create a self-sustaining on-demand HPC ecosystem by removing barriers to the uptake of modelling and simulation and tailoring new services to the requirements of industry.

To address the challenge of developing an infrastructure fit for purpose, Fortissimo has been driven by end-user requirements where business-relevant application experiments have been used to test and demonstrate both the Marketplace and the “one-stop pay-per-use shop”. Furthermore, to ensure wide applicability, the participants in the experiments have represented all actors in the value chain.

The prototype Fortissimo HPC-Cloud infrastructure has been built from the existing hardware resources of the beneficiaries connected together using off-the-shelf solutions augmented by “glue” software. This “glue” software has been developed only where necessary.

5.2 The Major Outcomes of Fortissimo

The following major outcomes have resulted from Fortissimo:

- A prototype “one-stop shop”, the Fortissimo Marketplace, where end-users new to HPC can get expert advice on opportunities to improve their competitiveness through the use of HPC combined with access to the expertise necessary to exploit those opportunities and where more experienced users of HPC can have easy access to HPC services;
- Business models have been developed to address the long-term sustainability and viability of the Fortissimo Marketplace. Significant emphasis has been placed on developing business models, with a broad scope, covering market expectations and pricing, which benefit all levels of the value chain enabling them to establish a viable business in the provision of services and leading to a sustainable Fortissimo Marketplace;
- A wide awareness of the potential benefits of the HPC-enabled modelling and simulation across European manufacturing. The creation of this awareness has been based around the success stories resulting from the 53 end-user driven experiments;
- A new Marketplace for the provision of on-demand HPC services. Some of these services are described later in this document in section 7, but it is anticipated that novel services will also be developed in response to the significant and diverse commercial opportunities the Cloud of HPC resources will create.

These outcomes have significant potential to improve the competitive position of European manufacturing industry and to create new business opportunities for the diverse actors in the on-demand HPC value chain including infrastructure providers, service providers, ISVs, HPC experts, application domain specialists and end-users.

6 The Experiments

A central activity in Fortissimo has been the performance of 53 experiments focusing on real industrial problems. These experiments have clearly demonstrated the benefits of advanced on-demand HPC-enabled simulation. They resulted in 44 success stories which have been the

cornerstone of an extensive dissemination and awareness-creation campaign. The remaining nine experiments demonstrated a proof-of-concept, but not a sufficiently strong business case for further development. The success stories are available on the Fortissimo website¹. Furthermore, the experiments have provided important feedback into the development of the Fortissimo Marketplace and to an analysis of the benefits of on-demand HPC-enabled simulation in the accompanying Fortissimo Impact Report.

In most experiments an economic return greater than the investment of public funding made by the EC was noted. However, not all benefits can or should be reduced to purely monetary returns: Improved products and services; improved reputation; faster design cycles; feasibility; environmental impact of less waste; and environmental and societal benefits should also be taken into account.

The experiments involved both naïve and experienced end-users. The former would not otherwise have been involved in an activity capable of giving them a significant business benefit. The latter were looking to increase the scope of existing applications (bigger, faster, lower cost etc.).

Creating and promoting success stories, derived from successful experiments, is a key factor in reaching the Fortissimo goal of promoting the use of digital simulation to SMEs. A wide range of industrial sectors and applications are represented in the experiments. This is essential for the effective demonstration of the flexibility of on-demand HPC simulation and how it can address the challenges facing individual SMEs.

The success stories encapsulate the positive outcomes of the experiments where the benefits of the results of the experiments can be clearly demonstrated. These 44 success stories form a diverse body of material due to grow in the follow-on project Fortissimo 2.

7 Business cases for the Fortissimo Marketplace

This section comprises a discussion of the business opportunities of on-demand HPC from the perspective of all potential participants in the value chain. The following section 8 presents recommendations to support the rapid exploitation of viable business opportunities.

Different kinds of business models serving user segments of the Marketplace have been considered. To determine the sustainability of the different business models, various business scenarios have been analysed. This analysis has included the costs involved in these different business scenarios based on their operation and sustainability. This has been done by reviewing the possible revenue streams that could be generated based upon the available key resources, partners, and activities, and the customer segments, customer relations, channels and value propositions. The following sub-sections summarise the outcomes of this analysis as a set of business cases.

7.1 Business case for an HPC Centre

A HPC provider could potentially choose to maintain direct relationships with strategic customers, but to interact with smaller, non-strategic, customers through the Marketplace. In this case the Marketplace is a sales and marketing channel. The membership fee that the centre pays represents the cost of access to the Marketplace. The benefit for the centre is in the form

¹ <https://www.fortissimo-project.eu>

of increased sales and lower cost of sales to small customers. The Marketplace generates revenue from commission on sales plus a membership fee.

7.2 Business case for an end-user of on-demand HPC services

The end-user is the consumer of services from the Marketplace. The end-user takes advantage of an existing service meaning that it knows what it wants. The end-user may have a complex need. The end-user pays for services when they are consumed. The payment is made directly to the Marketplace, or via a broker for a fee. A user might also pay a membership fee to gain access to specific services (such as white papers and advanced matchmaking).

7.3 Business Case for a Potential ‘Solution as-a-service’ Service Provider

As an example to present this type of service, IES Ltd wants to sell services to users via an ‘as-a-service’ model. It needs HPC, data and a virtual machine resource to implement this. The Marketplace facilitates this through a matchmaking and container service. The matchmaking provides potential ‘as-a-service’ providers the opportunity to identify potential partners. The potential partners are existing members. The potential ‘as-a-service’ provider sets up contracts with partners to build a solution. The service provider pays the direct costs, or shares the investment. The Marketplace helps with contracts and shares in the benefits. The container service takes care of the provisioning of the service and makes it easy for the provider to implement its service. The potential ‘as-a-service’ provider must become a member. The container provides access to HPC and a virtual machine. It also provides accounting and billing and provides flexibility to implement novel business models. The Marketplace facilitates contracts, revenue collection from the end-user, revenue distribution to stakeholders and cost reconciliation between ‘as-a-service’ provider and partners. The Marketplace gets revenue from the commission on sales, membership fees and a container service fee.

7.4 Business cases for ISVs and code owners and providers

The ISV provides software. The Marketplace promotes which machines and centres the ISV software runs on, how to use it and how much it costs. The Marketplace also forms a relationship with the ISV so that a user licence can be instantiated on demand. The user searches for the software or is directed to an HPC centre capable of hosting the software. The user pays the Marketplace for use of the software and for the cycles used.

The Marketplace generates revenue from the ISV membership fee, commission on sales, but passes on the licence revenue to the ISV. The ISV could also use a business container. This would represent a fulfilment service, encourage the proliferation of technically focused ISVs with a limited sales activity and enable the implementation of novel business models.

Note that the ISV could become a service provider, but need not do so. The ISV can use the Marketplace as a back-end service because an end-user will not notice where a job is running. Business containers are especially interesting for small ISVs.

There are two options for ISVs as a service provider. The first is that they are offered an IaaS/PaaS option with which their web-based online services can make use of Fortissimo compute services as back-end facilities. The second is that, through the business container option, the ISV is provided with support utilities to provide services online through the Fortissimo Marketplace. The users of these services see these either as: (a) using their ISV services (and thus do not see the Fortissimo Marketplace), (b) use the services through the

Fortissimo Marketplace. For Fortissimo: there are different revenue options. The business containers offer more services to the ISVs and are thus generating higher revenues.

7.4.1 Output of the Fortissimo ISV Forums

During the course of Fortissimo, three yearly forums were held involving ISVs. The specific goal of these forums was to discuss and determine appropriate and attractive models for ISVs to participate in the Fortissimo Marketplace. The conclusions drawn from these three forums are:

- The need for on-demand HPC services is acknowledged by all participants in the value chain;
- The business potential of the Fortissimo Marketplace is now widely recognised;
- There was a strong feeling in all ISVs present at the forums that Fortissimo's goals are aligned with their own;
- Clouds of HPC resources and an EU-level Marketplace are considered as enabling tools for innovation in EU industry and especially in SMEs;
- ISVs think that they and expert consultants are cornerstones in any strategy for the Fortissimo Marketplace and should be treated accordingly, since they are the key enablers to bring HPC to industry;
- Most small ISVs feel it is the Fortissimo Marketplace's responsibility to provide them an easy way to interface their software to HPC resources;
- Different levels of competences and expertise need to be treated in different ways by the Marketplace: a one-size-fits-all solution is not appropriate;
- Small ISVs are more likely to be interested in the opportunities provided by an on-demand HPC Marketplace than large ISVs which have competence, capabilities and market scale to build up their own HPC infrastructures;
- Most ISVs involved in the CAE industry have an HPC Cloud strategy, although the chosen approach varies radically;
- Building a successful on-demand HPC Marketplace presents serious challenges. The road to success is likely to be a combination of competence with flexibility and security;
- Data Analytics alone have not yet reached a maturity level to allow profitable services. However, Fortissimo may contribute to the creation of awareness and subsequent market demand by means of the success stories.

7.5 Business case for an Expert

As indicated above, there are end-users that may have a complex need. The domain or HPC expert pays a membership fee in return for Marketplace matchmaking, that is putting business their way which represents an opportunity for the expert to grow sales. The end-user pays the expert for services provided (through the Marketplace). The Marketplace generates revenue from a membership fee and commission on sales.

8 Marketplace Status and the Way Forward

These recommendations concern the rapid exploitation of a viable business across the value chain centred upon the Fortissimo Marketplace.

A prototype Marketplace has been set up which defines and supports interaction between the different players across the value chain. Awareness of this Marketplace has been created via an extensive dissemination activity making full use of the success stories developed. The target of this dissemination is not only end-users whose business and products can benefit from advanced

on-demand HPC-enabled modelling and simulation, but also the other potential players in the value chain including HPC centres, domain and HPC experts and ISVs and other code owners.

The previous section 7 presented business cases for the various actors in the value chain which form an initial starting point for the development business tactics and strategies for the Fortissimo Marketplace.

The Fortissimo Marketplace now exists as a usable ecosystem supporting interactions between all players in the value chain. A legal entity has been established to carry out the business of the Marketplace. A confidential business plan has been developed to support and develop that business. That business plan sets out how the activities of the Marketplace will develop. The challenge now facing the Fortissimo Marketplace (and the legal entity which conducts its business) is to compete in a challenging market with several growing players. Flexibility, opportunism and the right approach to promotion and sales will be essential components in the tactical and strategic approaches to the establishment and development of the business of the Fortissimo Marketplace.

9 Impact

The major impact from Fortissimo comprises:

- The development of the Marketplace;
- The outcomes of the experiments;
- The outcomes of the dissemination activities;
- The development of business models.

These impacts are presented briefly in the following sub-sections.

9.1 The Marketplace

The Fortissimo Marketplace has been developed where hardware, expertise, applications and other tools are easily available and affordable on a pay-per-use basis. The potential use of this Marketplace by industry represents a major impact of the Fortissimo.

9.2 The Experiments

53 industry-relevant experiments have been carried out (see section 6). Impact from these experiments is being realised in two ways:

- New HPC-based services have been identified as a result of the experiments and implemented and sold;
- Industry has been made aware of the potential of advanced simulation. Experts from the HPC and application domains have become aware of the demands of industry for advanced simulation and HPC.

9.3 Dissemination

A significant activity based around the success stories from the experiments has created substantial awareness of the potential of HPC across industry, politicians and the general public.

This dissemination activity has created awareness of the capabilities and potential of on-demand HPC-enabled simulation to all potential participants in the value chain and has stimulated the market for the provision of the necessary infrastructure, software, services and expertise as well as creating awareness amongst potential end-users.

9.4 Business models

Significant activity has taken place towards the understanding the interplay in the market between users and providers at large. A specific activity has focused on the needs of ISVs to support the one-stop-shop and pay-per-use concepts.

10 Conclusions and Overall Recommendations

The outcomes of Fortissimo have significant potential to improve the competitive position of European manufacturing industry and to create new business opportunities for the diverse actors in the on-demand HPC value chain including infrastructure providers, service providers, ISVs, HPC experts, application domain specialists and end-users.

A central activity in Fortissimo has been the performance of 53 experiments focusing on real industrial problems. These experiments have clearly demonstrated the benefits of advanced Cloud-based-HPC simulation. They have resulted in 44 success stories which have been the cornerstone of an extensive dissemination and awareness-creation campaign. These success stories are available on the Fortissimo website². Furthermore, the experiments have provided important feedback into the development of the Fortissimo Marketplace and to an analysis of the benefits of on-demand HPC-enabled simulation in the accompanying Fortissimo Impact Report.

Different kinds of business models serving user segments of the Marketplace have been considered. To determine the sustainability of the different business models, various business scenarios have been analysed. This analysis has included the costs involved in different business scenarios based on their operation and sustainability. This has been done by reviewing the possible revenue streams that could be generated based upon the available key resources, partners, and activities, and the customer segments, customer relations, channels and value propositions.

The major impact from Fortissimo arise on several fronts, namely: the development of the Marketplace; the outcomes of the experiments; the outcomes of the dissemination activities; and the development of business models.

New HPC-based services have been identified as a result of the experiments and implemented and sold. Industry has been made aware of the potential of advanced simulation. Conversely, experts from the HPC and application domains have become aware of the demands of industry for advanced simulation and HPC.

Fortissimo 2, a follow on initiative to Fortissimo is now underway. This will not only further the objectives of Fortissimo, but it will also extend their scope and that of the Marketplace.

The Fortissimo Marketplace now exists as a usable ecosystem supporting interactions between all players in the value chain. A legal entity has been established to carry out the business of the Marketplace. A confidential business plan has been developed to support and develop that business. That business plan sets out how the activities of the Marketplace will develop. The challenge now facing the Fortissimo Marketplace (and the legal entity which conducts its business) is to compete in a challenging market where there are already several growing players. Flexibility, opportunism and the right approach to promotion and sales will be essential components in the tactical and strategic approaches to the establishment and development of the business of the Fortissimo Marketplace.

² <https://www.fortissimo-project.eu>