FInest – **F**uture **In**ternet **e**nabled optimi**s**ation of **t**ransport and logistics networks

D4.2

Requirements and design of transport and logistics experimentation environment

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Abstract

Work package 4 in the FInest project deals with the identification and design of an experimentation environment for testing, demonstrating, and evaluating the technologies developed during the project based on FInest use cases and real data, on large-scale trials. The activities are closely related to the specification of FInest use cases and demonstrators, and inclusion of real-data and physical sites.

This document describes the initial design of this experimentation environment and assessment of existing technologies suitable for it. This document also includes a refinement of the initial requirements for such an experimentation environment as submitted in Month 6, based on the project demonstrators as presented and explained in work package 3 and work packages 5-8, and on insights obtained from the last six months activities in the project.

Document History

Version	Date	Comments
V0.1	5-03-2012	First draft
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V1.0	30-09-2011	Submitted version

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Acronyms

Acronym	Explanation
3PL	Third Party Logistics
EE	Experimentation Environment
FI	Future Internet
FInest	Future Internet Enabled Optimisation of transport and Logistics Business Networks
FI-PPP	Future Internet Public Private Partnership
FIRE	Future Internet Research and Experimentation
KPI	Key Performance Indicator
T&L	Transport and Logistics
WP	Work Package

1. Introduction

FInest aims at developing a new platform based on Future Internet (FI) technologies that will open new opportunities for innovative e-business processes for the Transport and Logistics (T&L) domain. It is hoped that through the successful demonstration of the FInest platform, new processes will emerge and will be adopted by stakeholders in the T&L domain. This kind of transformation is far beyond the addition of new technology and it involves process changes (radical in some cases) and organizational changes. The challenge is to develop new concepts and processes in the most effective and efficient manner. Therefore, the importance of a realistic, as close to real environment for testing is essential.

The goal of this deliverable is to provide the following:

a) Refined requirement analysis to the preliminary list provided in *D4.1 – Initial requirements.*

b) Initial design of the experimentation environment

c) Preliminary assessment of reusable technologies and experimentation sites

Deliverable 4.2 - *Requirements and design of transport and logistics experimentation environment*, aims at assessing reusable technologies and experimentation sites, suitable for meeting the requirements and the architecture of the experimentation environment as defined in this document. The requirements list is part of *D4.1 Initial requirements* submitted at Month 6 of the project. This document broadens this list and casts it to specific demonstrators that have been chosen by the project to constitute four representative scenarios in the domain of Transport and Logistics (T&L). We present an initial design of the experimentation environment. A refinement of this design will be done as part of *D4.3- Interim specification for transport and logistics experimentation environment* at Month 18. The ultimate goal is to delineate an implementation plan for Phase 2 of the project. In this phase, scenarios will be actually carried out and tested in the Experimentation Environment (EE).

2. FInest experimentation environment

2.1. What is the main goal of the experimentation environment?

Simulation is a powerful tool to test, observe, and gain understanding of new concepts, processes, and technologies under current and future scenarios. Simulation of an end-to-end scenario can enable a deeper understanding of the FInest platform, and the evaluation of future processes on top of this new technology. Furthermore, it enables the understanding and assessment of a new processes prior to any implementation. Moreover, by extending simulations to include real-data the project can achieve a better understanding and evaluation of real-world scenarios. For example, the FInest team could assess the addition of a new location or milestone to a route, or the addition of a new player to an existing process, before "going live", by testing/simulating the new scenarios in the provided experimentation environment. This enables an understanding of the essential features of FInest, how the components used in a scenario will interact, and an estimation of the effectiveness of the scenario being tested.

The FInest team envisions an area “sandbox” in which business people and different stakeholders in the T&L supply chain can explore, interact with, and understand how the FInest technology will work in practice. Specifically, users of the EE will be able to experience FInest enabled technology and test possible end-to-end processes and what-if scenarios before their deployment on top of FInest. The proposed virtual EE will provide the platform for testing and assessing the use case scenarios in Phase 2 of the project and will allow for large scale trials in phase 3.

Our intent is not to validate FInest and test its conformance to its specifications, but to provide an environment in which people can *"try and play"* with using FInest to test new collaborative scenarios before these processes are implemented in practice. The FInest platform provides a new way of collaboration through an information hub that enables access to the data and processes based on *roles* and *views* over the data (*Views* are a general term that represents a mechanism to restrict what parts of data and process a participant can see [5]). We aim to demonstrate this in a "safe environment", a playground identical to the platform in production.

2.2. Basic capabilities

In order to achieve the aforementioned goals, the EE should possess the following features:

- *Ease-of-use* – the design and run of a test should not require any special training;
- *Repeatability* – the capability to run the same test more than once;
- *Comprehensiveness* – understanding the scenario and its outcome by providing means for analysis of test results;
- *Reusability* – possibility of use and run of past tests;
- *Configurability* – the capability to re-run a test with different sets of data and parameters; and
- *Programmability* – the capability of capturing end-user activities in scripts that can be automatically run.

2.3. Potential Stakeholders

Potential stakeholders of the envisioned virtual simulation environment are all parties involved in international freight transport & logistics, including [2]:

- Global logistics service providers (“3PL” and globally operating carriers)
- Various ‘T&L suppliers’ involved in international logistic supply chains (including Small and Medium Enterprises - SMEs)
- Customers with a large demand for logistics services, such as large enterprises
- Secondary logistics service providers (insurance, finance, etc.)
- Public authorities (customs, trade organizations, national traffic management, etc.)

2.4. Users of FInest experimentation environment

FInest groups the different users into two categories:

- *Experimenters/testers*: the actual user of the system, the person who designs and runs experiments/tests. Experimenters possess knowledge about the T&L domain (domain experts) and about simulation technologies. They are also experts in the functioning and operation of the simulation environment.
- *Participants*: people/organizations (business users) that form part of the test or experiment. These can be providers or consumers of services employed in the tests or anyone of the potential stakeholders described above.

Figure 1 shows a schematic picture of FInest EE potential users and mode of interaction.

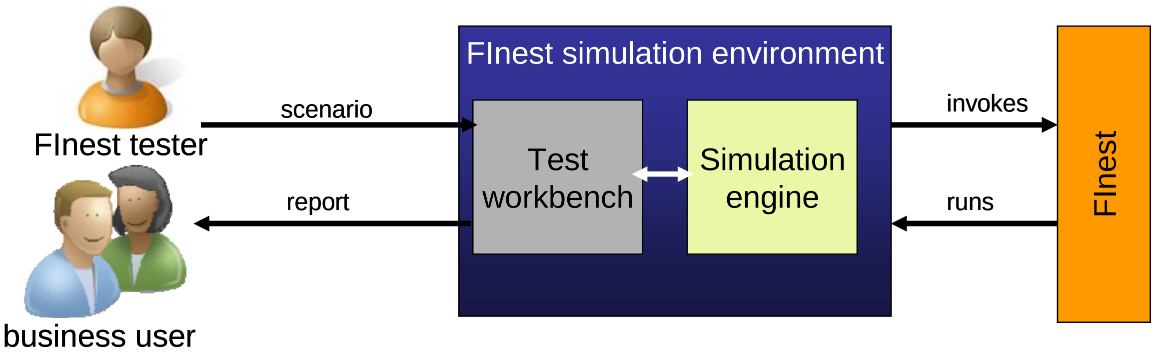

Figure 1 - FInest EE interactions modes

2.5. Key performance indicators

Originally stemming from the IT sector, performance measurement approaches form a modern instrument of service control and have started to become prevalent in logistics and supply chain controlling in the last decade. Key Performance Indicators (KPIs) are measures of strategic importance to a company or department enabling personnel to evaluate and manage processes and organizations. For example, Supplier On-time-Delivery Performance, which indicates the percentage of orders that are fulfilled on or before the original requested date, can serve as a metric for supply chain flexibility [1].

While KPIs are out of scope for work package 4, there is a strong relationship between testing/trying a new process and a notion of an assessment of its performance. Operators would like to answer questions such as: How do we know that the process has succeeded? How do we know if it would be beneficial to implement the new process? Therefore, the FInest team plans to enable the application of KPIs to a certain test by choosing a certain KPI from the set stored in the system (Figure 3). For instance, some common KPIs from the air cargo business that can be stored in the FInest EE data store are the following (for a comprehensive survey of KPIs and T&L refer to [10]):

- *On-time delivery (%)*: The percentage of shipments that arrived on the receiver's premises within the agreed date time out of all shipments that were delivered;
- *Order fulfilment cycle*: The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct quantity, with the correct documentation, to the correct customer;
- *Order fulfilment cycle time*: the speed at which a supply chain provides products to the customer;
- *Shipping document accuracy;*

- *Flown as planned;*
- *Arrived as promised;*
- *Quantity per shipment;*
- *Average number of stops per trip.*

It's worthwhile noting that information required to measure the KPIs will be available from the test and event logs (see Figure 3).

2.6. Terms

We introduce the following terms to be used throughout the document.

Scenario – A file that defines the events/steps that occur during each testing session

Vusers – Virtual users that play human users in the scenario

Users – Human interaction that takes place during the running of a scenario

Vusers scripts – The ordered set of actions that a Vuser performs during the scenario. In other words, the set of instructions executed during a test without user intervention.

Performance – Measurement of a scenario according to predefined KPIs. The Finest team believes that it can exploit the FInest EE to assess the performance of a new process that it would like to try before going live, in order to compare it to existing ones.

Test/experiment – The process to define a scenario, its performance measures, to run, and to analyze it. A FInest test usually consists of 5 phases as depicted in Figure 2.

Session – The elapsed time from the authentication of the user by the experimentation environment until his/her logoff. It can include one or more tests or partial tests.

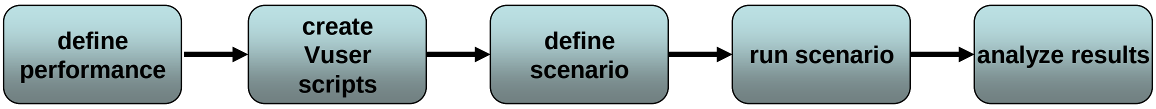

Figure 2 - A test in FInest experimentation environment

The steps of a test/experiment in FInest:

Define performance – Define one or several new KPIs or choose from available KPIs. This step is optional, since the test may not be designed to assess the process in terms of performance.

Create Vuser scripts – Capture the end-user activities in automated scripts.

Define scenario – Augment the Vuser scripts and the performance with human interaction and use of real testing infrastructures into a coherent set of actions to be run. This step pre-processes the actual running of the test by writing down the scenario to be run.

Run scenario - Drive, manage, and monitor the defined scenario in the FInest EE. The output of the run is a log that is stored for later use and analysis.

Analyse results – Create reports based on the scenario performance and the actions taken during the run.

3. Experimentation environment requirements

The main goal of the EE is to be able to run scenarios articulated in FInest. Therefore, as a first step, it should be able to simulate the demonstrators as specified in the technical work packages of the project (WP5-8). The alignment to the demonstrators is twofold:

1. Harmonize and align the work in WP4 to the work done in other work packages of the project.
2. Validate the list of requirements against the list imposed by the demonstrators and refine the current list as necessary.

In order to ensure that all requirements stemming from the demonstrators are covered, WP4 has followed these steps:

1. Reviewed each demonstrator and extracted potential requirements for the experimentation environment
2. Mapped each extracted requirement to the existing list and refined the list accordingly (by adding a new requirement or updating an existing one).

The remaining list was validated as per new insights obtained in the project during the last six months. The final outcome is presented in Tables 1-3.

The FInest team distinguishes between technical, functional, and non-functional requirements. Technical requirements refer to capabilities of the systems external to the EE and with which, through which, and on which, the experimentation environment will function. Functional requirements capture and specify intended behavior of the experimentation environment while non-functional requirements relate to the experimentation environment itself and how well it performs its functions. Tables 1-3 describe the list of requirements for these categories respectively.

3.1. Technical requirements

Table 1 – FInest EE list of technical requirements

Category	ID	Title	Text
EE interfaces	TR001	Underlying run engine	The EE should be able to invoke the FInest platform to run its tests in an automatic and easy way.
	TR002	Front end	The EE should be able to invoke the FInest test front-end to design the desired scenario in an easy way.
	TR003	Use of real data	The EE should be able to access external data stores of test sites and sensors.
	TR004	Amount and quality of real data	The EE should have access to real, large amounts of data for large scale trials in phase 3 of the project. Furthermore, the data should come from heterogeneous devices based on different technologies,

Category	ID	Title	Text
			so a representative sample of IoT inputs can be obtained. Data should encompass air, land, and sea transport in order to be able to test any possible scenario in FInest.
	TR005	Mobility	Support for tracking mobile assets such as vessels, containers, and trucks. Most entities in the T&L domain may move around in a real world environment, thus making the IoT devices attached to them mobile. A particular challenge is the tracking of entities in cases where no Internet connectivity exists (e.g. a vessel located in deep sea).
User involvement and impact	TR006	Impact evaluation	Mechanism for the evaluation of the social impact and acceptance of the FInest platform in the T&L community.

3.2. Functional requirements

Table 2 – FInest EE list of functional requirements

Category	ID	Title	Text
Authentication, Authorisation, and Accounting	FR001	Authentication	When an experimenter provides their personal credentials to the FInest EE, the latter must authenticate the experimenter. The authentication process should comply with the use of roles and views as defined by the FInest architecture. Different views will project different sets of data to different roles (e.g., forwarder or shipper).
	FR002	User account management	At any time the EE shall enable the experimenter to grant and revoke user access privileges.
	FR003	Session management	The user must logon only one time in order to be able to access the EE and begin a session. During the session period there will be no need to re-type the user credentials.
	FR004	Multiple sessions	Multiple users shall be able to login into the same experiment.

Category	ID	Title	Text
	FR005	Authorization	When a user wants to execute any action, the system has to verify that they are authorized to do this action.
Experiment Management	FR006	Experiment configuration	When an experimenter designs a test, the system must provide a mechanism to specify and configure experiments including test name, version, working directory, and etc. "What-if" scenarios will be easily configured by changing test parameters. A desirable feature is the ability to inject new content into an existing test.
	FR007	Identification	Unique identification of a test and each object in the test process.
	FR008	Logs	For each test a separate detailed log will be kept, shared, and be accessible.
	FR009	Automatic mode	The EE should provide the means to specify, run, and simulate Vusers scripts. The script language should be simple to learn and apply.
	FR010	Manual mode	The EE should provide the means to simulate user interaction. Furthermore, a single test shall support the combination of automatic and manual processing. All scenarios should be able to be applied and run simulating manual interaction with FInest. Manual interactions should be recorded and stored for future re-use.
	FR011	Executable	The resulting test should be viewable, sharable, and executable (can be run and compared to the actual log). The same test can be re-run including changes in the configuration of the test. Furthermore, the EE shall provide the option to insert breakpoints and checkpoints during the run of a Vusers script.
	FR012	Reusability	An experiment data store will store all the information regarding the experiments, including a specific and

Category	ID	Title	Text
			detailed log. A test can be easily retrieved and adapted to support new scenarios.
	FR013	Monitoring and reporting	The EE shall support the analysis and reporting of the test performance based on the KPIs defined for the test.
	FR014	Error recovery	Error handling and recovery during a test execution (examples: DB connection, script error message).
Resource management	FR015	Reservations	When the experiment includes one or more test beds in the experiment (quay in a Port, a warehouse), the system should force the experimenter to make reservation for the test beds before starting the experiment.
Storage	FR016	Inventory DB	The EE shall support an inventory DB where it shall keep track of available data and resources
Network	FR017	Connectivity	The experimentation environment of FInest is envisioned as a fundamentally distributed facility with network connections among all FInest partners.
Validity	FR018	Applicability	The FInest EE shall be able to test any possible scenario that can be run using the FInest platform.
	FR019	Performance	The EE shall provide basic fail/pass flag conditions for every test applied. Moreover, the FInest EE shall provide a means to apply defined KPIs to a test or to define new KPIs by a combination of existing metrics. For example, monitoring time of arrival and comparing to promised (arrived as promised KPI), and comparison of quantities (quantity per shipment KPI), and combining them.
Integration	FR020	Interfaces	Smooth integration with the FInest platform. No additional connecting interfaces are required between the FInest (extended) GUI and the EE (see Figure 3).

Category	ID	Title	Text
	FR021	Transparency	Capability of providing all data and information available during the run of a scenario from the FInest platform, *in a transparent way (as the test is run on top of the FInest platform without any intermediate software layer).* This also encompasses the capability of receiving alerts from FInest as in the real-time environment. Examples of data and information and alerts that shall be available during a test execution can be found below.

Examples of data and information available during execution of a test (subject to roles and views):

- Access to market shippers
- Access to contracts
- Details on space availability in vessels or containers per itinerary and ability to reflect space that becomes available due to booking changes
- Access to shipping and offers
- Access to port calls info
- Access to port resources information (port resource management)
- Ability to modify an existing plan and launch a re-plan if necessary. As a result, a new booking will be initiated.
- View available transport services, select option and leg in the route.
- View plans per user

Examples of alert pop-ups during execution of a test (subject to roles and views):

- Contract violation
- Booking changes or cancellations. Relevant stakeholders (e.g., carriers, forwarders and drivers should be notified of the changes). Furthermore, the EE should be able to alter planned booking due to discrepancies in the booking (weight, number of pieces, pickup/drop off location and time, size) or even launch a re-planning procedure.
- Confirmations and rejections

3.3. Non-functional requirements

Table 3 – FInest EE list of non-functional requirements

Category	ID	Title	Text
User interface	NFR001	Easy to use	The user must find the user interface intuitive and easy to use. The capability of designing the scenario must be sufficiently user friendly to be used routinely by the test designers themselves, with minor set-up times and without prior training. This capability will enable business users to run tests.
	NFR002	Web interface	An experimenter should be able to login to the FInest EE from a remote location via a web-client.
	NFR003	Documentation	The EE shall include some help files or user manual.
Stability	NFR004	Experiment fallback	In case of failure, the system should enable reset to the initial settings
Scalability	NFR005	Scale-up	The EE should cope with large volumes of data, varieties of producers, sensors, and actuators for large trials.
Usability	NFR006	Easy to operate	The tool should be easy and intuitive to use and have meaningful messages from the system.
	NFR007	High performance	High performance in terms of response time of the simulation environment to stimulate its use as a test environment.
Privacy and security	NFR008	Information security	Access to all data and information will be based on access rights and privileges of the EE users.
	NFR009	Compliance	In addition to information security, the EE should ensure compliance with all company IT/Information security policy (e.g. Cargo 2000, [9]).

4. Initial design of the experimentation environment

In line with the objectives of the experimentation environment and the requirements listed above, the high level design of the FInest EE is presented in Figure 3. A refinement and more detailed architecture will be provided in *D4.3 Interim specification for T&L EE* to be submitted at Month 18 of the project. In general, the envisioned experimentation environment will operate on top of the FInest platform and will invoke it in each test run, utilizing FInest technologies and databases. Therefore it is foreseen that an experimentation environment in which there are three interconnected major components is required:

1. ***FInest test*** – an identical replication of the FInest platform for testing purposes to avoid playing in the FInest production environment. It is anticipated that in order to enable simulations for all the desired scenarios the team will need to extend the FInest UI to support the required automatic and manual modes of defining tests. This is depicted by the *Test user interface layer* in Figure 3.
2. ***FI-WARE*** – as FInest will operate on top of FI-WARE this interface is required to be able to mimic real scenarios.
3. ***FInest simulation environment*** – the core focus of this deliverable. The depicted modules are explained henceforth.

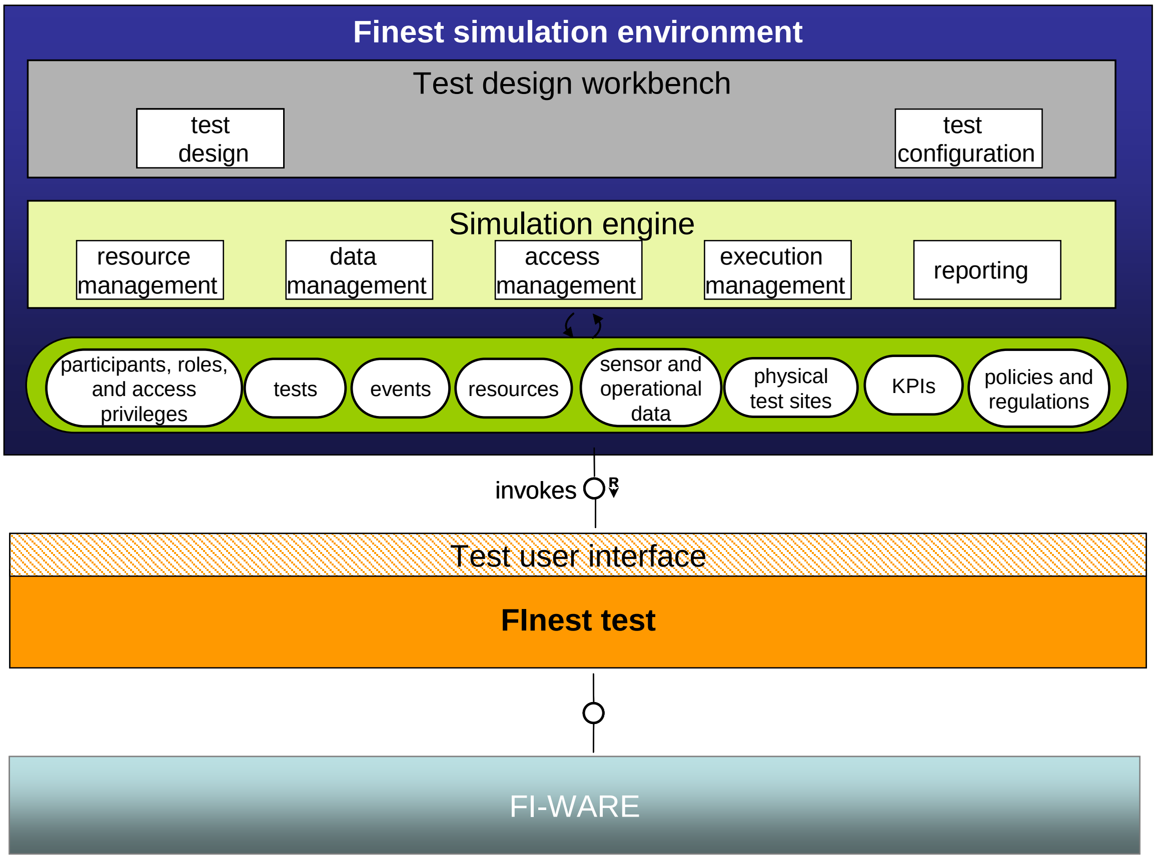

Figure 3 - High level conceptual architecture FInest experimentation environment

4.1. FInest simulation environment

The FInest simulation environment is composed of two main modules:

1. The test design workbench, and
2. The simulation engine.

4.1.1. Test design workbench

The test design workbench is the front-end of the virtual simulation environment. It is composed of two main modules:

1. ***Test design*** – this component facilitates the definition and design of a new test or experiment, or the re-use of a stored test. It enables the possibility to define scripts for automatic testing and human interaction for manual testing through FInest test UI.
2. ***Test configuration*** – this component facilitates the customization of the test to the specific environment. This is achieved by the change of parameters in a specific test stored in the system and by re-running the test using the new set of parameters, or by injecting new input into an already stored test and its run.

4.1.2. Simulation engine

The simulation engine provides the run-time support for the EE. When operating, it maintains information on (shown using “rounded rectangles”) on:

- ***participants, roles, and access privileges*** –In this data store information about all registered users of the EE will be saved. In addition to basic information like username and password, information about the user’s access privileges will be kept as well.
- ***tests*** – This data store will hold descriptions of historical and ongoing tests, both manual and automatic. For each experiment a log will be kept and accessible.
- ***events*** – This data store will store events relevant to the T&L domain to be used in the running of specific scenarios, e.g. a new airport destination, longer waiting time in customs, change in the size of a container.
- ***resources*** **–**This data store will hold descriptions of all resource data available at a given moment. The data store will be searchable by keywords to identify resources required for an experiment or for a service. It is assumed that raw data from sensors will be processed by FIWARE and stored in this database in a way the EE system can access it.
- ***KPIs*** – Collection of performance metrics that can be applied for test evaluation
- ***policies and regulations*** **–** This data store will hold useful information of relevant policies and regulations that can be applied in a test scenario.

As one of the main goals of the FInest EE is to utilize real-data and physical test sites, the envisioned EE architecture will utilize the following two data stores (this is not raw data but data that will be stored in a way that can be applied to tests by FInest simulation engine):

- ***physical test sites*** data store will hold information about test-bed facilities available for the experiment, such as a quay in a port or an airport.

- ***sensor and operational data*** data store will hold real data from sensor networks and operations to be utilized by the EE during simulation.

Operation is achieved by the five components shown in the *Simulation engine* layer:

1. ***resource management*** – the management of both virtual and physical resources required for the test
2. ***data management*** – similar to the resources, this component manages the data for the test
3. ***access management*** – of users according to their access rights (roles and views).
4. ***execution management*** – this module is accountable for the execution of the scenario workflow or test. i.e. the sequential execution of the automatic and manual steps defined in the test, including the definition of KPIs.
5. ***Reporting*** – analysis of the test performance according to the selected KPI(s) and reporting facilities.

4.1.3. Requirements coverage

Table 4 below shows a requirement to module mapping in the FInest EE to demonstrate that all requirements in Section 3 are covered by the proposed high-level architecture of Figure 3 (by at least one module and data store).

Table 4 - Coverage of FInest requirements by the proposed high-level architecture

Module/data store	Requirements covered
FInest test	TR001, FR017, FR018, FR021, NFR003, NFR005, NFR007
FInest test user interface	TR002, FR009, FR010, FR020, FR021, NFR001, NFR002, NFR006
Test design workbench	
test design	FR006, FR007, FR018, FR019, FR020
test configuration	FR006, FR007, FR018
Simulation engine	
resource management	TR003, TR004, FR015
data management	TR003, TR004
access management	FR001, FR002, FR005, NFR008
execution management	FR003, FR004, FR008, FR009, FR010, FR011, FR014, NFR004, NFR009
reporting	TR006, FR013

Module/data store	Requirements covered
Data stores	
access rights	FR001, FR002, NFR008
tests	FR012
events	FR016
resources	FR016
operational data	TR003, TR004, FR016
physical test sites	TR003, TR005, FR016
KPIs	FR019
policies	NFR009

5. Preliminary assessment of reusable technologies and experimentation sites

The FInest platform will allow for new types of collaborations, enabling data and information available via an information hub to all parties in the T&L supply chain based on their roles in the collaboration. These requires identification of potential software tools that can assist in the simulation of such collaborations and meet the requirements specified for such an environment; and for physical tests that can be part of these collaborations.

5.1. Technologies assessment

As previously mentioned, a solution for test design, test creation, test maintenance, test execution, and test data management on-top of the FInest platform is required. Four types of potential types of tools that can apply to these purposes have been identified:

1. automatic software test
2. living labs
3. simulation
4. self development by the FInest team

Each of these approaches will be briefly discussed in the following sub-sections.

5.1.1. Automatic software testing

There are many available software tools that enable automatic software testing. The automation enables services to improve accuracy, save setup time, repeat scenarios when changes are made, and more. The main goal of these tools is to check whether an application conforms to its specifications and correctly performs all its required functions.

Some of the more common types of software testing are: functional/unit testing; integration/system testing; regression testing; load testing; acceptance testing; and documentation testing [7].

There are many of these tools available in the market. Some of the most popular are: Quality Test Professional (QTP) and Load-runner (from Mercury); Quality Center (from HP); and Visual Studio Test Manager 2010 (from Microsoft) [7]. However, all these tools are intended for use by quality assurance users with the goal of validating the software/unit in terms of functionality against a list of requirements. The FInest team's purpose is not to validate the FInest platform in the sense of ensuring the quality of FInest as a software package, but to provide an environment in which business users can interact, experiment, and test the functionality of the platform.

Still, special attention was paid to HP Business Process Testing [8] which is part of the Quality Centre product family. This software provides the ability to assemble business processes on the fly via components, which are simply modules of a business process. These components are implemented beforehand in the software by subject matter experts or quality assurance engineers and can be reused in every test that requires the same functionality. Another benefit of the product is the automatic generation of documentation that describes every business process, all steps taken, all data used to certify the process, every data element used and the results of each action taken. At first sight, it seems that this product can be relevant to the team's purposes, since it enables the composition of processes on the fly. However, there is a long set-up period in which the components are created for later re-use. Furthermore, the large variety of potential processes in FInest makes this componentization challenging. Moreover, in [8] they list the three pre-requisites to be a candidate for HP Business Process Testing:

- There is overlap among the processes (since the more overlap the more components can be re-used)
- The company transitions to automated testing
- There is an intent to move towards the HP Quality Center model in which HP Business Process Testing is a part

Since the objectives of the project does not fulfill at this stage any of these pre-requisites, and the focus is on a business user tool to interact with the FInest platform, the team believes that an automatic software testing tool is not a suitable option for the FInest EE.

5.1.2. Living labs and FIRE

Since 2001, the European Union has been supporting a new paradigm for technological research – the Living Labs. This concept is designed to boost open innovation by ensuring that all relevant stakeholders, including end users, are closely involved throughout the research and development process of new products and services (see for example, SAP living lab in transport and logistics [3] and the FP7 Cassandra project [4]).

Living labs are a work, demonstration, and event space that provides a collaborative platform for logistics companies, research organizations, universities and IT providers. The main idea of Living Labs is that innovators and creators are simultaneous users of the solution. Living Labs are used for the development and testing of prototypes, technologies, and logistic solutions.

Future Logistics Living Labs is an integrated system encompassing the recent developments in the following research fields:

- Interoperability and collaboration
- Standardization and harmonization
- Logistics performance and optimization
- Sustainability
- Safety
- Constrains on export and trade

At this stage, the FInest team believes that living-labs are a broader solution to what it is looking for in the FInest EE. The goal of the FInest EE is to test, evaluate, and experiment with the FInest platform, rather than to build up utterly new solutions or to accelerate the time from ideas to new products. However, this option is left open for phase 3 of the project in which the project will need to move to large trials.

Another EU initiative that the team will follow and assess for matching is FIRE (Future Internet Research and Experimentation, http://www.ict-fire.eu/home.html). The FIRE initiative aims at creating an open research environment, which facilitates strategic research and development on new Internet concepts giving researchers an instrument to carry out large-scale experimentation on new paradigms. Work package 4 will follow FIRE activities to test the potential reuse of existing European test sites developed in the course of the FIRE initiative.

5.1.3. Simulation tools

Simulation is the imitation of the operation of a real-world process or system over time. Simulation technology is a recognized means for planning, evaluating, and controlling processes [10].

In [10] one can find a taxonomy of simulation tools and a comprehensive list of the most frequently used simulation tools and providers, including the field of use of the tool and typical features. Relevant to FInest are the tools that provide capabilities of simulating any business process, such as: Cosa BPM, PACE, ExtendSim, WITNESS, and iThink. However, while these tools can presumably simulate any business process, FInest collaborations are characterized by a very dynamic (artefact/business object centred [5]) process; the applicability of these tools to FInest is therefore limited. In addition, simulation tools require considerable work to set-up the models, which are very specific and include all the decision criteria that will be required during the run [6].

Another classification of simulation tools is by large-scale simulations [10]. Here, one of the most popular tools is ProC/B, which is used for analyzing dynamic processes. There are also examples of specific large-scale simulation of supply chains [10]. One of them is the large-scale model of an air freight transport network, which had the aim to reduce costs (packaging, warehousing and other costs at all hubs within the network) by using a new control concept applied across the network. Data related to system load (such as number of planes, trucks, inter arrival times, throughput times, etc.) has to reflect reality, where a stochastic behaviour of the system (delays, deviations…) can be observed. Another example of a large-scale simulation is a model of a tri-modal sea port and interior transport with the use of GIS (Geographical Information Systems). This study is based on a new approach in modeling of intermodal transport chains. The presented seven-step procedure starts with creation of an Origin-Destination (O-D) matrix and then proceeds with an iterative process of intermodal routing and choice of transport chain alternatives, volume assignment, transport mean assignment (including capacity, cycle time, etc.), cost and time calculation and a final evaluation. Still, the main problem remains the complexity of transport chains and the need to model the processes beforehand. In this case, missing the core feature of FInest collaborations that are characterized by a high degree of dynamics.

In addition to the complexity and dynamics of FInest collaborations, expressed by the level of interplay between FInest modules, it is too early at this stage to assess the level of openness that FInest will have for integration with simulation tools (and therefore the amount of work that will be required for integration), therefore this option is left open for re-assessment in phase 3 of the project.

5.1.4. Self development

This option implies extension of the FInest UI to cope with the requirements of the EE as well as the code development required for the simulation environment (see Figure 3). Obviously, the disadvantage of this option is the time invested in code development. On the other hand, this guarantees the best and smoothest integration with the FInest platform, and best reflects collaborations being created on the fly.

The focus of the FInest EE for phase 2 is the ability to test the scenarios specified in the project. The team believes that this option, while carefully adapted to the minimal set of requirements that fulfill the set of scenarios specified for phase 2, and at the same time, extendable to handle large trials, is the most suitable solution. Other relevant options (living labs and simulation tools) will be re-evaluated as part of the assessment towards phase 3 of the project.

5.2. Experimentation sites

The main objective of the INFINITY (http://www.fi-infinity.eu) project is to capture and communicate information about available experimental infrastructures in Europe and beyond, in order to facilitate large scale experimentation and testing for Future Internet projects and applications and service developments. To this end, the INFINITY project has submitted its Milestone 5.1 report entitled "initial survey of infrastructures" that aims at "identifying and performing an extensive survey of existing and emerging test and experimentation infrastructures and other assets that have the potential to be used and exploited by the FI-PPP”. The information extracted from the surveys will then populate a web repository. The first survey is about to be circulated among identified ICT infrastructure owners in Europe. At this stage, INFINITY focuses only on ICT infrastructures, therefore physical infrastructures suitable for FInest that don't have a sound ICT infrastructure associated with them, are out of scope. The practical outcome is that at this stage, the FInest project will need to rely on FInest partners’ facilities for real experimentation sites that can be used in FInest scenarios.

As the main goal of the EE in phase 2 is to run the project use case scenarios, the team has identified several relevant physical sites owned and operated by FInest partners, grouped by use case, as listed below.

5.2.1. Use case 1: Fish transport

- Port of Ålesund, Norway
- Customs, Ålesund, Norway

- Norwegian Food authority, office in Ålesund
- Container Terminal, Ålesund, Norway
- KN, Ålesund, Norway
- NCL Operation Department, Haugesund, Norway
- One of NCL container vessel
- One vessel

5.2.2. Use Case 2 - Air freight

- KN agents in Xiamen (China): Consolidation point of Airport Xiamen
- KN agents Amsterdam: Consolidation point of Airport Amsterdam
- Amsterdam Airport
- Xiamen Airport
- Air France KLM Operation Center: Consolidation point of Airport Amsterdam
- Air France partner in Xiamen: Consolidation point of Airport Xiamen
- Customs Amsterdam: Consolidation point of Airport Amsterdam
- Customs Xiamen: Consolidation point of Airport Xiamen

5.2.3. Use Case 3 – Consumer goods

Import from Far East

- Arcelik: Purchasing department, production planning department, logistics department (Istanbul)
- Material Supplier (Korea)
- Logistic Providers: Inland transporter, freight forwarder, carriers
- Port authorities: Loading port (Busan) , unloading port (Gebze, Turkey)
- Custom authorities: Customs brokers (Istanbul) , customs (Istanbul)
- Warehouses: Arcelik's warehouse, customer's warehouse (Istanbul)

Export to UK

- Arcelik: Purchasing department, production planning department, logistics department (Istanbul)
- Material supplier (Arcelik, Istanbul)
- Logistic providers: Inland transporter, freight forwarder, carriers
- Port authorities: Loading port (Gemlik, Turkey) , unloading port (Felixstowe, UK)
- Custom authorities: Customs brokers (Istanbul), customs (Istanbul).
- Warehouses: Arcelik's warehouse (Istanbul), customer's warehouse (United Kingdom)

6. Summary and next steps

The ultimate goal of the FInest experimentation environment is to enable large-scale testing and demonstration of the technologies developed during the project based on FInest use cases and real data. To this end, the project has a dedicated work package (WP4 – Experimentation Environment) to lead all the related tasks to be able to demonstrate the use cases defined in the project in phase 2, and broaden the scope to large trials in phase 3 of the FInest project.

In this document an expanded and refined preliminary list of requirements has been presented, which will eventually be the basis for the specification of the FInest EE and phase 2 implementation plan. In addition, a conceptual design of such an environment has been articulated, and possible technologies and sites that can be used towards this end have been surveyed. The FInest team believes that a self-development solution that meets the requirements enclosed in this report is the most suitable solution for the FInest EE. The team's next step will be a more detailed specification of the architecture of the envisioned experimentation environment.

7. References

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