Pan European Laboratory for Next Generation Networks and Services

Anastasius Gavras
Eurescom GmbH, Heidelberg, Germany
gavras@eurescom.de

Heinz Brüggemann
CELTIC Office, Heidelberg, Germany
brueggemann@celtic-initiative.org

Dorota Witaszek
Fraunhofer FOKUS, Berlin, Germany
Dorota.Witaszek@fokus.fraunhofer.de

Kristiina Sunell
ICT Turku Ltd. Turku Finland
Kristiina.Sunell@ictturku.com

José Jimenez
Telefónica I+D, Madrid, Spain
jimenez@tid.es

***Abstract*–The Pan-European Laboratory (Panlab) is a concept that is being introduced to enable the trial and evaluation of service concepts, technologies, system solutions and business models to the point where the risks associated with launching of these as commercial products will be minimised. The accomplishment of this objective, which should encompass many different European collaborative projects, is an important step towards the establishment of a truly pan European collaboration network. A Common Technology Vision for ICT and the Panlab serves as a Technology Roadmap and as a Strategic Development Guideline for European and global telecommunications. Furthermore it defines a Pan European Laboratory (Panlab) for Next Generation networks and Services in terms of legal and operational general conditions, as well as in terms of technical infrastructure. The result is a framework under which a Panlab should operate. The Panlab will build a full chart of the testing labs and sites available and will present a plan of coordination between these so that the full benefit will be realised. It will pave the way for a clear view of where in Europe is the best place to test a specific technology, system, service or application. It will enable the implementation of a physical infrastructure (interconnection facilities, remote management capabilities, etc.), aiming at establishing integration, testing, validation/verification and possibly certification services for product prototypes of European collaborative projects. The ultimate goal is the establishment of the grounds for a future operational and long-term self-sustainable Pan-European laboratory including a business model that would advise on the continuation as an independent entity.**

I. INTRODUCTION

The objective is the establishment of a Pan-European Laboratory for Next Generation Networks and Services. It is a concept that is being introduced to enable the trial and evaluation of service concepts, technologies, system solutions and business models to the point where the risks associated with launching of these as commercial products will be minimised. The accomplishment of this objective, which should encompass many different European collaborative projects, is an important step to the establishment of a truly pan European collaboration network. The activities are split into two phases:

Vision phase: Production of a "Common Technology Vision" that distils a long-term vision for the ICT industry and landscape. This includes the long-term milestones that need to be set on the ICT industry agenda and guidance on how to best reach them. From this common technology vision the long-term requirements for a pan-European laboratory for next generation networks and services will be concluded. The features and capabilities that such a laboratory shall offer will be captured. The focus of the Vision paper is the integration, testing, validation and certification requirements of the industry in the long term, whereas long term is defined here as 10 years and beyond. Such a roadmap describes the long-term requirements for the operation of the Panlab.

The core activities include the development of the "Common Technology Vision". The outcome of this activity is a "Technology Roadmap" serving as a "Strategic Development Guideline" for European and global telecommunications. The indications and propositions of the "Common Technology Vision" will serve as an input document for all European collaborative projects regardless of the framework in which they are embedded. Specifically it would target relevant projects in the European Framework programmes as well as the Eureka cluster programmes, namely the CELTIC community, but also the ITEA and MEDEA+ clusters. It will also be an input to the full development of the 7th European Framework program. The document should be structured according to a layered approach, ranging from components, core and access networks to service platforms. Particular attention should be given to key aspects such as security and fixed to mobile integration.

Definition phase: Detailed definition of the laboratory in terms of technical infrastructure, as well as in terms of legal and operational general conditions. The result of this phase is a framework under which the Panlab shall operate, and the technical specification of the Panlab infrastructure, as well as a description of the approach to implementation.

The second main activity includes the detailed definition of the laboratory in terms of technical infrastructure, as well as in terms of legal and operational general conditions. The result of this phase is a framework under which a Panlab could operate.

II. STATE-OF-THE-ART SITUATION

The underlying motivation for all collaborative frameworks is to help to set up a close to the market collaboration between different companies in Europe. This is accomplished by a number of different projects aiming at different areas of work in telecommunications. At present, the activities in different groups and consortia are only loosely connected. The main "gluing" elements of European collaborative actions are the framework programmes such as the Work Programme of the Information Society Technologies thematic priority for integrating and strengthening the European research area. Another "gluing" element in the area of telecommunications is the "Celtic Purple Book[1]" which provides a common vision be-

[1] http://www.celtic-initiative.org/Documents/CELTIC-PurpleBook-V2.pdf

tween the approaches of the different projects.

However, a more focused vision is needed. That vision should help to establish the common objective of the European research in this area. There are a number of documents that can be of some guidance in the objective: the VI and VII Framework program have helped to determine the long term research objectives in Europe, the ITEA roadmap provides an excellent indications of the developments expected in the software industry, covering the home, enterprise and mobility environment. However, a specific document that should outline the "strategic European vision" on telecommunications is still required.

Even if not available in all of its facets, yet a vision must not remain a pure vision and must be further defined in detail and implemented. For the Panlab this means to define all the details that are necessary to implement and provide such a service to the European technology market. Examples of large existing testbeds in the satellite telecommunications domain are the ESA Artemis testbed[2] and the GALILEO system testbed[3].

III. THE BIG PICTURE – VISION AND CONTEXT

From a very abstract point of view the big picture looks like a three layered construct, encompassing the network infrastructure, the supporting software infrastructure, as well as the services and content offered over the infrastructures. In each of these layers numerous activities exist to research and develop suitable solutions that support the Lisbon objective for Europe being the most competitive knowledge society by 2010.

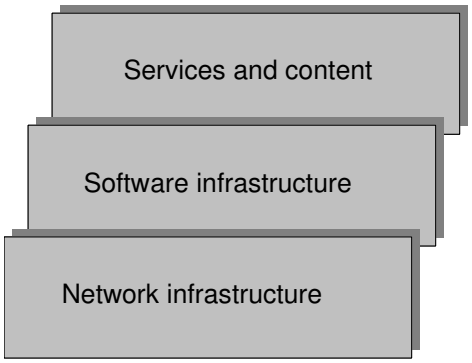

Fig. 1. The big technology picture in support of the knowledge society

The Panlab provides the manifestation of the unified vision for the different areas and technologies. The Panlab will provide the grounds to implement testing facilities for each of the three layers and for the technologies researched or developed in these layers. Projects, interested to employ the Panlab for their research and development activities would be able to define their testing and connectivity requirements already at an early phase of their work thus assuring available testing means at the time when they are expected to be used.

Among the many activities within the three basic layers one problem comes more and more into focus when different technologies are being researched, developed and implemented: There is an increasing necessity for assured and traceable interoperability and full and reliable functionality from end-to-end across several systems. Without reliable methods and tests that confirm a smooth functioning without severe limitations between a majority of services, platforms and networks a competitive knowledge society cannot be built to the degree it actually should and could attain. Small-scale and island solutions can only be acceptable for a transition period until better interoperable solutions have become available. The Panlab concept provides a long-term environment for the implementation and testing of solutions. The Panlab testing facilities and methodologies, provide the necessary means to further develop and implement an environment for intense and, later-on, certified end-to-end interworking across heterogeneous platforms, systems, services, and networks.

The idea of the Panlab is the concept of a federation of distributed test laboratories that are interconnected and providing access to required platforms, networks and services for broad interoperability testing. The coordination of the required access and test connections is established through a centralised Panlab office. Obviously, in the long term a Panlab must never remain in a static configuration but will have to be extended, adjusted and improved by any new available platform, service and system that can be offered by the connected laboratories or new laboratories joining the Panlab. The rules and procedures of how this can be achieved have to be developed.

The main "customers", but also "providers" of laboratory elements (systems), are IST projects that are going to be defined within the new 7th Framework Programme, especially within the currently defined Technology Platforms, projects that will run under the EUREKA cluster frameworks, as well as any other, national or international collaborative initiatives.

The following initiatives are identified as potential customers:

- CELTIC (EUREKA ICT cluster for end-to-end telecommunications systems)
- ITEA / MEDEA (Eureka ICT cluster for services, platforms and microelectronic systems)
- IST FP7 e-Mobility technology platform
- IST FP7 NEM technology platform
- IST FP7 NESSI, ARTEMIS
- IST FP7 other ETP focusing on software, services or security (e.g. ENIAC)
- Any other national or European collaborative initiatives that is currently not yet identified

Essentially the bottom layer lies within the domain of CELTIC and the e-Mobility technology platform. The middle layer lies in the domain of ITEA and IST (e.g. ARTEMIS, NESSI). The top layer lies within the domain of NEM. Apparently a number of different collaborative projects might claim more than one layer, but there is certainly always a major focus of the activities.

From the currently established framework programmes the Eureka clusters are, currently, the most immediate customers as their work programmes have been established and running since several years. In addition their projects are already focusing on the provision of concrete testing facilities. This is

[2] http://www.esa.int/artemislaunch/
[3] http://www.esa.int/esaNA/galileo.html

namely true for CELTIC projects which, in their project definitions, have already considered the contribution to a pan European laboratory as default requirements.

Also of particular interest are the new FP7 Technology Platforms. As these platforms are currently under definition concrete requirements for a Panlab have not yet been indicated. However, as soon as these platforms have been set-up and calls for the first project proposals will be issued, the availability of a Panlab will add a number of additional possibilities for these projects, in particular, for the consideration of interoperability and functional end-to-end testing.

The long-term vision of the Panlab is that of a business activity, that offers testing, validation and potentially certification services for the "research market". Under which conditions and potentially under which regime a Panlab offering could be established is beyond the scope of this project. However, it is within the scope of the project to propose a suitable business model that could allow for a long-term sustainable establishment of such integration, testing, and validation services after the end of the project. Only if this continuation of the Panlab operation can be achieved and assured, the real value of the Panlab concept, to be a reliable and available testing facility, will become possible.

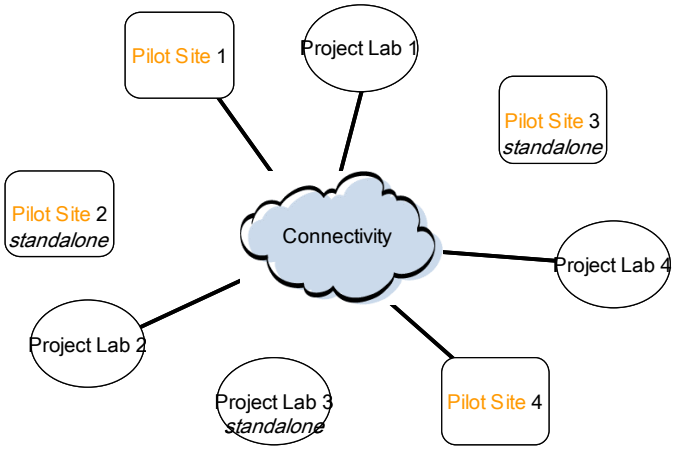

Fig. 2. Possible topology of the Panlab

Furthermore, the Panlab, once in full business operation, could even be extended to an accredited and recognised laboratory to carry out certified interoperability tests from end-to-end by assigning a certificate to services, products, etc. indicating that these product passed the interoperability tests across defined systems, platforms and networks. If this extension can be achieved for the Panlab Europe could then dispose of a quite unique facility.

IV. ISSUES ADDRESSED

Since it is impossible to provision for all possible forms of testbeds that would require a large amount of equipment and systems to be deployed in a single place the Panlab will adopt the working style of a distributed interconnected but integrated laboratory. This approach has obviously the benefit of flexibility, but at the cost of the management of the distributed environment. The issues range from logistics, availability of qualified personnel, and remote management of systems to the legal and operational details that need to be in place in order to allow for interconnection and testing at "competitor's" laboratory environments.

The main issues that arise from this context and which can be mapped to different activities are listed below:

- Vision and Roadmap

For a long term operation Panlab there must exist a long term and agreed vision for the ICT landscape in Europe in the timeframe 10 years and beyond. A number of visions have been drafted and are available. This activity will distil and agree a Common Technology Vision from which long-term requirements can be drawn for the establishment of a Panlab.

- Legal framework, agreements

In order to interconnect existing laboratories and prototype environments as well as running pilots a common legal framework must be developed and agreed among the potential stakeholders in the industry and the research environment. Experience to date has shown that too often an ambition to interconnect testbeds fail due to the non-existence of commonly agreed and available legal grounds. The attempt to establish such legal grounds on a per case basis is too costly and time consuming.

- Operational guidelines

Assuming a legal framework in place, the operational procedures of how different testbeds can be connected and how tests are performed during an established connection have also to be defined. The mere physical interconnection of testbeds and laboratories is only the first step in a long chain of steps that will have to be followed in order to successfully perform an integration, testing and validation task. Operational questions that arise are for example to clearly identify the rights and responsibilities of the different players involved, as well as the chain of command. Also essential is to define how to resolve conflicts and problems is cases for example, that certain functionalities fail due to incompatibilities. Last but not least the definition of access rights to the management of remote assets is not only a technical challenge.

- Connectivity between testbed sites, pilots

Even if the current deployment pace of broadband wireline and wireless connectivity across Europe is very high, the establishment of connectivity through new and innovative network technologies will always be an inherent issue. This is due to the research and experimentation that will have to take place in order to find out about the most viable network technologies and solutions. The challenge is to find ways to achieve connectivity between testbeds that offer the newest technological capabilities and still remain cost effective by reusing existing infrastructures. A good past example of such challenges is the effort to interconnect IPV6 islands though current Internet connectivity.

- Requirements capturing of the "customers"

This activity will concentrate on ways to capture the future requirements of the customers in terms of integration, testing and validation. The challenge here is how to identify in a very early stage the needs of future research projects. Thus the main approach can only be at a meta-level and define the methodology of how to address this forward-looking issue.

- Inventory of available systems and provided interfaces

As was explained earlier, the Panlab concept calls for a very dynamic environment, in which current state of the art systems, components, and capabilities can be made available on demand. This requires the ability to maintain an inventory of artefacts that can compose a certain environment, as well as the provided interfaces a "customer" can access and use to test his own system or prototype.

- Inventory of supported standards

Another challenge is the ability to somehow qualify and name the necessary standards that Panlab components conform to. In the current standards landscape with a very large number of standards it is indeed very difficult to agree on certain standards. However standards are essential for the global ICT market as they provide the only means to assure end-to-end interoperability of systems. Thus again the feasible approach is to define the way to select appropriate standards on a meta-level, by inventorying functionalities and mapping them to the different standards available or in progress.

- Long term maintenance and upgradeability to state-of-the-art

Finally the Panlab will have to evolve constantly to be able to always offer the latest state-of-the-art capabilities and functionalities. This activity will define how to identify the need include new systems and functionality or to upgrade existing systems and available functionality, as well as how to maintain operations of established and popular systems or available functionality. This activity will also define the necessary conditions upon which one can decide to phase out a system and no longer include it in the inventory. The same requirement applies also for the inventory of supported standards. The Panlab will need a process that can guide the decision to include new and phase out no longer needed standards.

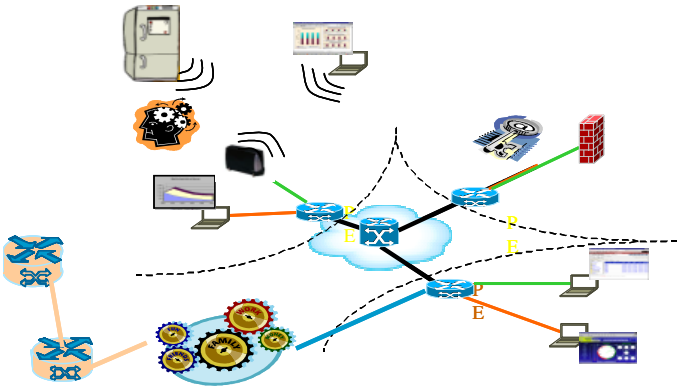

Fig. 3. The Panlab is an aggregation of the state-of-the-art

In any case it is important for the long-term sustainability of the Panlab to adopt a market-oriented approach in the definition phase.

In the implementation phase of the project the ambition is to provide a tailored environment for "customers" to integrate, test and validate their "products". The tailored environment would be an aggregation of the state-of-the-art components available at the time of the customers' requirement to perform the anticipated integration.

V. DEFINITION

A primary objective of the project is to define the means for integrating existing and future laboratories and testbeds. Usually a laboratory describes a permanent institution where scientific research and experiments are conducted. Laboratories share some common features, very broadly speaking, high-speed connectivity, processing capabilities and storage capabilities. Furthermore depending on the focus of laboratories testing and monitoring equipment is included. In contrast testbeds are set-up temporarily for testing and evaluating a certain concept and its implementation. In this document the terms 'laboratory' and 'testbed' will be used to some extend interchangeably.

In order to establish a certain environment for integration testing and validation by interconnecting different available testbeds a number of prerequisites have to be met. These prerequisites are both technical and non technical in nature. On the non-technical issues the main challenge it to define a legal framework under which federated testbeds can operate. Also a non-technical issue is the definition of the administrative procedures (methods and processes) of how a federation of testbeds should operate.

On the technical side the objective is not to just identify and describe existing testbeds in the form of technologies available, but rather to define the way of how to describe and categorise them. Having this information available will enable us to identify additional infrastructure components needed to run the federation. The additional infrastructure components may include existing tools, but it is expected to include a number of essential new components that will be needed for the federation.

A. *A simple example*

A simple example is that a test has to be performed in an environment which is a composition of two platforms P_a and P_b belonging to different administrative domains D_a and D_b and which are connected through network resources N_c belonging to organisational domain D_c. How can the distributed cross-domain management for such a configuration be setup? There are legal, operational and technical issues to be solved. Three sub-activities need to be addressed in this activity:

- Define and agree a legal framework under which a Panlab could and should operate. Under which legal regime do D_a, D_b and D_c connect their resources?
- Define and agree operational procedures that have to be followed when a "customer" acquires services from the Panlab. What is the protocol for making sure that the Panlab as an institution and its "customer" has timely access to the requested resources?
- Identify the technical implications of remote access and usage of distributed resources. Distributed cross-domain management is an open issue at large in the context of next generation information and communication networks and services. The purpose of this largely automated way of remote management is to relief the resource owners in the long term from binding own human resources during the execution of tests within the Panlab.

B. Legal issues

Interconnecting different testbeds belonging to different administrative domains means granting some level of access to remote resources that are owned by different stakeholders. This has the consequence that a legal agreement must be in place that governs the rights and obligations of all stakeholders involved. Such a legal framework must include among others:

- definition of terms,
- handling of intellectual property rights (IPR), both as foreground and as background IPR,
- definition of confidentiality
- process for resolution of conflicts
- process to handle cases of misusing rights or neglecting obligations
- clauses for termination of relationships
- …

Obviously the above list is not exhaustive.

Furthermore, and in order to pave the ground of establishing a long-term sustainable Panlab, further conditions must be met. Inevitably a legal entity will have to be established, and to which the results of the project need to be transferred. This legal entity will have to assume the management of the Panlab associations, effectively manage the different contracts between the stakeholders that engage in interconnecting their resources for the purpose of testing.

The transfer of such assets to such a legal entity will be well prepared within the project, considering the ambition to have a long-term impact on the ICT industry and research market. Legal documents will be drafted and consulted with a large population of organisations that are potential providers of testbeds and customers of the capabilities offered. In the long run, this larger group of organisations is customer of its own services and a potential provider of testing resources. In the simplest form such legal documents have to include the legal form of this entity, its rights and obligations, as well as the rights and obligations of organisations engaging in a relationship under Panlab terms.

C. Approach to technical infrastructure

The term testbed covers a variety of infrastructures. Even the testbeds dedicated for in a given research field can exhibit big differences. The testbed can be used for different purposes:

- To prove new concepts and technologies – new developed technologies are included into the testbed in order to tests prove/investigate claimed/desired features
- To integrate new components – an existing infrastructure allows to integrate into it new developed components
- To test/demonstrate – the testbed provides an environment for testing. It includes tests in real environments, simulators, testing tools, etc.

There is a need to define a process of testing – how to organise the test process, how to pay, how to define an offer and find users. There may be differences depending on the purpose of the testbed. This variety of the testbeds requires some effort to categorise the testbeds, their capabilities and define means for description.

The Panlab needs a catalogue of components that can be aggregated to provide a certain environment. For this purpose it is important to define how such a catalogue would look like and how an environment can be specified that can be build out of such components.

A component is usually described by means of functionality it provides and by means of interfaces it offers. The meta information, that is what information is used to define the components, will help to define and produce such a catalogue. The purpose of such a catalogue is threefold:

- Identify existing components that can be used to compose a testing environment. These would be available sub-labs in the participating companies, labs available in other companies and where appropriate, commercially working labs, which generally focus on specific test functionalities.
- Identify the suitability of new components that result from running projects and which may become components of the Panlab catalogue.
- Identify missing components that will have to be provided under commercial or other terms by a third party

In the definition of resources it has to be considered:

- Which testbeds are available
- Which testing tools are supported
- How a testbed can join the testbed federation
- What information is needed in a description of the testbed (matrix with supported functionality and available capabilities)
- How to extend the definitions with new offers

The metadata used for the description should help to define and publish an offer.

The testbed has a lifecycle. The lifecycle in general comprises the phases of:

- Design,
- Setup,
- Operation and maintenance
- Termination.

In reality the phases of the testbed lifecycle are often overlapping – e.g. while some components are operational or even terminating, new parts can be designed and setup. This will be also the case in the Panlab, being a federation of testbeds. The testbeds will evolve with the time, new testbeds will join the federation, and some of them will leave. Therefore is it so important to have a way to manage all the testbeds. The problem is how to provide a global remote administration and management service for the Panlab. How to store and manage all the information? And finally who should provide this service?

Offering a testbed has many consequences. This depends partly on the kind of the testbed. In the interconnected testbed federation the test will be executed not only locally but also remote – here the secure remote access has to be guarantied. Additionally it has to be defined which resources are visible to the others, open interfaces and policies that govern the usage of the testbed resources.

Plans for experiments have to be provided. Such a scheduling concerns distributed resources and should consider sharing of services/resources between different testbeds.

The operation of a testbed covers analysis, diagnostic and troubleshooting. There is a need to define the form of a trouble ticket in a case of a fault – how to describe the problems and

define the workarounds. The detection, isolation and correction of faults is an even more complex problem in the case of connection of heterogeneous test environments. Network connectivity and performance problems have to be identified and repaired. The problems have to be analysed and documented.

During the operation of a testbed the problems influence the development of the testbed leading to extensions and changes that will need to be performed:

- To make the testbeds more flexible, to assure compatibility
- To provide secure access and control
- To separate the resources – to run different tests in parallel (not exclusive usage of testbed resources), to separate control, and reports
- To provide scheduling
- To provide better tools for monitoring and management
- To provide measurement
- To support new technologies, platforms

D. *Administrative and organisational issues*

In the overall Panlab context several resources crossing organisational and administrative boundaries have to be interconnected. A governing framework has to be developed that addresses the administrative and organisational issues. Such issues need also to be clear on the legal grounds that need to be defined.

Such a framework needs an underlying modelling framework and associated concepts have to be defined and agreed among all entities participating in the Panlab. The following sketches a skeleton and initial nomenclature that could be used to define the framework.

The bases of the Panlab are the resources and assets owned by administrative domains and are separated by reference points. In order to specify the policies and allowed interactions between administrative domains one needs to specify the visibility and rights of each resource in the domain with regard to interconnected domains. These rights and visibility are included in the contract. The contract is established between administrative domains and can be negotiated. However for streamlining the establishment of contracts only the technical aspects of a contract will generally be subject to possible negotiations. The general terms and legal grounds will be a fixed part of the contract.

- *Administrative domain*: An administrative domain is defined by the requirements of one or more roles and is governed by a single objective.

An administrative domain is defined by the requirements of one or more roles. Administrative domains interact with each other through reference points, which are the implementations of the relationships between administrative domains. The concept of administrative domain is based on ownership. Ownership implies the universal privilege of owning and managing the assets and resources inside the domain.

- *Contract*: A contract is the context defining constrains for one or more reference points to operate under.

A contract provides the basis for the context to govern the reference point subject for interconnection. Within the constraints specified in the contract, the context can be modified by negotiation. This can only be the case for the technical part of a contract. The contract terms and legal grounds can never be modified as a result of the negotiations within the Panlab scope, as this might violate the policies negotiated for other contracts in the Panlab scope.

- *Reference Point*: The manifestation of a relationship in the Panlab. The reference point consists of several related specifications governed by a contract.

The reference point consists of several related specifications governed by the contract. A reference point specification can be split into reference point segments that constitute meaningful, self-consistent specifications. For example one segment specifies remote access control for using remote resources, another segment specifies remote management and monitoring of the remote testbed.

- *Relationship*: An association between two roles.
- *Role*: The expected function performed by a stakeholder in the Panlab environment.

The roles are identified by analysing the current and expected future needs of a stakeholder in the Panlab scope. The definition of the roles are driven by the certain needed separations, for example:

- *Technical*: areas of different development speed of technology are placed in different roles.
- *Economic*: roles, which are considered providers or customers of Panlab services are assigned to different roles.

Roles can be combined in administrative domains to suit the needs of the stakeholder. A relationship expresses the interaction requirements between two roles. The manifestation of a relationship between two administrative domains is the reference point.

- *Stakeholder*: A party that holds a business interest or concern in the Panlab. A stakeholder owns one or more administrative domains

In the implementation phase of the project the ambition is to provide a tailored environment for "customers" to integrate, test and validate their "products". The tailored environment would be an aggregation of the state-of-the-art components available at the time of the customers' requirement to perform the anticipated integration.

VI. FUTURE OUTLOOK

The Panlab will have a direct impact on the quality of research results, providing efficient means to integrate, test and validate these. From the research economics point of view this will help many research projects and other initiatives to more easily plan for testing and validation of their prototypes and results in a larger context. Being able to interconnect with existing testbeds will give higher assurance to the players involved that their systems are capable to integrate in a large scale and are market oriented.

ACKNOWLEDGMENT

The authors would like to thank Jacques Magen, Juha Saarnio, Peter Herrmann, Thomas Magedanz, as well as all members of core group of the CELTIC initiative for their valuable contributions and feedback.