# Generic Resource Federation - Mechanisms and Prototypes Serving the FIRE and FI PPP Visions

Sebastian Wahle
Next Generation Network Infrastructures
Fraunhofer FOKUS
Berlin, Germany
sebastian.wahle@fokus.fraunhofer.de

Thomas Magedanz
Lehrstuhl Architektur der Vermittlungsknoten
Technische Universität Berlin
Berlin, Germany
tm@cs.tu-berlin.de

## I. INTRODUCTION

This presentation shall contribute to the discussion around heterogeneous resource federation models, strategies, and implementation scenarios. From the author's point of view, overcoming heterogeneity is the most challenging issue where not only the resources but also the federation mechanisms and implementations themselves are heterogeneous when federating across the boundaries of federations. Federation might take place on several abstraction layers where in the end different federations might agree to federate on yet another overarching level. This will ultimately lead towards a massive federated resource pool where users can assemble desired functionality across layers and administrative boundaries upon demand in a seamless manner. This vision is driving our work.

Several initiatives and projects worldwide currently investigate federation mechanisms. Among those are several well-known projects from the GENI and FIRE initiatives, a full overview has been published before [1]. All those initiatives and projects are currently designing and implementing federation mechanisms and procedures with specific use cases in mind, for example offering a large scale experimental facility to the Future Internet research community.

Federating arbitrary resources across multiple administrative domains and on multiple federation levels, involves so many technical, operational, and legal issues that it can be considered a valid research field with many yet unsolved issues. In order to realize the vision of fully federated information and communication technology resources that can be used transparently and seamlessly, the following fields have to be addressed: resources description, resource registration, resource access control, service level agreements, resource usage policies, resource management, resource life cycle, operational procedures, legal framework, provider/user incentives, business framework, market platform, etc.

Although many of the above listed issues have been addressed and widely discussed for single domains, additional constraints arise for multi level federations where administrative domains allow resource usage beyond the first abstraction layer. For example, a university might establish a resource federation where different departments adhere to a centralized resource control/management instance, resource description model, operational procedures, etc. and commit resources to a university-wide resource pool. The university might now join a nation-wide initiative (e.g. GENI) where several universities with similar resource control/management schemes agree to federate. This federation is then essentially a federation of federations. The next level is still imaginable: a federation of nation-wide federations (e.g. GENI and FIRE agree to federate). This is basically a recursive model that can be investigated at any meaningful granularity. Generally, the distribution of control power is a central characteristic of federations which is also addressed by formal definitions: *A federation is understood to be an organization within which smaller divisions have some internal autonomy* (Oxford definition). Merriam-Webster defines federal as: (1) *formed by a compact between political units that surrender their individual sovereignty to a central authority but retain limited residuary powers of government*; (2) *constituting a form of government in which power is distributed between a central authority and a number of constituent territorial units.* Although such definitions have a political background, the federation model outlined in the next section has been designed with this in mind.

## II. FEDERATION MODEL

This section introduces the *Base Model* and derives different levels of "surrender"; the *Central Scenario* and the *Distributed Scenario*. The Base Model follows the definition of federation given in the previous section which uses the concept of surrendering individual sovereignty to a central authority. This understanding is extended for our field to support resource federations *on a par*. Independent of the level of surrender, similar functional entities are found in most federation architectures to enable cross-domain and cross-technology federation. The entities are shown in Figure 1 and are defined below. They constitute a proposed FIRE federation model [2]. The entities are meant to be meta-entities that could be mapped to the entities defined by other approaches such as ORCA, Panlab, PlaneLab, or SFA. Such mappings shall ultimately allow for heterogeneous federations across the different "silo" approaches that are currently driven independently.

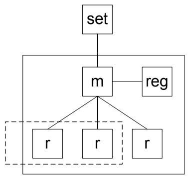


Fig 1: Federation model entities

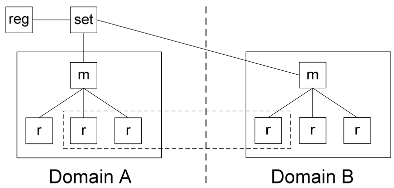


Fig 2: Full surrender scenario

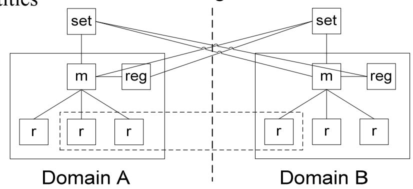


Fig 3: Federation on a par scenario

*Resources (r):* The model abstracts from concrete resource types. A resource can be anything that can be controlled by software. Examples are: physical and virtual machines, software packages, dedicated hardware such as sensors and routers, as well as abstract constructs such as for example domains, accounts, databases, and identities

*Domain manager (m):* software that controls resources inside an administrative domain. It exposes resource management functionalities at the border of a domain and connects to a resource registry. Supported operations on resources are typically the CRUD (create, read, update, delete) commands for controlling resources via a common interface.

*Registry (reg):* holds data records for domain resources. Registries may or may not expose an interface to (external) setup utilities (set).

*Creation / setup tool (set):* resides within or outside of a domain and communicates with domain managers and registries. Set utilities might provide user interfaces for the configuration, deployment, and monitoring of resources.

*Virtual grouping of resources (dotted rectangle):* each administrative domain enables access to a number of resources. Collectively, all administrative domains provide a large pool of resources. Experiments usually require only a subset of the total resources that need to be provided in a certain configuration. This subset may or may not span the border of several domains and is here referred to as a virtual grouping.

*Administrative domain (solid rectangle):* is typically represented by an organization such as a research institute and provides a collection of resources.

The *Central Scenario* is what we also call the *full surrender* scenario in Figure 2 where the resources committed from domain B can be fully controlled via domain A. An example of the full surrender scenario is the Panlab federation [3] where all Panlab member domains allow Teagle, the central setup tool (set), to control resources in their domain. It relies on a central registry where resources from all member domains are registered. The advantage of this scenario is that resource representations backed by centrally administered resource models and operational procedures can be simplified.

The *Distributed Scenario* is what we also call the *federation on a par* scenario in Figure 3 where the participating domains allow the mutual control of resources across the borders of their domains. Here, the set utilities are allowed to access each other's domain managers and registries. This enables the full scale of resource sharing across organizational boundaries. However, in order to achieve this, a number of agreements need to be in place such as common resource descriptions and management interfaces. Legal and operational procedures as well as resource access and usage policies are more difficult to realize compared to the central scenario. This scenario has been implemented to federate Panlab resources and resources from a private PlanetLab installation [5]. Other scenarios that implement something in between the two extreme scenarios explained above are possible and can be applied to meet requirements and constraints in specific federation contexts.

## III. PROTOTYPE

*Teagle* [4], [2] is the central federation resource search and composition engine for Panlab and can be mapped to the *set* entity of the Base Model. Currently, Teagle implements the following functions:

- Registry (users, resources, configurations, etc.)
- Creation Environment (setup and configuration of virtual resource groupings, this is called the VCT tool)
- Request Processor (validates configurations and triggers setup execution)
- Orchestration Engine (generates an executable workflow that orchestrates services form different domains to provision resources for the experimenter)
- Web Portal (exposes search, configuration interfaces, and general information)

In our prototype implementation resources are controlled by resource adaptors (RA) that are plugged in to the Domain Manager (DM) framework. An RA can be seen as a device driver that supports resource specific communication shielding Teagle from this complexity. Examples for this type of communication are SPML, SNMP, or command-line interface commands. Any type of resource can be supported by the DM as long as an RA can be implemented and the configuration options can be described and modeled so that the *set* and *reg* entities (Teagle) can handle them. This approach allows us to manage heterogeneous resources that support a variety of different communication mechanisms, reside in different layers, and belong to different administrative domains.

[1] Thomas Magedanz and Sebastian Wahle. Control Framework Design for Future Internet Testbeds. e & i Elektrotechnik und Informationstechnik, 126(07/08):274-279, July 2009. ISSN: 1613-7620 (online).

[2] Sebastian Wahle, Thomas Magedanz, and Anastasius Gavras. Towards the Future Internet - Emerging Trends from European Research, chapter Conceptual Design and Use Cases for a FIRE Resource Federation Framework, pages 51-62. IOS Press, April 2010. ISBN: 978-1-60750-538-9 (print), 978-1-60750-539-6 (online).

[3] Website of Panlab and PII European projects, supported by the European Commission in its both framework programmes FP6 (2001-2006) and FP7 (2007-2013): http://www.panlab.net

[4] TEAGLE portal website: http://www.fire-teagle.org

[5] Konrad Campowsky, Thomas Magedanz, and Sebastian Wahle. Resource Management in Large Scale Experimental Facilities: Technical Approach to Federate Panlab and PlanetLab. In 12th IEEE Network Operations and Management Symposium (NOMS 2010), April 2010.