

Scaling processes and data flow across the global enterprise

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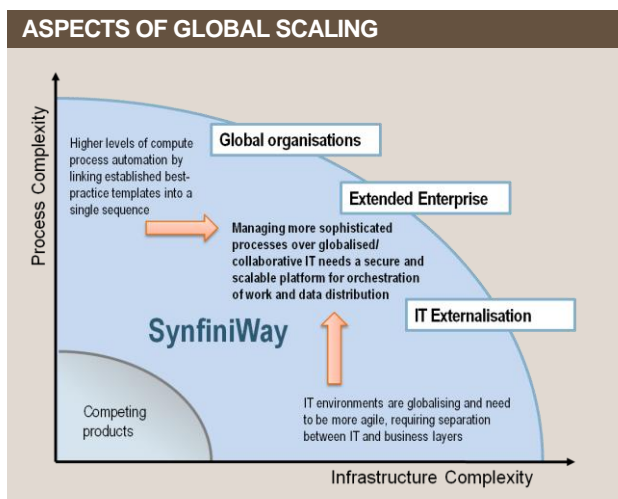
INTRODUCTION

Businesses today are under increasing pressure to improve the way they bring products to market. The requirements of an organisation are not just concerned with cost savings in IT, but building an IT infrastructure that increases business effectiveness and brings competitive advantage. Capturing and exploiting intelligence within an organisation becomes an essential part of adapting to competitive pressures. And innovation within the business process chain can raise product quality and reduce time to market. Finally, all this takes place in an environment of globalisation affecting interactions between the members of an organisation's workforce and their usage of IT assets.

To meet with these demands, organisations are pushing the boundaries of conventional technologies. And with the advent of truly global organisations spanning multi-site, multi-country and multi-regions, business processes require the capability to operate over a dynamic and global scope of resources which are distributed across multiple business networks.

As a consequence, **global scaling** has become a critical factor enabling organisations to meet the challenges of today's competitive and collaborative environment. However, achieving scale means confronting two dimensions of complexity:

- complexity within the increasingly connected and heterogeneous infrastructure;
- complexity from the more interlinked and interdependent processes.



Distributed and grid computing paradigms contain tremendous potential to address some of the key issues associated with global scaling and yet the dynamic and complex nature of these environments leads to many daunting challenges. Issues such as global resource management, remote collaboration, distributed job scheduling, global data delivery, security, multi-domain administration, and heterogeneous software environments are but a few of the complexities inherent with a distributed IT infrastructure.

The goal of SynfiniWay is to address the key business drivers of the global enterprise and build a software environment that makes distributed and global IT infrastructures usable on a daily basis. To achieve this, SynfiniWay introduces an innovative way of utilizing the global information infrastructure as a platform for computation, data sharing, and collaboration to make distributed computing usable, comfortable, and effective.

SynfiniWay supports global networks and business processes by combining key technologies within a single integrated framework. These include:

- High level meta-scheduling
- Support for complex business workflows
- Implicit point-to-point data movement
- Uniform service oriented view of IT resources
- Single sign-on to all authorised resources
- Distributed administration
- Dynamic resource discovery
- Security, reliability, and performance

By combining these essential facilities into one integrated framework, SynfiniWay gives enterprises a single interface for both usage and management of a global IT resource pool. End-users can access any resource directly from their desktop with existing tools integrated with SynfiniWay. Business processes developed with SynfiniWay are instantly capable of utilising global IT resources. The entire framework can be dynamically expanded or contracted as new resources are deployed or existing resources are decommissioned without affecting end-users.

Extending the framework to include external compute centres is a simple matter which can be achieved without changes to business logic or users work practices, allowing an enterprise to address their needs to scale-out user process execution and data access without limit.

END-USER VIEW

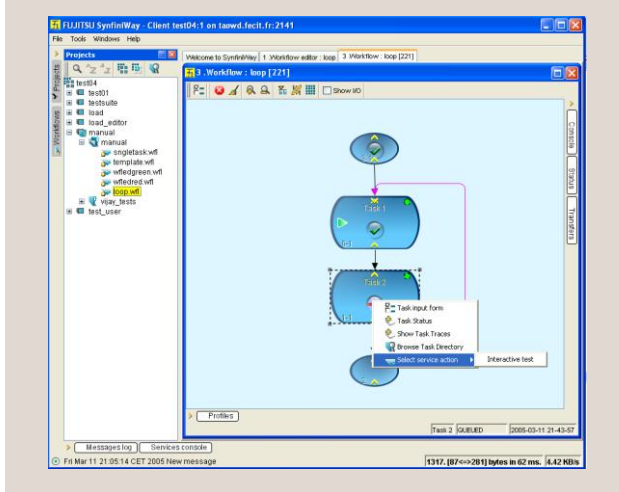
SynfiniWay hides from the user the hardware and network complexities most commonly attributed with today's computing environments. Users can run jobs on a multitude of hardware platforms without having to worry about which machine or architecture is needed for each execution step or where and how data is moved from its current location to the systems involved in the execution sequence. Complexities regarding the interface with batch subsystems and other system facilities become transparent to the user.

SynfiniWay can be applied to a variety of environments, including the linking of local and remote computing resources. On distributed production environments in which systems are scattered over geographically separated locations, SynfiniWay transparently manages the resources of the participating systems. It allows a user to submit jobs on a network of hardware systems and have their results returned to the local machine on which they are working. This is achieved through a single interface which has access to published services in the SynfiniWay framework.

Java client

Connection to the framework can be achieved using a Java-based GUI, known as the "SynfiniWay client".

SYNFINIWAY GRAPHICAL USER INTERFACE



This tool is used for workflow editing and also acts as a workflow submission and monitoring interface. Utilising the single sign-on mechanism, users can access resources in a uniform way across the entire global pool.

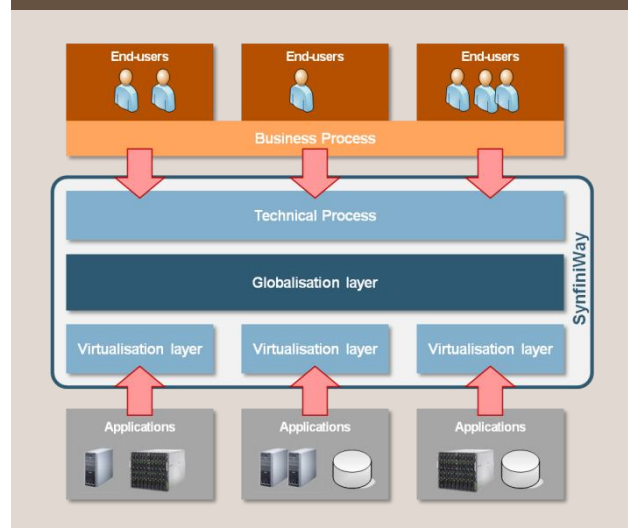
Web client

Connection can also be achieved using a Web client. This client allows the user to launch and monitor workflows, browse directories on the remote systems for which he has authorisation and transfer files between the remote systems.

Application Programming Interface (API)

The API enables an enterprise to integrate easily within existing desktop tools and processes, interfaces with the SynfiniWay framework, extending the value of current tools. The so called "Global Desktop" concept can be realised when traditional desktop applications are linked with the data and process execution environment created by SynfiniWay, allowing access and use applications to scale.

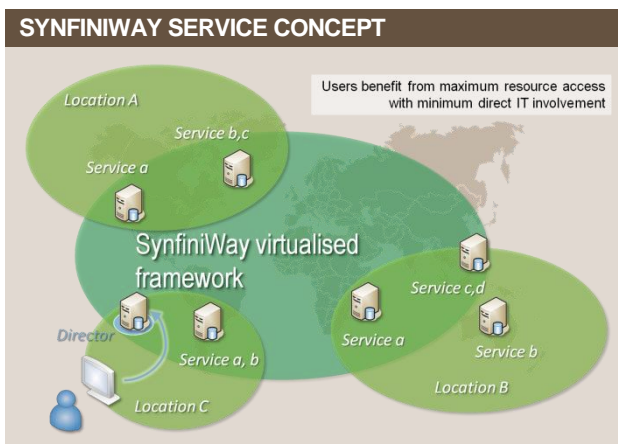
APPLICATION ENABLING – GLOBAL DESKTOP



SERVICE-ORIENTED APPROACH

Applications utilised on a SynfiniWay framework are made available to end-users as services. The service approach provides an abstraction layer that enables users to build business logic that is replicable, resilient and completely independent from the IT infrastructure layer. Enterprises can develop, disseminate and execute business expertise throughout their organisation with the confidence that it can be used from any point within the SynfiniWay framework.

Simple or complex tasks can be abstracted into services, allowing a user to easily run services regardless of how intricate they may be or what underlying IT infrastructure is required. The service abstraction forms a virtualisation for the computing resources required to run services.



The benefits of this virtualisation are that users no longer need to be aware of any details of the application installation environment: what machine it is installed on, what is the architecture, how is it executed and so on. The SynfiniWay service mechanism avoids users ever having direct contact with any server used to run services.

Files associated with service execution are delivered to the service by the framework regardless of the execution location. Files linked to follow-on services in a workflow are automatically transferred to the selected execution location. Users are therefore freed from having to manage data movement.

File movement resiliency ensures SynfiniWay gets the required data to the destination in the shortest possible time, regardless of IT failures.

Service definition

Enabling applications to work with SynfiniWay requires a simple definition on the Service Manager (SM) where the application is available. The following definition shows a simple service definition for a service called “My-service”. This service has two actions. One called ‘run’ and the other named ‘status’. The ‘run’ action will be used to start execution of the application and ‘status’ will be used to display some information about its current state. The mediator parameter tells SynfiniWay how to launch the action.

```
<Service name='My-service' dynamic='no'>
  <Action name='run' mediator='Batch-subsystem' />
  <Action name='status' mediator='interactive' />
</Service>
```

In addition to this definition, there is a script associated with each action that implements how it operates. SynfiniWay starts the action script when requested by the framework. The ‘run’ action will be sent to an SM from the workflow manager once a workflow is submitted and the task is scheduled for execution whilst the ‘status’ action will usually be sent directly to the SM based on an end-user request via the GUI.

Service location selection

If a service, such as ‘My-service’, is defined on more than one SM then the meta-scheduler policy is used to decide where the service will execute. In the event one service location becomes unavailable, user processes do not stop since the meta-scheduler can automatically select from the remaining locations.

Limits for how many instances of a service can be started by an SM can be set on a global or user basis.

CONCEPTS

There are some key concepts that underlie the technologies used in SynfiniWay. The following table describes the basic concepts that help to understand how the framework manages data and workflow execution.

MAIN CONCEPTS	
Service	An abstraction of an application, command or other executable defining one or more actions that can be applied to it.
Action	An activity that is related to a service. For example, a service may provide actions like: 'Run' : start execution of a service/application. 'List' : show the files on an execution machine. 'Monitor' : check an application's status.
Task	An instantiation of a service.
Workflow	A business process definition which enables a sequence of tasks to be executed with linking, branching and conditional logic.
Project space	An area assigned to a user or group of users which is used to hold one or more workflow definitions and related data. The project space is a generic file storage location which can be used to store any data.
Community	A group of one or more linked neighbourhoods that contains at least one Director.
Neighbourhood	A group of SynfiniWay components that share the same network event server. Normally this would imply the servers could open direct socket connections with each other.

Technology base

The entire SynfiniWay framework is based on object-oriented technology, and each defined concept is related to a class of objects manipulated through the network. Java™ was chosen for the programming language to ensure maximum portability.

Dynamic self-healing framework

The scope and nature of the framework implemented through SynfiniWay meant that its design had to cope with dynamic fluctuations in resource availability. Network failures and system outages are more likely on a framework that encompasses a global scope, therefore SynfiniWay employs technologies to manage these eventualities. The framework has mechanisms to detect server and/or network failures allowing it to instantly adjust to operational changes so as to minimise the impact on end-users. For instance, the meta-scheduler automatically adjusts the list of available servers when attempting to decide the best location to run a service.

In addition, the file transfer mechanism will continually retry interrupted transfers until they are successfully completed.

If multiple network links exist between server locations, SynfiniWay can automatically detect operational from non-operational links, enabling it to route requests using the available links.

Dynamic resource discovery

As a further consequence of this design strategy, the framework inherits the capability to dynamically increase or decrease the servers, services or data locations available on the framework. Administrators can deploy new servers, services or add new data locations in real-time with no impact on current users. The framework automatically detects new resources and makes them instantly available to authorised users.

These capabilities shield end-users from fluctuations which are inherent in large dispersed IT infrastructures, adding to the overall availability and resiliency of the entire framework.

COMPONENTS

Implementation of a framework that manages and controls a set of distributed resources requires components to be spread across the IT infrastructure. A design objective of SynfiniWay is to reduce the complexity of setting up and maintaining a vast distributed framework. To achieve this we built a rich software stack that includes major functional units as software agents. Each component runs the necessary agents to provide it with the required functionality. Therefore rather than having to separately install and configure an array of separate components SynfiniWay requires just a single component on each server providing resources to the framework. The components are:

- Director
- Service Manager
- Acquaintance Manager
- Authentication Manager
- Metascheduler
- Catalog Manager

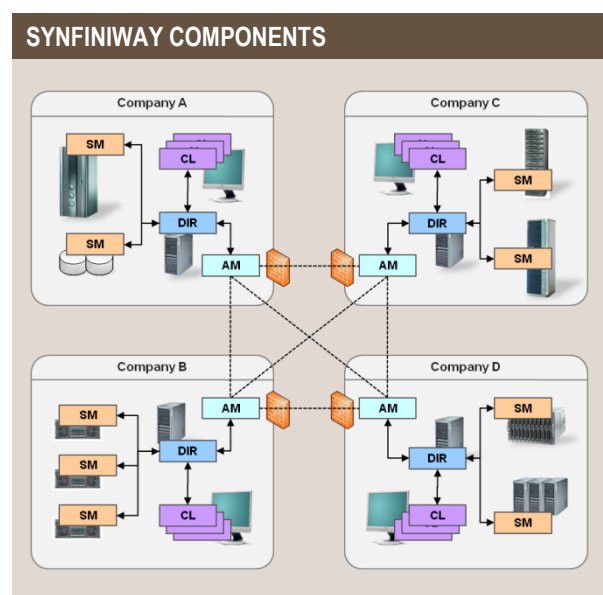
The entire framework is built with these 6 components. End-users connect to the framework either through the Java client or the API.

SYNFINIWAY COMPONENTS	
Director (Dir)	Manages end-user connection, authentication and authorisation. It provides agents to manage workflow task scheduling and execution as well as data migration management.
Service Manager (SM)	Publishes and runs services on behalf of users. It contains "mediators" which describe the various ways a service could run (e.g. interactive, LSF, PBS, SGE ..etc). User mapping is used to run jobs under the appropriate system user-id.
Acquaintance Manager (AM)	Links one neighbourhood to another to allow resource discovery, file transfer and workflow execution between components residing in different neighbourhoods. The AM is equivalent to a network gateway for SynfiniWay components.
Authentication Manager	This component is responsible for authenticating and validating a user's right to use the SynfiniWay framework.

Metascheduler	Responsible for the placement of work on the different Service Managers, and for the scheduling of the work over time.
Catalog Manager	In charge of storing and retrieval of persistent objects (Workflows, Profiles, Roles, ...). The storage of these objects is replicated in the different neighbourhoods.
Client (CL)	Provides connection to the framework via the Director. Submits and monitors workflows and data transfers. The Java client enables workflow creation and editing.

Building a community

The community of SynfiniWay resources consists of all the resources available through a linked set of neighbourhoods. Directors should be installed in areas where clients connect to the framework. For each batch system or server where services will run an SM must be installed. AM's are needed to link neighbourhoods together as necessary. Putting all the components together enables the creation of a global community of virtualised IT resources. The following diagram shows a community with 4 neighbourhoods and 9 compute or data service locations.



WORKFLOWS

The SynfiniWay workflow conceptual model is based on the WfMC (Workflow Management Coalition) V1.0 specifications with proprietary extensions.

A workflow consists of a set of tasks which are linked by sequence and/or data dependencies. Workflows in SynfiniWay support

- Split and join predicates to manage execution of multiple execution streams in a single workflow
- Workflow and task variables
- Branch conditions for looping control
- Multi-instance tasks to ease implementation of parametric study workflows
- Break points to interrupt/continue workflow execution

Workflow editing

A workflow is developed on the basis of previously published services. Each task of a workflow is associated with a service, which is parameterised through input/output variables. Branch conditions can be set to manage any transition from one task to the next. A visual editor is used to build the workflow graph.

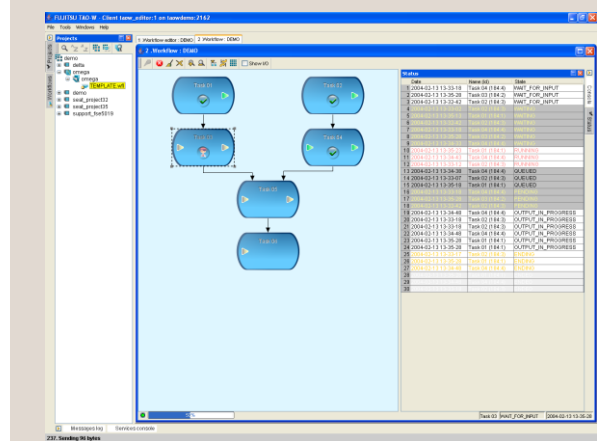
Workflow execution

Authorised end-users can launch existing workflows at any time by selecting them within the projects browser. A workflow template is parameterised using a “profile” form. The profile contains control parameters for each service together with its input/output file definitions. Many profiles can be created for the same workflow template. Profiles are used to define a separate run or experiment for the same business logic (workflow). The workflow is then launched from the profile form to start workflow execution.

Workflow monitoring

Once a workflow is launched, it can be monitored through the GUI or API interfaces. The GUI provides a status panel which displays the entire history of all events that occurred since the workflow was launched. In addition, the dynamically updated workflow graph indicates which workflow tasks are completed, which are running and those still to be run. File transfers which are currently active can be displayed through the transfer panel.

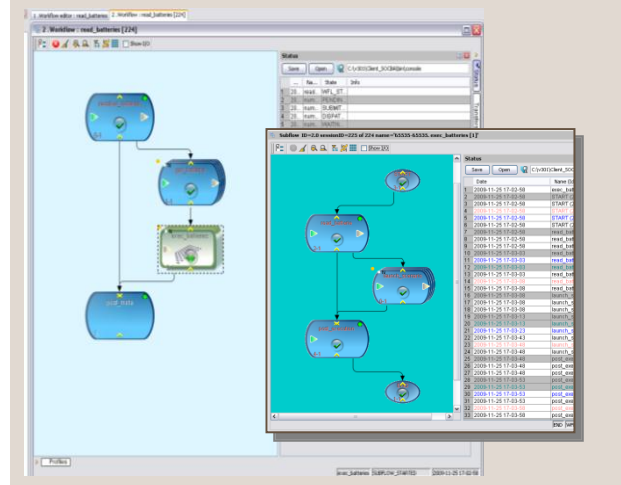
WORKFLOW MONITORING



Subworkflows

Subworkflows are used to organise a collection of tasks that are used in multiple workflows. The workflow editor can integrate existing tested workflows as components in other workflows. This maximises reuse of tried and tested workflows, and enforces the ability to share subprocesses (business processes, data, resources, etc) between organisations while the respective protecting intellectual property.

WORKFLOW AND SUBFLOW

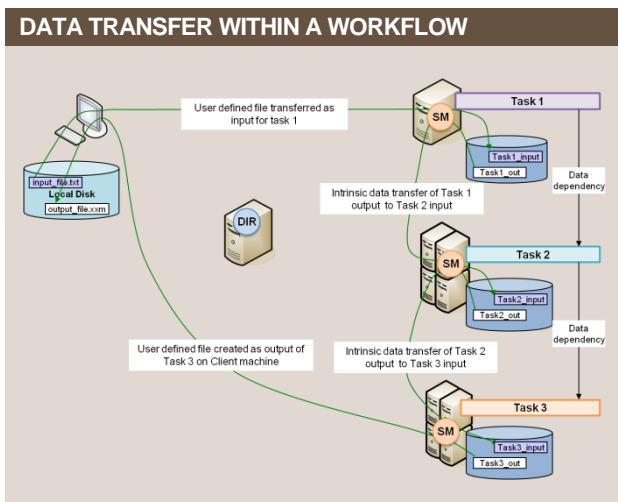


DATA HANDLING

SynfiniWay not only allows users to execute applications across a distributed network of systems, but it also enables data to be stored, moved and utilised on or between the various participating systems. Data movement has two characteristics within a workflow:

- Data input to and output from the workflow
- Data moved between the tasks of a workflow

Movement of data between the tasks of a workflow is completely described in the definition of the workflow itself, by linking the output of one task to the input of another. The user does not need to specify anything for such implicit data flow, preserving the virtualisation model of the SynfiniWay framework, and allowing the scheduler to select the optimal location for executing the task. The tasks of a workflow can be executed over a distributed set of servers, which may be on different LANs, behind firewalls, and even out of direct line-of-sight. To transfer data SynfiniWay establishes a connection between the source and destination through which data is passed as a continuous byte stream. Data will move along the shortest path in the SynfiniWay framework, directly between the machines executing the dependent workflow tasks.

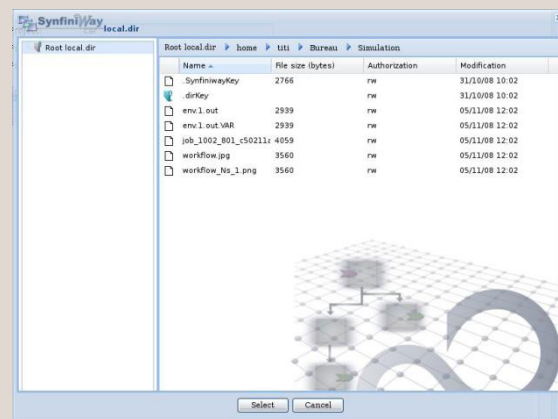


Workflows can access data storage areas on the Director and on the Service Managers in the SynfiniWay environment. In addition to this automated transfer method data can also be accessed and moved between sites explicitly by the user.

Viewing and manipulating data

Data files located anywhere across the entire SynfiniWay framework can be displayed and accessed using the Global File Explorer capability. As a minimum this means the files on the local disk for the client machine, but other storage areas may also be visible through the views in the Java client GUI or through the SynfiniWay framework portal.

FRAMEWORK PORTAL FILE BROWSER



Users can select and move files simply between any points on the framework with a single operation, irrespective of the network path and intervening systems between the source and destination.

Data highlights

SynfiniWay has unique strengths for data handling that position this solution for the rapid growth in data flow driven by business models for externalisation, globalisation and collaboration.

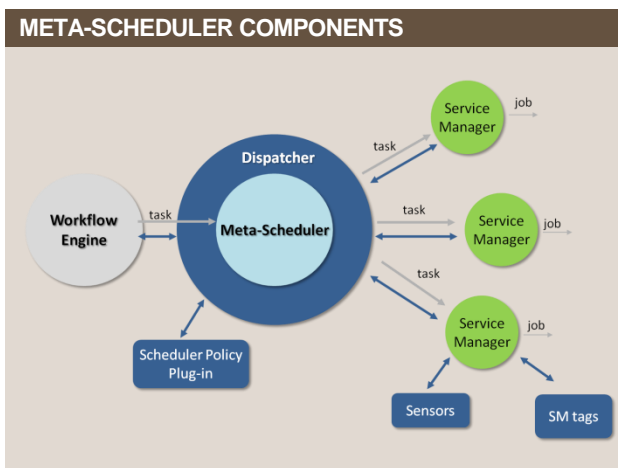
- Fully optimised transfer speed for large files and bulk movement of multiple files.
- No staging is used to eliminate overhead, and increase security. Encryption also insures security
- All data transfers, whether implicit in the process or explicit by direct user action, are resilient to infrastructure failures.
- Strong authorisation security is enforced through the virtualised access mechanism.
- The reliability of data transfers is checked by the Message Digest function.

META-SCHEDULING

Overseeing the activities of a global network of resources between heterogeneous platforms and various service implementations presents real issues for workflow and task management.

SynfiniWay employs for this oversight a resilient meta-scheduling capability to make sure resources are used in the most effective way. Optimal usage of resources yields faster results with less wastage.

Meta-scheduling requires philosophies which differ from those of local scheduling systems. The following image illustrates the position of the meta-scheduler between the workflow engine and the Service Managers.



The workflow engine submits a task to the meta-scheduler, which then decides on which Service Manager the task will execute, and what timeslot the task will get.

Service Manager filtering

With the wide scope of both resources and users that SynfiniWay manages, a mechanism capable of restricting service execution to a specific set of Service Managers is necessary. SynfiniWay therefore supports placement constraints and SM tagging which allow an easy means to identify the SM using extended attributes.

Placement constraints allow you to restrict service execution to specific SMs or to SMs with a specific architecture.

Tag attributes are used by the meta-scheduler as a second level of filtering when deciding what SM's are

available to run a service. As an example, a tag called "domain" can define the execution domain to be used.

This tag would be used to select in what area workflows tasks should be run. Thus SM's of an enterprise could be tagged with: "BE" (Belgium), "FR" (France), "DE" (Germany), "NL" (Netherlands), etc. When set for a workflow this tag will direct the meta-scheduler to limit SM selection to the set of SM's that match the tag specified. If no tags are specified, then all SM's are candidates.

Perhaps you would like to distinguish "production" systems from "research" resources. An SM tag could be used for this purpose.

Meta-Scheduler Policy

After having filtered the SMs, the meta-scheduler uses a policy to decide on the precise Service Manager to use when a task is to be run. SynfiniWay incorporates a number of standard policies. One standard policy is based on workflow priorities and submission times. If workflows have different priorities, then the tasks of the workflow with the highest priority have precedence over the tasks of the workflow with a lower priority. If the workflow priorities are identical, then the tasks of the workflow that was submitted the earliest have precedence over the tasks of later submitted workflows.

New policies can be developed or existing ones can be extended to ensure any custom features required by an organisation are employed.

Resiliency

If for some reason or other (expired license, insufficient disk space, ...) an SM does not manage to execute a task it is scheduled to do, then the task can ask for a rescheduling. This means that the task goes back to the meta-scheduler, which then reschedules the task onto another SM. The maximum number of times this rescheduling can take place is configurable.

SECURITY, RELIABILITY, PERFORMANCE

Security, reliability and performance are vital issues in the implementation and usage of a global and distributed IT infrastructure. Your IT department will want to be able to control in detail the access to the company's resources. They will not accept the risk of interception of passwords or confidential material in the framework. Companies need an industrial-strength IT framework with which they are assured of the arrival of data at final destination, and of the execution of submitted tasks.

Security and Trust

SynfiniWay gives extremely high priority to the security of the IT framework. Users have a single sign-on to get into the framework. They are assigned a role, which defines their permissions. The roles are customisable for each organisation. The permissions defined in the role include permissions for operations in the IT framework, such as editing workflows, creating users, executing tasks. In addition the role defines which workflows, files, and disks the user is allowed to access. This **role-based security** allows a very fine-grained control of user permissions.

Naturally the encryption of data transfers, whether they are between tasks in a workflow, or manually between sites is supported.

The IT framework can encompass sites in different locations, with data transfers through firewalls. SynfiniWay brings an extra layer of security on top of firewall security.

Reliability

The execution of tasks in the framework has a built-in **resiliency**. If for some reason or another (expired license, insufficient disk space, ...) an SM does not manage to execute a task it is scheduled to do, then the task can ask for a rescheduling on another SM. This way the execution of the task is guaranteed.

Also file transfers in the framework have built-in **resiliency and reliability checks**. If the underlying network breaks during transfer, the SynfiniWay file transfer will pause and resume when the network is active again. If the break takes too long and there are alternative paths, an alternative path is chosen for performing the file transfer. The integrity of file transfers in the framework is guaranteed with a message digest, if this has been asked for in the workflow.

High-Availability solutions are used to provide a duplicate set of resources for a critical component so that in the event of a failure the duplicate resources take over the services that were offered by the failed component. In the case of the SynfiniWay Director the system can be deemed as having failed if any of the following occur:

- The server system itself fails for any reason (Processor, Memory, Power, Disk failure ...)
- Network interface card failure (loss of connectivity)
- Server Operating System failure (s/w failure)
- JVM failure or hang (software failure)
- SynfiniWay server fails (software failure)

To reduce the down-time from unscheduled stoppages it is possible to implement a fail-over system for the Director that can quickly take over the responsibilities of the main server.

Performance

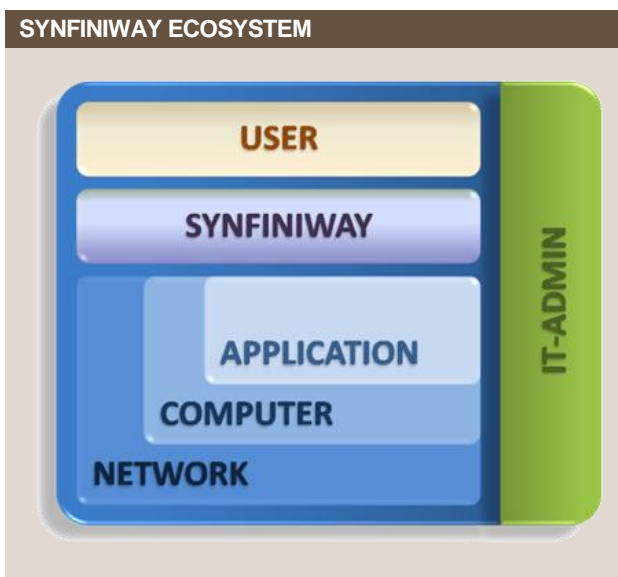
One of the hallmark features of SynfiniWay is its highly efficient file transfer protocol. This file transfer mechanism allows files to be transferred directly from the source to the target computer system, without being stored on any of the intermediary systems, and going through any number of firewalls between source and target. This mechanism uses the **shortest path** for transferring files to a target computer from the source. The files are sent in binary format, and are not converted to XML or other more lengthy formats.

High performance is also attained by replicating the Catalog Manager, which is in charge of storing and retrieval of persistent objects (Workflows, Profiles, Roles, ...) This Catalog Manager is replicated in the different neighbourhoods of the IT infrastructure, leading to a fast access to these objects from anywhere in the framework.



USAGE TOPOLOGIES

The SynfiniWay software has been made to be as flexible and user friendly as possible. It can be deployed over a local area network (LAN) as well as over a wide area network (WAN), including public Internet connections, to enable transparent and location-independent access to all available resources by the end-users. SynfiniWay unifies Grid and Cloud technologies as a unique IT-abstraction middleware to form a homogeneous virtualization infrastructure solution.



The framework created by SynfiniWay has the ability to adapt to and integrate with any networked computing topology. The following examples highlight some of the typical scenarios used.

Local system usage

Users access resources on their intranet environment. A SynfiniWay client or API-enabled desktop can gain access to the data and services and run workflows on the enabled systems. Data movement between any of the components is possible and common data areas can be used to enable data sharing between groups of users.

Extended Grid usage

If the SynfiniWay network consists of remote service execution locations as well as local execution systems, the user does not need to take any additional or special actions to access authorised services in the other

SynfiniWay Neighbourhoods. Resources and data can be freely accessed as if they were local.

Building a cloud

Cloud computing is addressed as an on-demand service-oriented environment. The goal is to optimize IT resource, improve cost savings and manage efficiently a virtualized infrastructure.

By tightly integrating functions to control actions and monitoring over all IT resources – computer, application, network – SynfiniWay enables the globalised distributed system to act on-demand in the most efficient and effective way. This is possible through:

- the dynamic on-demand application infrastructure layer which provides with the abstraction of IT resource
- the delivery infra-structure and automation layer to coordinate the actions of the multiple tiers of the architecture (software agents) in response to specific events
- the monitoring and accounting layer which gives visibility to which resource is used, where and when

INTEGRATED SYNFINIWAY DELIVERY MODEL



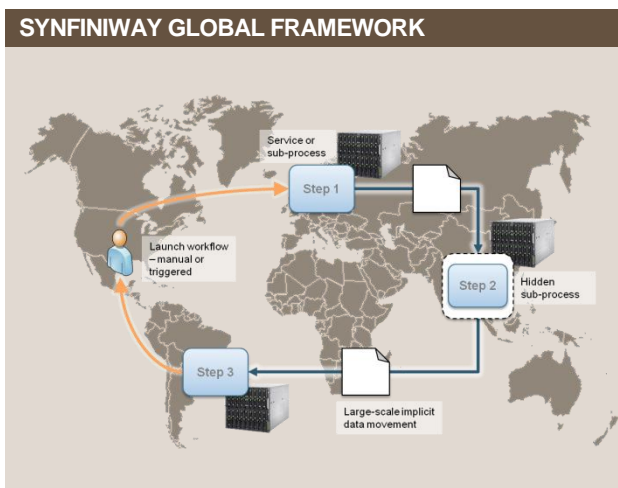
GLOBAL SCALE

Today, SynfiniWay is a powerful and yet easy-to-use environment that empowers end-users with the ability to use applications as services regardless of their location within the enterprise network. Building on the global virtualisation layer, workflows connect multiple service instances (tasks) into a fully captured business process.

Initiation of workflow tasks and data movement between tasks is completely managed by SynfiniWay, rendering the distributed resource management completely transparent to the user. Meta-scheduling ensures that resources are optimally consumed, while duplicate service execution locations allow for higher resilience throughout the business process.

SynfiniWay in operation

SynfiniWay brings elements to help organisations meet demands for an expanded scope of industrialised resources to their end-users desktops. The workflow facility provides the means to capture and automate business processes using the global resource pool.



As such SynfiniWay fills a gap in the current IT landscape of an industrialised global IT framework capable of workflow management, meta-scheduling and transparent global data movement. It incorporates the means to build and deploy resilient and robust workflows that, due to the virtualised layer they are developed on, can be built in one location and deployed anywhere.

Summary

Under pressure to build products quicker, cheaper and with higher quality, enterprises are realising the benefits in robust procedures such as multi-disciplinary optimisation and parametric studies. The higher resource demands and needs for automation are pushing the requirements for a new scale of IT frameworks capable of addressing distributed and global resources.

SynfiniWay focuses on bringing the resources and intelligence of distributed development teams and/or distributed IT resources together through resource virtualisation and global workflow scheduling and management.

Resource scheduling ensures resources are allocated in an optimal way. The end-user interaction with the IT layer is eliminated ensuring they can concentrate solely on duties related to their role. Expertise and business intelligence can easily be disseminated to engineering groups bringing improvement in process efficiency and reliability through proven and reliable business methods.

In summary, SynfiniWay adapts to the changing IT landscape to ensure continuance of service, reliable and yet easy usage of distributed IT resources as well as the capability to develop and distribute highly robust business processes.

Why not investigate what SynfiniWay can do for you?

CONTACT FUJITSU

OFFICES OF FUJITSU SYSTEMS EUROPE LTD

PARIS OFFICE

3 allée Hélène Boucher
Orlytech/Paray Vieille Poste
91781 Wissous Cedex
France

Tel : +33 (0) 1 49 75 85 30
Fax : +33 (0) 1 49 75 85 40

TOULOUSE OFFICE

Parc le la Plaine
8 rue Maryse Hilsz
31500 Toulouse
France

Tel : +33 (0) 5 62 47 58 30
Fax : +33 (0) 5 62 47 58 40

ASK FUJITSU

Contact us on +33 (0)1 4975 8530, +33 (0)5 6247 5830 or
contact@fujitsu.fr, or visit www.synfiniway.com