Logistics FOM Module in Snow Leopard: Recommendations by MSG-068 NATO Education and Training Network Task Group

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ABSTRACT: *NATO Allied Command Transformation (ACT) program Snow Leopard is supported by NATO Research & Technology Organization (RTO) Task Group MSG-068 Education and Training Network (NETN) in developing a reference federation architecture and FOM design for the NATO Training Federation (NTF) and NATO Live-Virtual-Constructive Federation (NLVC). As part of the MSG-068 task group common representation of- and patterns for logistics operations between different NATO and national simulation systems have been developed. A new service oriented design pattern for negotiating and delivering services is proposed as the basis for more advances logistics interaction patterns between federates. The FOM modules are extensions to the RPR-FOM v2.0 and based on the IEEE 1516-2009 modular FOM concepts. Logistics patterns for Supply, Maintenance, Deposit and Transport based on a general Service Consumer-Provider Pattern are described in this paper and an embarkment/disembarkment example of using the services is provided. This paper presents the logistics section of the first version of the NETN Reference FOM and Federation Agreements. Continued experiments, development and adaptation of systems to the patterns described in this paper will provide additional feedback and validation of the proposed Snow Leopard reference architecture.*

1. Introduction

In the light of future operations and real life challenges NATO is recognizing the need for development of a distributed and networked education and training capability which will integrate and enhance existing national capabilities and will focus on the education and training of NATO Operational and Tactical Headquarters' staffs and NATO forces preparing to execute NATO Response Force (NRF), Combined Joint Task Force (CJTF) and International Security and Assistance Force (ISAF) and any other future NATO missions.

Current and emerging operational requirements demand broader and deeper levels of interoperability and integration between NATO and Nations' headquarters and forces. Additionally, NATO is increasingly operating alongside non-NATO military and non-military players, which is putting new demands on current NATO tactics, techniques, and procedures. This combination of enhanced capabilities and evolving operational requirements are putting new demands on how we train headquarters and forces to ensure NATO and national command and control systems, weapon systems, and tactics, techniques and procedures are all interoperable with each other-and where appropriate with other Coalition Allies. This is true from the highest levels of the NATO Command Structure (NCS) down to the lowest

levels of the NATO Force Structure (NFS). For all these reasons there is a need for a common NATO training and education distributed environment where the NCS and NFS, and also NATO nations and partners can routinely train "as they fight" to boost standardization and interoperability, and at the same time reduce duplication of effort and enhance the efficient use of resources.

1.1 Snow Leopard

To meet this operational demand, Allied Command Transformation (ACT) M&S Vision [1] is *To deliver to NATO and Partners a persistent, distributed and joint training capability able to support training from operational to tactical level across the full spectrum of operations, while leveraging existing national expertise and capabilities.*

To accomplish this vision ACT has initiated the NATO Snow Leopard Program. The pillars of Snow Leopard are four projects focusing on developing the NATO Training Federation (NTF), the NATO Live-Virtual-Constructive Federation (NLVC), Advanced Distributed Learning (ADL) and Shared Scenarios. To support NATO ACT in this effort the NATO Research & Technology Organization (RTO) through its NATO Modelling and Simulation Group (NMSG) has initiated a Task Group, MSG-068 that will provide M&S recommendations to support these projects.

The near term objective of the Snow Leopard project is to provide the Alliance and partners with an Initial Operating Capability (IOC) of distributed simulation based training. This initial capability will be based on an HLA federation of the US simulation systems Joint Theatre Level Simulation (JTLS) operated at the Joint Warfare Center (JWC) in Stavanger (Norway) and Joint Conflict and Tactical Simulation (JCATS) operated at the Joint Force Training Center (JFTC) in Bydgoscsz (Poland).

In its final state Snow Leopard will enable NATO and partner nations' national training centers, utilizing their simulation and C2 systems, to interoperate in a multinational, distributed, networked training environment. The name of this capability is NATO Education and Training Network (NETN).

1.2 MSG-068 NETN

The objective of the MSG-068 NETN Task Group is to assess the distributed simulation and learning capabilities offered by NATO, Partner and Contact Nations, Schools, and Agencies that could contribute to the development of a NETN capability. MSG-068 will also recommend and demonstrate a way forward for interoperability, technical standards and architectures to link these training and education centers to provide a persistent capability. The task group will also identify and recommend roles and responsibilities of the NATO, Partner and Contact Nation organizations responsible for distributing and maintaining M&S capabilities within the scope of NETN.

The following topics are covered in MSG-068:

- Assessment of distributed simulation and learning capabilities with potential for inclusion in NETN.
- Recommendations for interoperability and technical standards.
- Recommendations for the development of NETN architectures.
- Recommendations for the assignment of roles and responsibilities for distributing, managing and maintaining NETN capabilities.
- Identify, develop and conduct experiments enabling NATO/PfP nations capabilities to participate in NETN.
- Roadmaps and technical reports in support of NETN.
- Demonstration of a limited NETN realization comprising JWC, JFTC and national simulation centers and systems.
- Run preparatory tests at ACT and national facilities and evaluating the results from these tests for risk reduction of the demonstration of the feasibility of the NETN-concept.
- Perform a demonstration of the feasibility of the NETN concept of a distributed networked training capability embracing JWC, JFTC and national simulation center and the corresponding simulators, simulation systems and C2- systems.

1.3 MSG-068 FAFD

One of the fundamental deliverables from MSG-068 is a reference Federation Agreements Document (FAD) and Federation Object Model (FOM) that will support the development and integration of both NTF and NLVC. To support this activity a subgroup for developing FOM and Federation Design (FAFD) recommendations was formed. This MSG-068 subgroup currently consists of 70+ experts on federation architecture and design working collaboratively to develop specifications that will increase interoperability and reuse among NATO and national simulation and training systems.

The objectives of this experts sub-group are:

- Assessment of existing NATO and national FOMs with respect to their applicability for an NETN Reference FOM under particular consideration of LVC connectivity (e.g. aggregate level systems and platform level systems linkage)
    - JMRM, JLVC (USA)
    - P2SN (SWE)
    - KOSI (DEU)
    - ALLIANCE (FRA)
    - CASIOPEA (ESP)
- Based on this assessment (and utilizing classes of existing standard FOMs as far as possible) a modular NETN reference FOM and the corresponding FAD documents are to be elaborated and documented.
- The NATO and national simulation and C2-system candidates for the NETN are to be assessed regarding their compliance to the reference FOM and FAD(s).
- Based on this assessment necessary adjustments/expansions to the systems considered to be applicable are to be defined and documented.

The following FAFD topics are in the scope of the MSG-068 FAFD work:

- Harmonized FOM representation and federation agreements related to entity level simulated objects.
- Harmonized FOM representation and federation agreements related to aggregate level simulated object.
- Harmonized FOM representation and agreements related to combat interactions (Aggregate-Aggregate, Aggregate-Entity, Entity-Aggregate).
- Common design pattern for federation execution control.
- Transfer of Control.
- Logistics Representation in FOM.

1.4 NETN FOM Modules

Standard NATO Agreement (STANAG) 4603 [2] specifies the use of High-Level Architecture (IEEE 1516) [3] for federating simulation systems. The upcoming updated version of IEEE 1516 (a.k.a. HLA Evolved) [4] provides additional and improved services and concepts that enable a more flexible and modular approach to FOM development. The MSG-068 FAFD subgroup uses the HLA Evolved modular FOM approach when defining the NETN Reference FOM.

RPR-FOM v2.0 [5] is is used as a base-line FOM Module on which other modules depend. These include both the SISO standard Link 16 BOM [6] and NETN extensions to the RPR-FOM. The FOM Modules and their dependencies are depicted below.

This paper focuses on FOM Modules related to Logistics operations and services which are, as described below, based on a more general design pattern for consuming and providing services.

2. Service Consumer-Provider Pattern

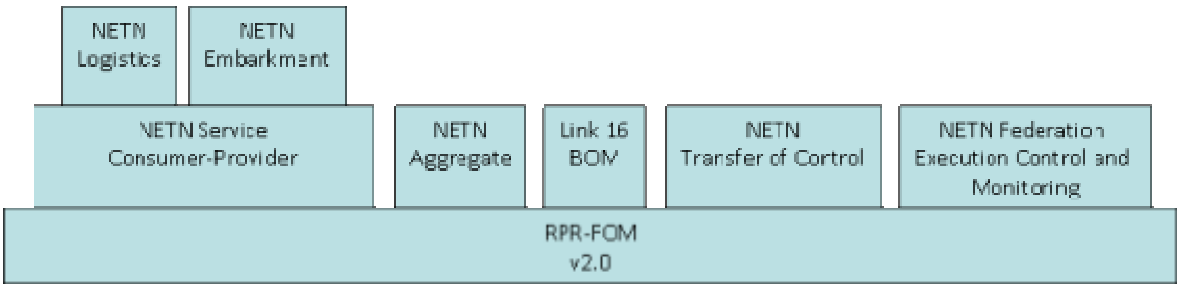
The MSG-068 FAFD Subgroup has defined a new basic design pattern for modelling requests, negotiations and delivery of services. The interaction patterns required for different types of services may vary but the basic principles and interaction class definitions are defined in the Service Consumer-Provider FOM Module.

The Service Consumer-Provider Pattern defines two types of entities.

- Service Consumer Entities: are entities requesting and consuming specific services offered and provided by other entities.
- Service Provider Entities: are entities able to offer and provide a specific service.

Similarly federates modelling these entities are called Service Consumer Federates and Service Provider Federates.

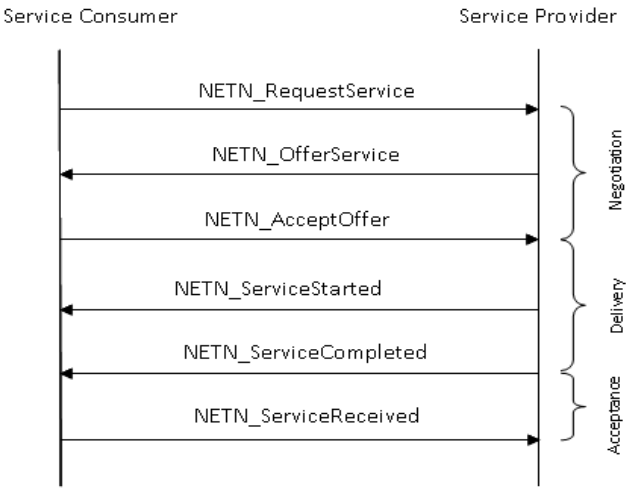
The pattern defines interactions between the entities providing and consuming a service. If these entities are modelled in different federates the interactions will be published and sent using HLA services.



2.1 Approach

The pattern is divided into three phases:

1. Service Negotiation: the service is requested, offers received and offers are either accepted or rejected.
2. Service Delivery: the selected provider starts delivering and continues until all service has been delivered.
3. Service Acceptance: the provider or consumer indicates the completion of the service delivery and waits for acknowledgment/acceptance from the other part.



The above interaction diagram shows the normal pattern for requesting services and receiving notification that the service transaction has completed.

Variations include service completion determined by the consuming entity and sent as a NETN_ServiceReceived interaction before the corresponding NETN_ServiceCompleted interaction is sent.

Exceptions include:

- early termination of the service by either the consumer or provider using the NETN_CancelService interaction
- rejection of service offer by the service consumer entity using the NETN_RejectOffer interaction

2.2 FOM Module

Interaction Classes

The Service Consumer-Provider Pattern defines a set of HLA interaction classes used to implement the three phases of the pattern. These interactions are provided as a FOM Module and can be extended to support specific service types.

Service Consumer-Provider Interaction Classes

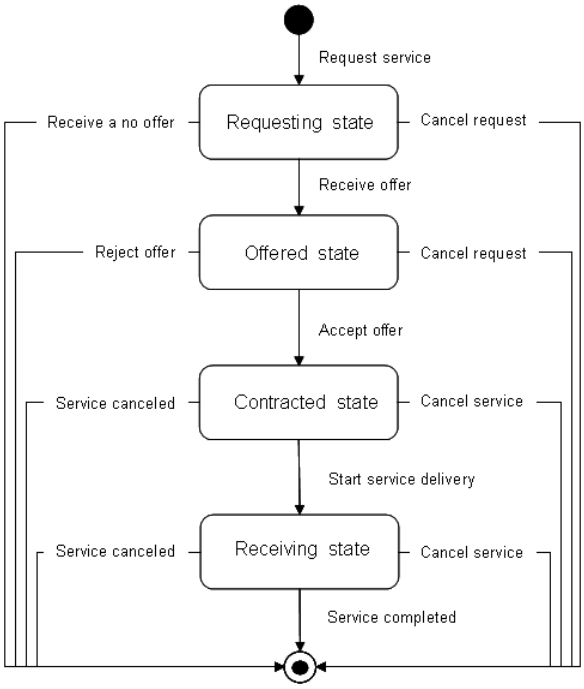
Class 1	Class 2
NETN_Service	NETN_RequestService
	NETN_OfferService
	NETN_AcceptOffer
	NETN_RejectOffer
	NETN_CancelService
	NETN_ServiceStarted
	NETN_ServiceCompleted
	NETN_ServiceReceived

Service Consumer

It is always the service consumer that initiates a request for a specific service. A service consumer can be engaged in several concurrent service requests and deliveries. For each requested service the state of the service consumer can be described using a state-transition diagram (STD).

The Service Consumer entity may be in one of four states with respect to a requested service:

- **Requesting state**. A service consumer entity is in the Requesting state when it has requested a specific service from another entity.
- **Offered state**. A service consumer entity is in the Offered state when an offer of the service delivery has been made by a service provider.
- **Contracted state**. A service consumer entity is in the Contracted state when an offer has been accepted.
- **Receiving state**. A service consumer entity is in the Receiving state during service delivery.



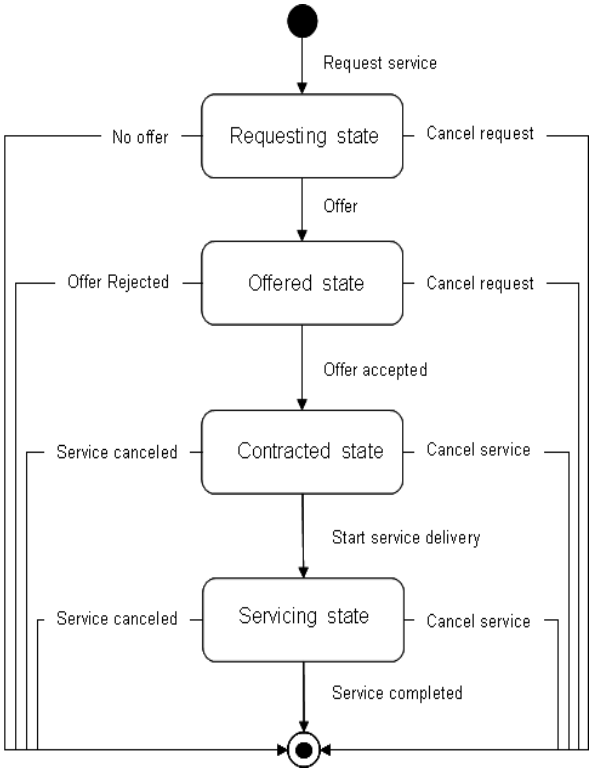
Service Consumer State Transitions and Conditions

Transition	Condition and actions
Request service	When conditions for requesting a service are met, the consuming entity shall issue a NETN_RequestService Interaction. The entity shall proceed from the initial state to the Requesting state.
Cancel request	When conditions for requesting the services are no longer met a NETN_CancelService interaction is sent and the entity proceed from the Requesting state to the end state.
Receive a no Offer	When a NETN_OfferService with a NoOffer indication is received, the entity shall proceed from the Requesting state to the end state.
Receive offer	When a NETN_OfferService with an Offer indication is received, the entity shall proceed from the Requesting state to the Offered state
Reject offer	When conditions for accepting a service offer are not met the service consuming entity shall issue a NETN_RejectOffer interaction and proceed to the end state.
Accept offer	When conditions for accepting a service offer exists the service consuming entity shall issue a NETN_AcceptOffer interaction and proceed to the Contracted state.
Cancel service	When conditions for receiving the services are no longer met a **NETN_CancelService** interaction is sent and the entity proceed from to the end state.
Service canceled	When a **NETN_CancelService** interaction is received the service consuming entity shall proceed to the end state.
Start service delivery	When an **NETN_ServiceStarted** interaction is received the service consuming entity shall proceed to the Receiving state
Service completed	When a **NETN_ServiceCompleted** interaction is received or when the consuming entity determines that the conditions for service completed are met the **NETN_ServiceReceived** interaction shall be sent and the entity shall proceed to the end state.

Service Provider

The Service Provider entity may be in one of four states with respect to a requested service:

- **Requested state**. A service producer entity is in the Requesting state when it has received a request for a service from a service consumer entity.
- **Offering state**. A service provider entity is in the Offering state when an offer in response to a requested service has been delivered to a service consumer.
- **Contracted state**. A service provider entity is in the Contracted state when its offer has been accepted
- **Servicing state**. A service provider entity is in the Servicing state when a service is being delivered to a service consuming entity.



Service Provider State transitions and Conditions

Transition	Condition and actions
Service requested	When a **NETN_RequestService** is received the service providing entity shall proceed from the initial state to the Requested state.
Cancel request	When a **NETN_CancelService** interaction is received from a service consuming entity, the entity shall proceed from the Requested state to the end state.
No offer	When the conditions for delivering a requested service are not met, a **NETN_OfferService** with a NoOffer indication shall be sent and the service producing entity shall proceed to the end state.
Offer	When the conditions for delivering a requested service are met, a **NETN_OfferService** including the offer shall be sent and the service producing entity shall proceed to the Offered state.
Offer rejected	When a **NETN_RejectOffer** is received the service producing entity shall proceed to the end state.
Offer accepted	When a **NETN_AcceptOffer** is received the service producing entity shall proceed to the Contracted state.
Cancel service	When conditions for providing the service are no longer met a **NETN_CancelService** interaction is sent and the entity proceed to the end state.
Start service delivery	When the conditions for starting the service delivery is met, a **NETN_ServiceStarted** interaction is sent and the service providing entity proceeds to the Servicing state.
Service Completed	When a **NETN_ServiceReceived** interaction is received or when the conditions for completed service delivery is met, a **NETN_ServiceCompleted** interaction is sent and the service producing entity proceeds to the end state.

3. Logistics FOM Module

The NETN Logistics FOM Module is based on the Service Consumer-Provider Pattern with extensions to support specific logistics services as defined below. Detailed description on how these patters map to the NETN Logistics interactions are included in this description. The NETN Logistics FOM Module is dependent on the RPR-FOM v2.0 due to the fact that several data types defined in the RPR-FOM are reused in the definition of parameters for logistics interactions. However, no extensions to existing RPR-FOM logistics interactions are proposed.

3.1 Service Types

The following Logistics services are defined in the NETN Logistics FOM Module:

- **Supplies** ; *Consumable Material* (bulk consumables, spare parts, etc. but not published as individual platforms) may be supplied from\- and stored in *Facilities* (storage areas, depots).
    - RequestSupply Consumer requests additional material, supplies move from service providing entity to service consuming entity
    - RequestStorage Consumer requests storage of material, supplies move from service consumer to service providing entity.
- **Repair** ; *Damaged material* (damaged platforms) is repaired by a maintenance unit nearby. The damaged platform is not moved by the maintenance unit (no transfer of control)
    - RequestRepair (The service consumer requests a platform to be repaired.).
- **Deposit** *Non-Consumable Material* (e.g. a platform or unit) is deposited at a facility (assembly area, railway station, port, etc.). This includes also the

service maintenance if damaged material (platform) is deposited in a facility.
    - RequestDeposit The service consumer requests a platform/unit to be deposited at a facility. The responsibility of the deposited platform is transferred to the service providing entity (the facility). The deposit request can be classified into
        - transporting
        - depositing
        - repairing
    - RequestEquipment The service consumer entity requests equipment (platform) from a depot. The responsibility of the platform is transferred to the service consuming entity.
- **Transport**; *Material* (consumable and non-consumable) may be transported.
    - RequestTransport The service consumer entity responsible for material may issue a transport request. During transport a non-consumable material may be deposited onto the means of transport.

Examples:

This pattern may be used for the following examples:

1. Resupply of units (consumer) by transportation means.
2. Supply of fixed wings in airports.
3. Supply of helicopter in assembly areas.
4. Transport of troops by train, ship and airplanes..
5. Repair of damaged platforms by a maintenance unit without changing the location of the platform.
6. Maintenance of damaged material deposited in facilities.
7. Embarkment and disembarkment of units.

3.2 NETN Logistics Objects

Logistics supplies the troops with material and carries out maintenance. Means of transport, transport resources and facilities for maintenance and storage are required for these tasks.

Means of transport

Depending on the federation, means of transport are published as platforms or as equipment of aggregate units. If transportation means are used as provider in the consumer-provider-pattern they have to be published as platforms. This suggested approach doesn't require the publishing of the loading of the means.

Example:

If a means of transport is to supply units, it then proceeds to a depot, or is itself a depot. Objects of other federates will then be supplied from the depot (supply facility).

Transport resources

The suggested transport resources are containers and flats. Depending on the federate agreements resources can be published as platforms. In this case resources can be exchanged between federates by the deposit and equipment requests. If the transport resources are not exchanged between federates, they do not need to be published within the federation.

Facilities

Facilities are the central element in the Logistics FOM through which material can be transferred.
Facilities may be created during a simulation or may be a part of the infrastructure (railway station, storage tanks depot, port, etc.). A facility may be part of a unit (ship, etc.).

The RPR-FOM v2.0 object class BaseEntity is extended with a subclass **NETN_Facility** with the following additional attributes.

Attribute	Definition
DamageState	*Describes the damaged appearance of an entity.*
ForceIdentifier	*Enumeration distinguishing the different teams or sides in an exercise.*
Name	The name of the facility.
IsOperational	True if the facility is operational and can provide service
StorageList	List of Materials (Amount, Type) stored in the facility (not published as individual platforms). Material loaded on means or on resources of transport which are located in the facility are also included. Material belonging to an object of the object list is excluded.
ObjectList	List of non-active platforms/units in the facility. Includes those platforms transferred to the facility with a ServiceRequest (Type = Deposit) or located by the provider-model in the facility.

3.3 NETN Logistics Interactions

The NETN Logistics module can be used to represent services for Supply, Repair, Deposit and Transport. The basic pattern used by all NETN services is the Service Consumer-Provider Pattern described in the previous chapter. The Logistics services use the interactions from the Service Consumer-Provider Pattern and extend these when appropriate to support specific types of logistic services.

The following Logistics interactions class extensions to the Service Consumer-Provider pattern are used in the NETN Logistics FOM Module.

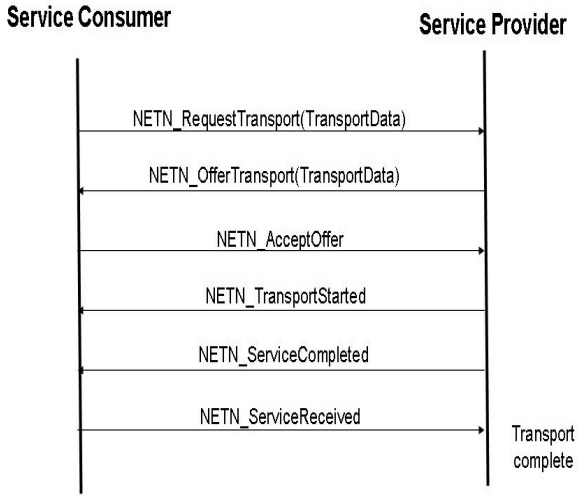
NETN Logistics FOM Module Interaction Class Structure Table

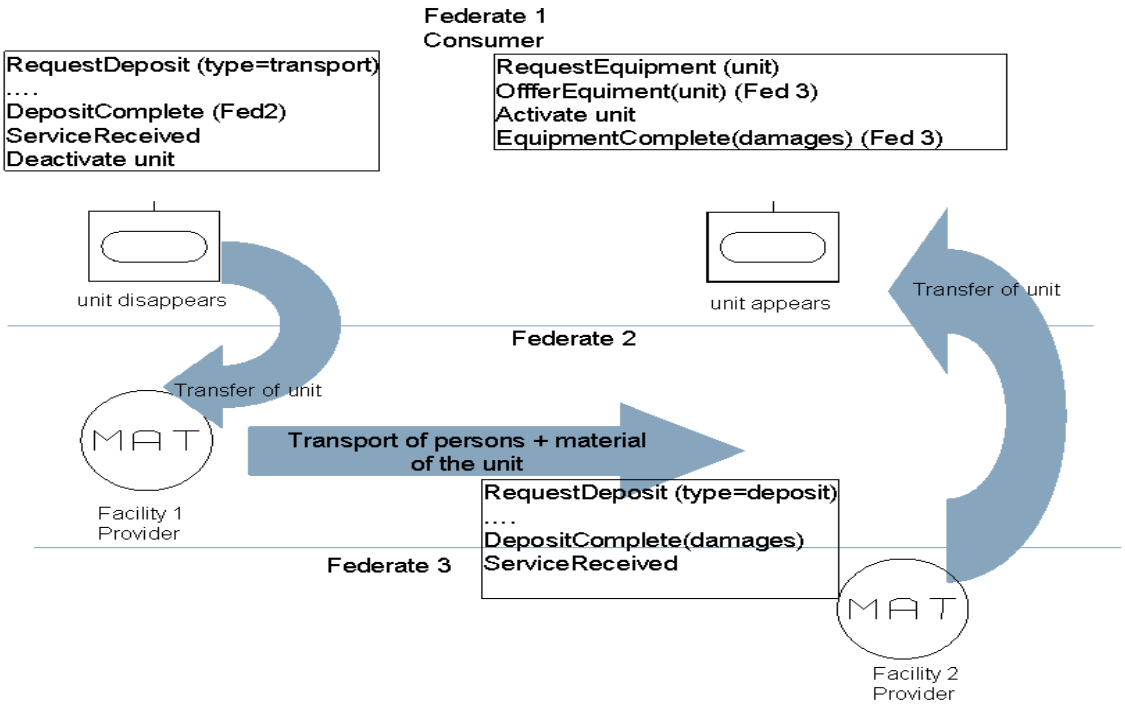
Class 2	Class 3
NETN_RequestService	**NETN_RequestSupply**
	NETN_RequestStorage
	NETN_RequestRepair
	NETN_RequestDeposit
	NETN_RequestEquipment
	NETN_RequestTransport
NETN_OfferService	**NETN_OfferSupply**
	NETN_OfferRepair
	NETN_OfferStorage
	NETN_OfferEquipment
	NETN_OfferDeposit
	NETN_OfferTransport
NETN_OfferAccept	
NETN_ServiceStarted	**NETN_SupplyStarted**
	NETN_StorageStarted
NETN_ServiceComplete	**NETN_DepositComplete**
	NETN_EquipmentComplete
NETN_ServiceReceived	

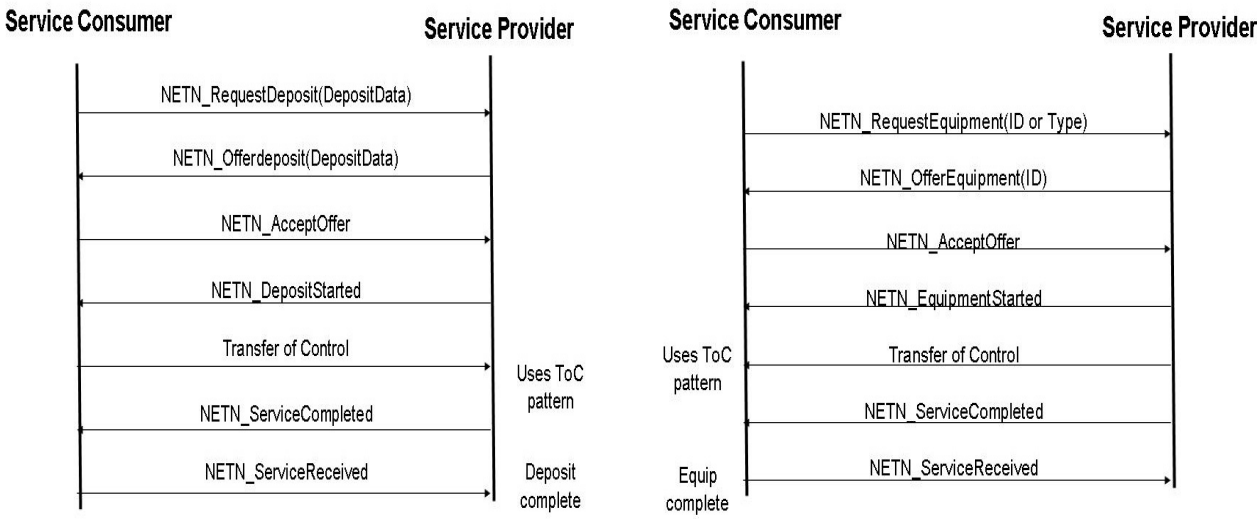
3.4 Example

1. Unit of federate (1) moves to the facility (1) of federate (2) in which this unit has to be deposited for transshipment (Facility may be a harbor, railway station, airbase, assembly area, etc.).
2. Federate 1 publishes a “DepositRequest (type = transport)”. In this request, the facility (1) is requested to deposit the unit with all the material and persons. The facility can accept or deny the request (reason: no place, not enough transport means, facility is not active, etc.).
3. At the end of the procedure of the consumer-provider-pattern, federate (1) accept the service and inactivates the unit.
4. Federate (2) organizes and carries out a transport for all the material and persons of the unit to facility (2) of federate (3) .
5. At the end of the transport at facilty (2) federate (2) publishes a "DepositRequest (type = deposit)" for the unit with all material and persons transported. If damages occurred during the transport, these damages have to be mentioned in the "DepositRequest".
6. After the procedure of depositing the material and persons of the unit in facility (2), federate (1) can start an "EquipmentRequest" to get the material and persons back from facility (2).
7. At the end of the procedure federate (1) the unit is active again and can be controlled by federate (1).

The introduced example deploys NETN basic interactions as listed in the table above, namely the NETN deposit, transport and equip interactions. The detailed Consumer Provider Pattern diagrams for these three interactions are illustrated in the next pictures.




Federate 1
Consumer
RequestDeposit (type=transport)
....
DepositComplete (Fed2)
ServiceReceived
Deactivate unit
RequestEquipment (unit)
OffferEquiment(unit) (Fed 3)
Activate unit
EquipmentComplete(damages) (Fed 3)
unit disappears
unit appears
Transfer of unit
Federate 2
Transfer of unit
MAT
Transport of persons + material of the unit
Facility 1
Provider
RequestDeposit (type=deposit)
....
DepositComplete(damages)
ServiceReceived
Federate 3
MAT
Facility 2
Provider


Service Consumer
Service Provider
NETN_RequestDeposit(DepositData)
NETN_Offerdeposit(DepositData)
NETN_AcceptOffer
NETN_DepositStarted
Transfer of Control
NETN_ServiceCompleted
NETN_ServiceReceived
Uses ToC pattern
Deposit complete
Service Consumer
Service Provider
NETN_RequestEquipment(ID or Type)
NETN_OfferEquipment(ID)
NETN_AcceptOffer
NETN_EquipmentStarted
Transfer of Control
NETN_ServiceCompleted
NETN_ServiceReceived
Uses ToC pattern
Equip complete

4. Summary

The design patterns for representing a service based pattern for logistics interaction have been presented. It is the intention of MSG-068 to continue working with these patterns adding detail to the FOM and associated federation agreements as necessary. The MSG-068 NETN design patterns for logistics services are currently being implemented in several simulation systems to provide additional engineering support and lessons learned. The goal is to show these patterns in action as part of the final demonstration of MSG-068 results in Q3/Q4 2010. The FAFD subgroup also believes that the patterns provided in this paper may serve as input and as inspiration to related SISO activities for producing standard FOM Modules that can be shared with the wider community.

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Author Biographies

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JEAN-PIERRE FAYE is the Resarch and Development Manager at Thales Raytheon Systems. Doctor in Mathematics of Paris University, he has more than 20 years of experience in simulation and C2 system architecture. He represents the NATO Industry Advisory Group within the RTO/NMSG organisation than monitor the Modelling & Simulation projects for NATO, such as the MSG-068.