9th International Command and Control Research and Technology Symposium

Coalition Transformation: An Evolution of People, Processes and Technology to Enhance Interoperability

Topic: C4ISR /C2 Architectures or Network Centric Applications

Networked Services

Point of contact: Thea Clark

Daniel Hall
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7949
Fax: +61 3 9626 7084
Email: Daniel.Hall@dsto.defence.gov.au

Thea Clark
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7059
Fax: +61 3 9626 7084
Email: Thea.Clark@dsto.defence.gov.au

Ruth Gani
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7301
Fax: +61 3 9626 7084
Email: Ruth.Gani@dsto.defence.gov.au

Gina Kingston
DSTO Fern Hill Park
Department of Defence Canberra
ACT 2600 AUSTRALIA
Phone: +61 2 6256 6166
Fax: +61 2 6256 6180
Email Gina.Kingston@dsto.defence.gov.au

Neill Smith
Mission Software Pty Ltd
52 Dempster Ave, Balwyn Nth
VIC 3104 AUSTRALIA
Phone: +61 3 9857 4716
Fax: +61 3 9857 8549
Email: nsmith@acm.org

Jon Bell
DSTO Russell
Department of Defence Canberra
ACT 2600 AUSTRALIA
Phone: +61 2 6265 3863
Fax: +61 2 6265 7218
Email: Jon.Bell@dsto.defence.gov.au

Lan Dong
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7739
Fax: +61 3 9626 7084
Email: Lan.Dong@dsto.defence.gov.au

Networked Services

Daniel Hall[†], Ruth Gani[†], Neill Smith[*], Lan Dong[†] Thea Clark[†], Gina Kingston[‡], and Jon Bell[•]

[†]DSTO Melbourne
506 Lorimer Street, Fishermans Bend, VIC 3001 AUSTRALIA
Phone: +61 3 9626 7059 Fax: +61 3 9626 7084
Email: <first>.<last>@dsto.defence.gov.au

[*]Mission Software Pty Ltd
52 Dempster Ave, Balwyn North, VIC 3104 AUSTRALIA
Phone: +61 3 9857 4716 Fax: +61 3 9857 8549
Email: nsmith@acm.org

[‡]DSTO Fern Hill Park
Department of Defence, Canberra, ACT 2600 AUSTRALIA
Phone: +61 2 6256 6166 Fax: +61 2 6256 6180
Email: <first>.<last>@dsto.defence.gov.au

•DSTO Russell
Department of Defence, Canberra, ACT 2600 AUSTRALIA
Phone: +61 2 6265 3863 Fax: +61 2 6265 7218
Email: <first>.<last>@dsto.defence.gov.au

Abstract

In order to create the agile and adaptive force needed to enable NCW and EBO concepts, the force needs to be conceived as components that can be rapidly assembled to provide mission capability packages to meet the commander's need. Previous work in this area has focussed on information exchanges. This paper proposes broadening our approach to consider 'networked services' as a way of describing how a complex network of potential services and providers can be realised to achieve a particular goal. Service exchange becomes the linking mechanism between operational nodes in an alternative architecture description of the force, its objectives or needs, and its capabilities.

This paper discusses the use of a services perspective, defines the terms used and then applies the service perspective to an example from the military domain. The issues raised are discussed and areas that need further research and analysis identified.

1. Introduction

The Australian Defence Force (ADF) has been investigating Network Centric Warfare (NCW) and Effects Based Operations (EBO) concepts to enable the ADF to become a more effective force. Alberts [1] states '*NCW is a set of warfighting concepts designed to create and leverage information*' whereas EBO has been defined as '*coordinated sets of* actions *directed at shaping the behaviour of friends, foes and neutrals in peace, crisis and war*' [2]. These concepts have then been linked: '*… network-centric operations are indeed a means to an end, and effects-based* *operations are that end*.' [2] However, in order to enable EBO we believe that we must extend our interest beyond information aspects. The ADF must '*focus on improving our understanding of the way in which people, systems and platforms link with each other and contribute to achieving the effects that we require*' [3].

For several years, the Australian Defence Science and Technology Organisation (DSTO) has studied information flows between platforms and used the C4ISR Architecture Framework, implemented in Australia as the Defence Architecture Framework (DAF), to describe capabilities [4]. These studies have been valuable in identifying capability gaps in the area of information flows and in prioritising the acquisition of related capabilities. However, the studies provided little insight into in the development of dynamic configurations of capability required for an agile network centric force.

These architecture frameworks focus largely on the exchange and processing of information to describe the interactions that occur between the elements within a force and, in turn, to describe how that force will go about achieving some operational objective. While this is a useful technique for some levels of analysis, it is not particularly effective at describing the interactions that are required to support EBO. Information-based descriptions are too narrowly scoped to encapsulate all of the elements required to create an effect.

In addition, DSTO research into ADF interoperability has recommended the use of the Levels of Information System Interoperability (LISI) model to give a measure of interoperability by examining information exchanges. It has also recognised that there is more to interoperability than just the exchange of information [5]. The NATO definition of interoperability defines it in terms of an ability to provide and accept services:

> *'The ability of systems, units and forces to provide* ***services*** *to and accept* ***services*** *from other systems, units or forces and to use the* ***services*** *so exchanged to enable them to operate effectively together.'* [6]

This definition illustrates that there is some level of acceptance that services form a holistic way of describing the interactions that occur between systems, units and forces. In the business domain, the definition of services can cover the creation and delivery of goods, the creation of information, and services that change the state of objects. This more general definition can also be applied to the military domain.

Much of the impetus for examining information services has come from the commercial Information Technology (IT) domain. Web Services is a relatively new concept within IT designed to allow software applications to create and publish information services and use services that have been published by others. Web services are independent of any particular type of software application, operating system or hardware platform [7]. They are also promoted as being more robust than other distributed computing technologies and therefore better suited to environments where network performance is not guaranteed.

While the military have started to consider the provision of information services rather than just information, particularly in relation to the U.S. Global Information Grid (GIG) [8, 9], very few papers have looked at services from a purely abstract perspective. One notable exception is the work conducted by Garschhammer et al to describe a 'generic service model' [10]. The Swedish Armed Forces [11] have also considered the application of a services model, not just to delivery of information within the military, but across the breadth of the miliary domain.

In order to create the agile and adaptive force that is needed for the NCW and EBO concepts to be realised, we have to be able to conceive of the force as components that can be rapidly assembled to provide mission capability packages to meet the commander's need. The emphasis on needs and the broadened scope of the service definition leads us to believe that it may be a more appropriate concept to support the delivery of effects based operations within a highly networked environment. A 'networked services' concept can be used as a way of describing how a complex network of potential services and providers can be realised to achieve a particular goal. Service exchange becomes the linking mechanism between operational nodes in an alternative architecture description of the force, its objectives or needs and its capabilities.

This paper discusses the use of a services perspective, defines the terms used and then applies the service perspective to an example from the military domain. The issues raised are discussed and areas that need further discussion and analysis identified.

2. Service Concepts

People use the word 'service' everyday with an implicit understanding of what that term means. However, we need to examine the underlying structure and attributes of service in order to understand how it may help in the military domain. Figure 1 is a class diagram based on UML notation, which shows the entities and relationships we will use in defining a service. This is useful as a way of exploring service related elements and establishing some solid definitions that can be used as a basis for further discussion.

While some concessions to a military domain have been made at this stage, for example, the term 'Operational Node' is a military one and the 'commands' relationship is used, a deeper examination of the issues associated with the application of the services model to a military domain is undertaken in section 4.

2.1 *Service Definitions*

2.1.1 *Operational Node*

The term ***operational node*** represents an entity that can play one of three roles within the Service paradigm. Those roles are:

- Customer. A customer identifies a need – their own or someone else's. The customer requires a service that would be able to satisfy that need. The customer is an intermediary between the consumer and the provider;
- Consumer. A consumer is the beneficiary of effects provided by the service. Often the Consumer and the Customer roles are played by the same entity. It is only when the identified need belongs to someone other than the customer that the role of the consumer becomes significant;
- Provider. A service is offered by a provider. The provider negotiates a contract with the Customer aimed at satisfying a Consumer's needs [10].

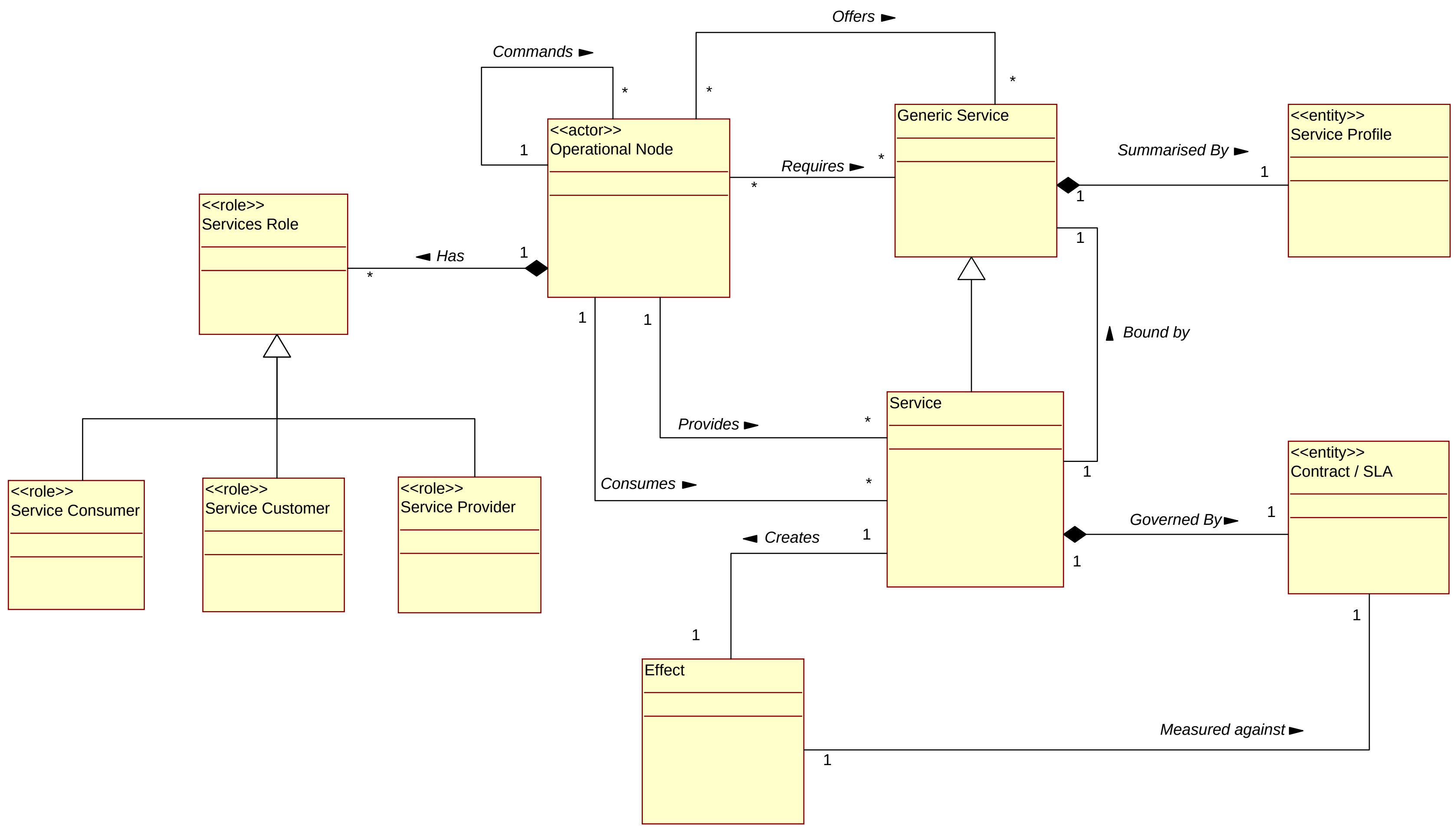

Figure 1. A Service and Related Entities.

2.1.2 *Generic Service & Service Profile.*

A provider offers a service concept or ***generic service*** to customers. The service provider's capability is defined by the attributes of the generic service. Common attributes could include a delivery locale, hours of operation, the types of physical product or information product that might be exchanged and the typical ranges of outcomes and effects.

The selection of a service is facilitated by the use of ***service profiles*** which describe the attributes of a generic service and these profiles may be stored in a service directory.[1] This directory allows a potential service customer or a broker[2] to find and compare services available from many providers.

2.1.3 *Service*

A ***service*** is created when a customer engages the provider of a generic service to deliver a service specific to that customer's (or consumer's) needs.

2.1.4 *Contract / Service Level Agreement*

The ***contract*** is the agreement reached between provider and customer. It is the product of the negotiation phase that applies constraints to the generic service. It defines the quality of service to be delivered by the provider and is used to judge the service once delivered. The contract embodies the Service Level Agreement (SLA).

2.1.5 *Effect*

The ***effect*** represents the ultimate deliverable of the service. The customer measures the effect against the contract to determine whether the service has been delivered. The consumer assesses whether the effect has met their original need. In an imperfect world satisfying a contract may not equate to satisfying the underlying need.

2.2 *The Quality of Service concept*

The contract SLA must specify Quality of Service (QoS) as a key component in the understanding between the provider and customer. QoS is the ability of a service to have some level of assurance that service requirements can be satisfied. QoS requires the cooperation of all service network elements involved in the service chain, top-to-bottom, end-to-end [12].

QoS is the sum of features and characteristics of a service, a guaranteed level of performance delivered to the customer. It is a list of customers' requirements and what the customer expects from the service provider [13,14]. It specifies performance (expected performance characteristics are needed to establish resource commitments) and synchronisation (the degree of synchronisation required between related services), level of service and the cost. There is also a need to have a QoS management function to encompass the degree of QoS adaptation that can be tolerated and mitigating actions to be taken in the event the contract SLA cannot be met.

---

[1] A 'directory' is a listing of generic services and their associated profiles and providers which can be readily searched.

[2] A 'broker' is someone or something that provides a service for matching a customer to the most suitable service provider.

2.3 *Using services*

The typical service usage lifecycle is as follows:

A customer recognises a ***need*** (their own or a separate consumer's need) that they cannot, or choose not to, fulfil themselves. The customer then uses a service ***discovery*** process to match a generic service to their need. The generic service provider is contacted and a ***negotiation*** process ensues between the provider and the customer. A ***contract*** is struck between the provider and the customer stating the provider's understanding of the desired service effect. Finally, the provider organises for the agreed service effect to be ***delivered***.

The above service usage can be varied. For instance, a broker can be employed to deal with service discovery, negotiation, and delivery. This is really just another service being provided to the customer, a service to smooth or enhance the customer-provider interaction. Alternatively, a provider may recognise a need that it can fulfil and instigate the negotiation process. The service provider may also contract part of the negotiated effect to other service providers, in other words sub-contracting.

Services may be contracted once per effect or in an enduring fashion. Enduring services would apply to situations where the same effects are required either continually or periodically under the same contracted conditions.[3] Agreements can be struck to provide a service if a particular event happens. The service may never be utilised but the readiness of that service is in itself a service, for example as a deterrent to some unwanted action.

3. Service Interaction

While a service provider may be able to deliver a service to a customer independently of other operational nodes, often the initial customer need can only be satisfied by combining several services from different providers. The interactions between services and the structures formed can be described as ***service trees***, ***service networks***, and ***networked services***. These service interactions are described below.

3.1 *Service Trees*

Service trees are spawned by decomposing the service contracted to fulfil the initial need. This service decomposition allows services to be subcontracted to other service providers. The tree extends as deep as necessary to satisfy the initial need. The number and type of supporting services that would be required at any point in a services tree depends on the context in which the service resides – the details of the contract struck and the resources available to the service provider at a particular point in time. This argument is equally applicable to the subcontracted service providers. This leads to the conclusion that in a dynamic and agile environment, service trees can often only be identified at the time of execution. Due to the influence of the context on the service, it may be difficult to predict how a service tree might evolve from just the initial need.

A representation of a service tree is shown in Figure 2. In stage n, the customer performs the identification of the need and the discovery process and the provider generates the service and the effect. This provider is also the customer for the subcontracted services in stage n+1. The

[3] Information services provide a useful example of enduring services - e.g. Internet service provision, news services. For these examples, the state that is being maintained could be described as a state of awareness of the consumer.

diagram thus shows the repeated application of the services lifecycle which was described in section 2.3. The subsequent stages of the tree show the multiple supporting services that are required, in this instance, to support the previous stage. Also shown is the cascading feedback of effects generated at each stage.

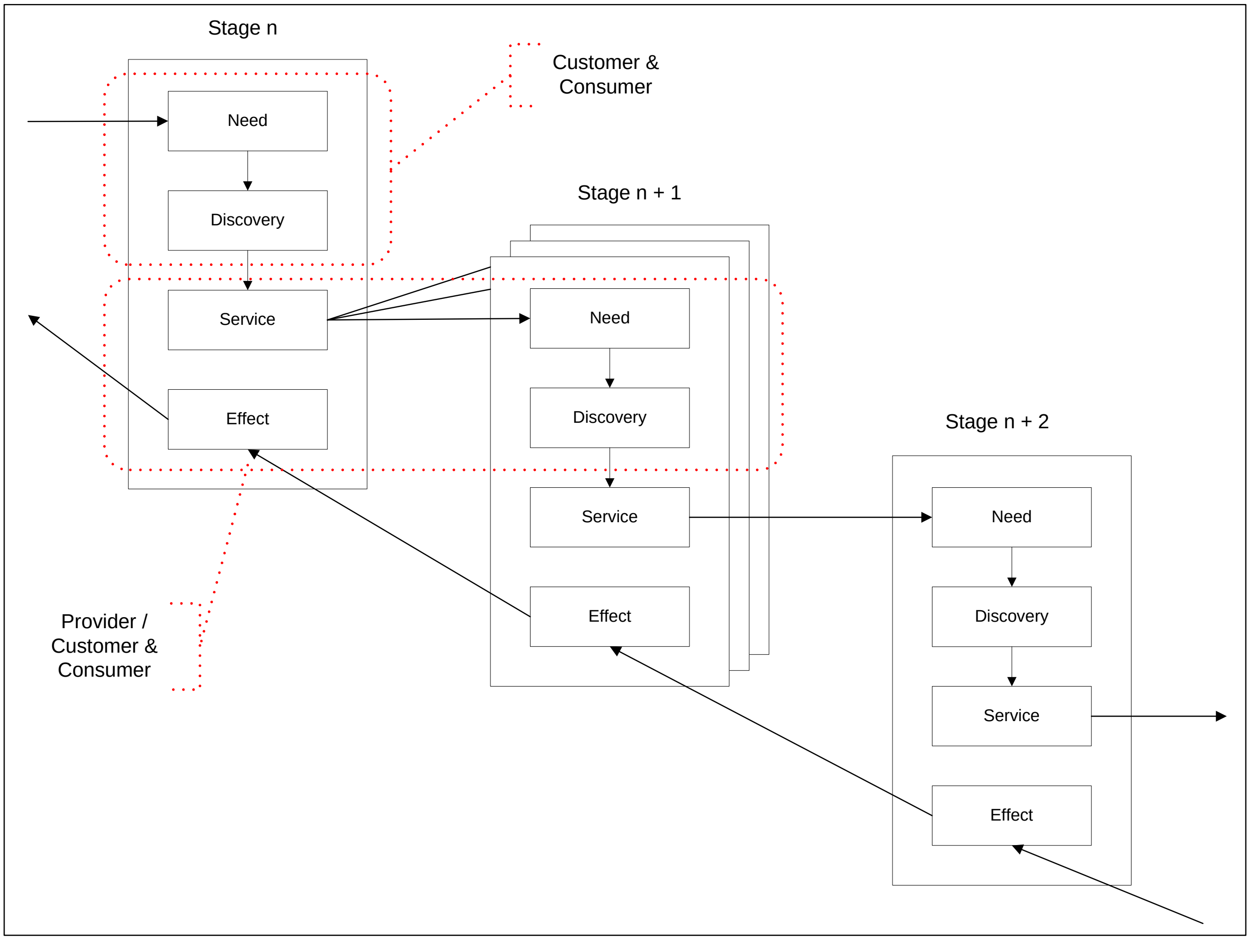

Figure 2. A Service Tree.

3.2 *Service Network*

The service tree describes a single need that spawns multiple services. A service network represents a snapshot of all of the instantiated services within the domain of interest at a given time. This may include multiple service chains initiated by unrelated needs. The service network shows relationships between services using multitasking operational nodes. The operational nodes are still discrete providers and/or consumers but now have a shared awareness of other operational nodes' activities. The relationships in this service network are context dependant and the network is dynamically changing over time. Time management and workload issues may become apparent in this complex world of potentially conflicting service trees utilising shared resources.

3.3 *Networked Services*

Networked services are designed to take advantage of an existing networked environment. The proliferation of virtual retail stores on the Internet is a good example. Another is the outsourcing of support services to offshore entities. These services are geared toward inhabiting and delivering to a networked world.

In order for a service tree, or a service network to be able to form, the appropriate interfaces and protocols between operational nodes would have to be defined. These protocols need to be standardised to facilitate interoperability and automated transactions and thus allow for the effective communication of need, service discovery and delivery of service effect to take place between multiple operational nodes. In the web services domain, defining these interfaces and protocols is seen as a key step toward being able to describe, or build, applications using services [15].

In a military domain, architectures are currently used as a way of describing the relationships that exist between entities in a particular force – e.g. information connectivity, command relationships.[4] If services are to be used to describe military forces, architectures will also be required to include descriptions of service interfaces as well as these other relationships.

3.4 *Levels of Concern*

A powerful technique applied within the networking domain [16] (and within computer science [17]) is the concept of Levels of Concern or Levels of Separation. Well-known examples of this approach include the Open Systems Interconnection (OSI) communication model [16] and the recently developed Model-Driven Architecture (MDA) from the Object Management Group [18]. Within the services domain we propose the following separation into Levels of Concern as shown in Figure 3.

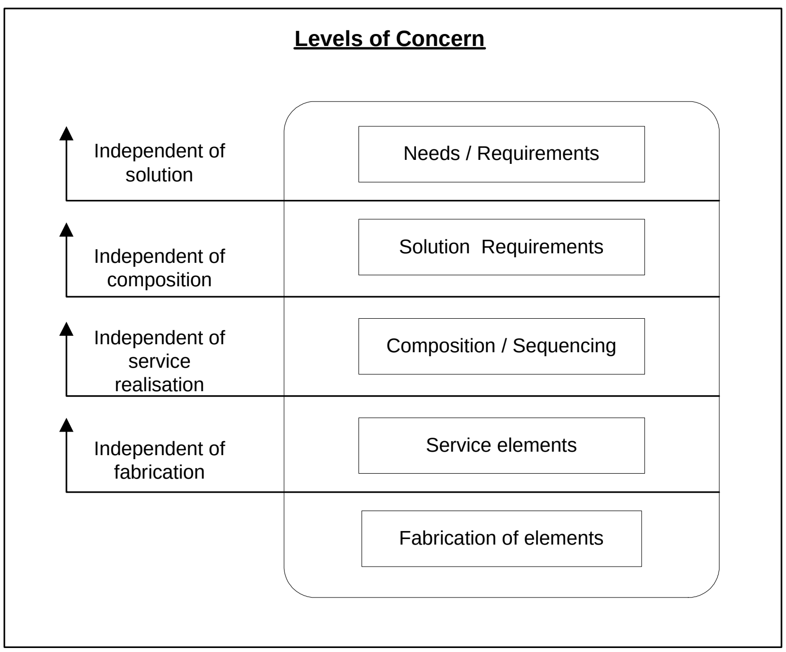

Figure 3. Levels of Concern

[4] Architecture has been defined as: 'A framework or structure that portrays relationships among all the elements of the subject force, system, or activity' [6].

This figure shows the initial need, which will be satisfied by a service, will have its own solution requirements and be structured by combining other services. This model can be recursively applied if the service elements require elaboration, that is, they may have needs/ requirements that should be developed by applying this model.

Within this approach, the critical goal is the independence between the levels. This figure shows that the expression of the service need/requirements must be independent of the solutions available. For example: a need expressed as 'survey the skies using a microwave radar' dictates a solution approach and does not decouple the need from the solution. The development of the solution requirements, derived from the needs, should be independent from the structure and composition of the solution. Solution requirements are taken to include specific requirements, like surveillance accuracy, and the broader system wide requirements like reliability, maintainability and QoS. The structure and composition of the solution should be developed independently of the service element's realization, that is, how a service component is provided should not influence the structure of the solution. Finally, the definition of the service elements should be de-coupled from the fabrication of the service elements. For example: from a service perspective whether a radar, which meets its requirements, is fabricated using an electrical or optical-based computer is immaterial.

The strength of this approach is that the decoupling of concerns allows the complexity of composed services to remain manageable, as only one level is considered at a time. More importantly, this decoupling allows for components within any level being substituted without impacting the overall service delivery. Although this is an idealistic model of service creation, it still provides a measure of 'goodness' in that the more a service solution breeches the goal of separation of concerns the less likely that it will be robust, modular or extensible. In addition, this approach supports the composition of new service solutions from existing solutions since the strong decoupling of levels allows a level (or elements from within a level) to be used in other service solutions.

In common with MDA this model only supports service creation through composition; it does not support internetworking between services. Development of an OSI–like service communication model will be necessary to facilitate the construction of a service network.

4. Applying the Service Model to a Military Domain

The following example shows how a military activity may be viewed in terms of service requests and provision of services. The aim of this exercise is to expose those aspects of a military domain that can be readily described in terms of a services model and those aspects where a direct mapping is more difficult.

The example describes the provision of a service offered by a Regional Operations Centre (ROC) to support a Combat Search And Rescue (CSAR) mission being conducted by a Maritime Patrol Organisation (MPO):

1. The ROC offers a response coordination service.
    a. The generic service promises to support coordination of a number of different mission types: CSAR, Close Air Support (CAS), Surface Warfare etc. It also promises to be able to support any of these mission types, over Australian

territory, at a given distance from the mainland and at a given distance from a forward operating base.

2. Details of this generic service, and the fact that it is offered by the ROC, are known to the ROC's headquarters (HQ).
3. The MPO approaches the HQ with a need for CSAR response coordination.
4. The HQ finds the best generic service fit for the need of the MPO. In this case, the service offered by the ROC.
5. In this instance the ROC's existing workload does not prevent them from providing this service to the MPO.
6. The HQ tasks the ROC to provide a response coordination service for the MPO.
7. The MPO and the ROC negotiate the details of the service.
    a. The MPO provides the ROC with information describing the type of mission and defines the scope of the ROC involvement.
        i. This is a CSAR mission.
        ii. Aim is to rescue downed aircrew from a crash.
        iii. The Area of Operation (AO) is defined.
    b. The MPO also requires regular updates (status reports) on the progress of the CSAR mission. This would be a logical part of a response coordination service because the organization coordinating the movement of the CSAR assets would be in the best position to provide a mission update.
8. The ROC will require a number of supporting services in order to provide this service.
    a. They require the following services that can be provided 'in-house': tracking, airspace management, air traffic control and maintenance of situational awareness (of the aircraft pilots).
    b. Due to the fact that the AO is a significant distance out at sea, the ROC requires a communications relay service in order to communicate with the search and rescue aircraft.
9. Fortunately, the ROC has an enduring service in place with an Unmanned Aerial Vehicle (UAV), an external provider, to provide communications relay support in this region.

4.1 *Matching Example to Service Concepts*

As an operational node, the ROC plays the role of a service provider, a service customer and a service consumer. The MPO is also a service customer and a service consumer. So the existence of these three roles, within a military domain, can be confirmed.

The capability of the ROC to perform response coordination would be described by a military preparedness directive and possibly other documents. These documents would define the boundaries of what the ROC was able to achieve in terms of some basic performance attributes. For example, maximum number of platforms that could be controlled at a given time, geographic areas that can be supported, duty cycle (i.e. can the service be provided 24/7?). These attributes collectively describe the generic service of response coordination. In addition, a summary of these attributes, a service profile, might logically be found in a capability fact book or service directory.

Once negotiations between the service provider and customer have concluded the agreement may either be in the form of written orders or a verbal brief.

Also demonstrated is the application of enduring service arrangements in a military domain. In the example a communication relay service is provided to the ROC by another operational node (the UAV) without the need to go through the processes of service discovery and negotiation with a service provider. Intuitively we could say that this type of service arrangement would be common in the military domain where the number of providers for any given generic service would be limited.

4.2 *Identifying gaps*

The response coordination service example highlights some differences between the military and commercial domains. They are listed in the following table:

Table 1. Differences between commercial and military domains

Service Behaviour	**Commercial Domain**	**Military Domain**
Service provider has ultimate say in whether or not to provide a service.	Yes	No
Service provider has ultimate say in assigning priorities to the service requests.	Yes	No
Service provider is able to suspend the provision of one service in preference for another.	No – A penalty would be incurred.	Yes
The service provider may outsource some elements of work to a similar service provider.	Yes	Yes – If they exist.

Many of the differences arise through the limited autonomy of operational nodes in the military domain as compared to nodes in the commercial domain. The military Command and Control hierarchy coupled with restrictions on workload management are the main problem areas. The remainder of this section discusses the key differences in more detail and suggests ways in which a services model may be adapted for application in a military domain.

4.2.1 *Command & Control*

For a services model to have any validity within a military domain it must be able to account for the behaviour associated with command and control. In the web-services domain there is no concept of compulsion for the provision of services. It is the service provider who is solely responsible for the decision to accept or decline a request for service provision and, as a rule, one request is no more or less important that any other request for service provision. In contrast, a military domain is closely tied to the concept of a ‘greater good’ – an overarching intent, which is derived from whatever mission or operation is being conducted at the time. Therefore, Command and Control (C2) is the mechanism by which this intent is imposed on the force.

So is C2 the limiting factor when applying a services model to a military domain? Perhaps it is worth considering that C2 is itself a set of services that can be provided by some operational nodes (namely those nodes that command other nodes). Based on the response coordination example, C2 services would include some sort of tasking service as well as a service that matched a need (as described by a request from a third party) to a service and service provider that is able to meet that need. This is analogous to the concept of a service broker. In an application of the services model to a military domain both the brokering service and the tasking service would be utilized during the setup phase of a service lifecycle.

Figure 4 demonstrates how the generic operation of the tasking and brokering services might work within a command hierarchy:

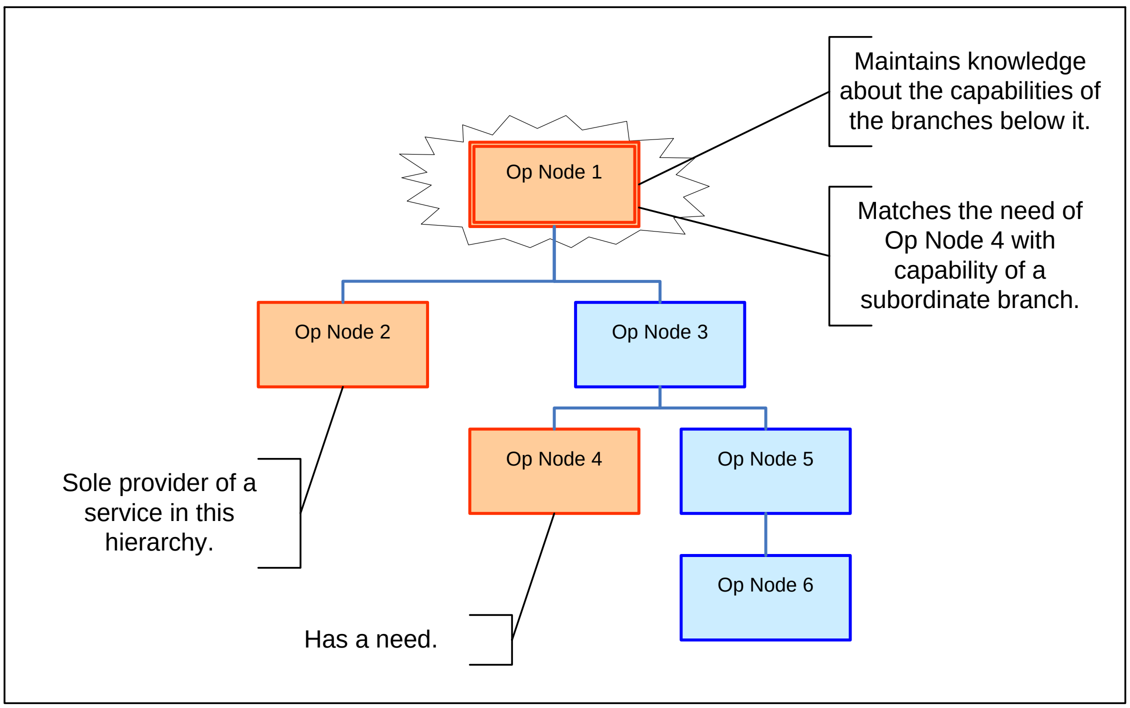

Figure 4. The Brokering and Tasking Service

Op Node 4 has a need that can only be satisfied by a service offered by Op Node 2. The need / request is passed up the command hierarchy until an appropriate match against a capability is found. If all operational nodes only have knowledge of the capabilities of their subordinate branches, the brokering service would need to be provided by the common parent of both the requester and the potential provider – in this case Op Node 1. [5]

[5] In this discussion we have referred to 'knowledge of subordinate branch capabilities' as a way of implementing a basic directory function (within the brokering service). The details of how this might be implemented (e.g. defining the relationship between branch capability and the total set of services that are offered within the branch) are really beyond the scope of this paper. However, these details may be explored further in future work.

Assuming that Op Node 2 was capable of providing the service then Op Node 1 would task them to do so. In this example the service provider sits directly below Op Node 1 and there would be no unity of command issues associated with this tasking. However, if the service provider sat at a lower level then Op Node 1 would not be able to task the service provider directly.[6] Instead, the tasking would be passed down the hierarchy, with branching decisions made at each node, until the appropriate service provider was reached.

There is a third C2 service that is not demonstrated directly by the response coordination example. If an operational node is unable provide a service due to its existing service-provision commitments then an assignment of priorities must be made. Whilst it may be possible for the service requestor to assign a level of priority to their own request which would avert some potential conflicts, however it is likely that conflicts would still arise between existing services and new requests where the priority level of each was the same. Figure 5 illustrates such a scenario:

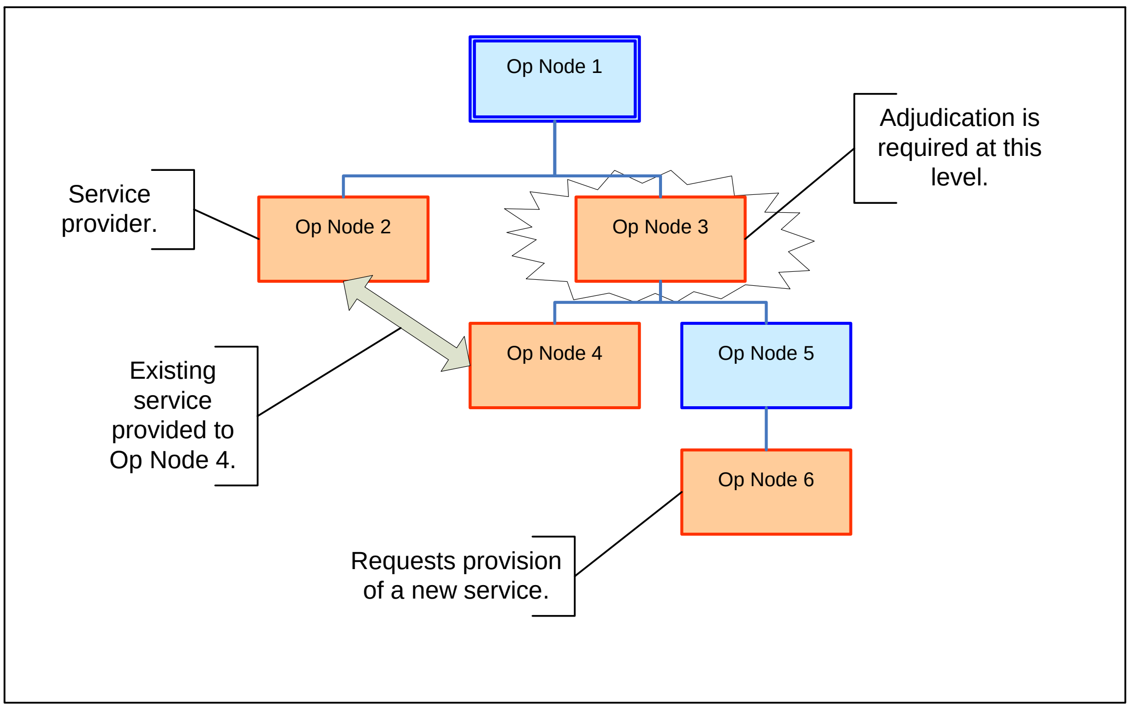

Figure 5. Service Provision Conflicts

In this diagram Op Node 2 is providing a service to Op Node 4. Assuming that Op Node 2 is unable to provide services concurrently, a conflict arises when Op Node 2 is requested to provide a service to Op Node 6.[7] In this instance it is Op Node 3, the immediate parent of both Op Nodes 4 and 6, who must adjudicate between the two competing demands.

---

6 Because of both the unity-of-command issue and the fact that Op Node 1 may not have direct knowledge of the service provider.

7 This is also assuming that the existing service has the same priority level as the new request.

Based on the previous discussion, the following set of C2 services is tentatively presented to cover those activities that are unique to C2 at all levels within a command hierarchy:

- Tasking
- Brokering
- Prioritisation / Adjudication

This does not imply that a node primarily involved in the conduct of C2 would only provide these services. Rather, these three services represent a C2 common denominator. For example, it is likely that an Air Operations Centre would be the sole provider of services such as targeting, air battlespace planning etc. However, as a node that commanded other nodes it would also provide these three services by default.

4.2.2 *NCW C2 Services*

The preceding discussion has assumed that a hierarchical command structure is in place. In an NCW world where flatter or more dynamic C2 structures may be the norm and self-synchronised activities may be needed to enable rapid responses to evolving situations, alternative ways of providing these C2 services are required. Individual service providers will need an understanding of commander's intent and a set of local rules that enable them to adjudicate priorities and tasking. The node with the greatest knowledge of what is required and the available resources should provide the adjudication service rather than the nominal command node.

4.2.3 *Resource Management*

The previous discussion of prioritisation and adjudication hinted at some of the problems of managing resources within a services model. Service providers, while constrained by their existing commitments, may have resources available to provide some elements of a new service. They may then be able to sub-contract out those remaining elements to other service providers using exactly the same service provider / service customer relationship.

Another practical consideration for the military domain might be the lack of secondary providers of the same generic service - particularly within a smaller defence force such as the ADF.

5. Outstanding Issues

5.1 *Framework*

There is more work to be done in defining a service architecture framework and what interoperability may mean in a services sense. As the DAF is already in use throughout the ADF it will be a valuable starting point for the development of a services framework.

A services framework should outline:

- How to formally describe what a service can do.
- The interfaces used for: needs expression, service discovery and effect delivery.
- Protocols to support inter-service communication, negotiation and coordination.
- Rules for determining the level of service granularity that is required for a given force and a given level of analysis.

In addition, there is scope for a study seeking parallels between the military language we use to describe the customer's need and the military language we use to describe the desired service effect. Clarity here will provide a link between a commander's intent and delivered capability.

5.2 *NCW Issues*

While the application of a services model may promote increased interoperability and flexibility (and ensure a greater focus on EBO) within a force, the discovery and adjudication processes proposed previously, to operate within a C2 hierarchy, appear unwieldy. This is becomes more apparent when set against the NCW requirement for agility. There is therefore a need to develop rapid discovery and delivery (deployment) mechanisms to remain relevant in an NCW world. The fast, agile, dynamic contracting of military services should bring potency to NCW concepts.

5.3 *Future Networks*

This paper has concentrated on the major issues associated with introducing a services approach into the military domain. The broader question of networking services raises issues of what functionality does the network or supporting infrastructure need to provide to facilitate service use. Today's physical communications networks are fairly rudimentary and provide only limited support for service decomposition and composition or support for service initiation, orderly completion and status reporting. Many of these concerns require further investigation and are beginning to be addressed within future Internet architectures and protocols.

The achievement of the goal of networked services needs to address issues such as how does the network enhance service robustness, service portability and assist in resource management. Management of resources needs to address the obvious issue of resource allocation, and the more difficult problems of authorization (can this service resource be used) and authentication (is this the service expected). These issues will become more significant as services are invoked remotely and possibly automatically via networks. Finally, mechanisms need to be developed to address the separation of the logical description of a service from its physical implementation, as it is only through such decoupling that service provision can evolve and improve with the introduction of new and improving technology.

We reinforce the need for these ambitious goals to be embedded in a coherent architectural framework that simplifies the provision of services and maximises the full potential of NCW.

5.4 *Capability development*

In a civilian domain the provision of services is subject to supply and demand feedback loops. If a service provider is continually unable to satisfy the requests of service customers due to lack of resources then they will invariably try to acquire more resources to meet the rising demand. Also, more providers of the same generic service will start to appear.

There is no direct analogue to this feedback loop in the military domain. Capability development is the primary mechanism for introducing new services and altering the ability to provide existing services within the military. The process of capability development is a carefully planned and deliberate one. Capability developers must take into account the importance of maintaining services that are rarely used as well as those that are required on a regular basis.

Applying a services model to aid the capability development process is an important area of future work.

6. Conclusion

This paper proposed the consideration of networked services as a way of describing how a complex network of potential services and providers can be realised to achieve a particular goal. Definitions of service concepts were developed and applied to an example situation in order to identify issues that may need consideration and to highlight the differences between a commercial and a military context. One key difference that was identified was the responsibility of C2 nodes for the conduct of adjudication, tasking and brokering. It was proposed that these three responsibilities represent a set of unique C2 services. Issues arising from the consideration of different C2 paradigms were also discussed including the need for rapid discovery and delivery mechanisms and resource management.

Areas of future work include the development of a framework and protocols that will support networking and interoperability between services, and the application of a services concept to the capability development process.

References

1. Alberts, DS. *Information Age Transformation: Getting to a 21st Century Military*. CCRP Publication Series, March 2003; p7.
2. Smith, EA. *Effects Based Operations: Applying Network Centric Warfare in Peace, Crisis, and War.* CCRP Publication Series, November 2002; p. xx.
3. Hill, R (Australian Federal Minister for Defence). Speech to *ADF Network Centric Warfare Conference.* Canberra, 20th May 2003.
4. C^4ISR Architectures Working Group. *C^4ISR Architecture Framework version 2.0.* United States Department of Defense, 18th December 1997.
5. Clark, T. & Moon T. *Interoperability for Joint and Coalition Operations.* Australian Defence Force Journal, 2001, No. 151, pp. 23-36.
6. Joint Publication 1-02. *Department of Defense Dictionary of Military and Associated Terms.* United States Department of Defense, 12th April 2001 (amended 23rd March 2004); p270.
7. Web Services Architecture Working Group. *Web Services Architecture.* Accessed 5th April 2004. <http://www.w3.org/TR/ws-arch/>.
8. Bieber G & Carpenter J. *Openwings – A Service-Oriented Component Architecture for Self-Forming, Self-Healing, Network Centric Systems (Rev 2.0).* Openwings.org. Accessed 5th April 2004. <http://www.openwings.org/download/specs/openwingswp.pdf>.
9. Meyerriecks D. *Net-Centric Enterprise Services. What Problem are we trying to solve?* Military Information Technology, 2003, No. 3, Vol. 7. Accessed 5th April 2004. <http://www.mit-kmi.com/archive_article.cfm?DocID=23>.
10. Garschhammer M, Hauck R, Hegering HG, Kempter B, Radisic I, Rolle H, Schmidt H, Langer M & Nerb M. *Towards generic Service Management Concepts: A Service Model Based Approach.* May 2001. Accessed 5th April 2004, <http://www.cnm.dfn.de/cnm/smtf01.pdf>.

11. Swedish Armed Forces Headquarters presentation. *Developing an NBD Defense*. 21st April 2002; slide 14.

12. Johnson V. *IP QoS FAQ*. Stardust Forums Inc., 1999. Accessed 7th April 2004. <http://www.inf.ufrgs.br/granvile/QoS/Imprimir/faq.htm>.

13. Fidelia Technology Inc. *Glossary*. 2003. Accessed 7th April 2004. <http://www.fidelia.com/products/user-manuals/glossary.html>.

14. GTZ GmbH. *Services for Rural development – Glossary of Definitions.* 2004. Accessed 7th April 2004 <http://www.gtz.de/agriservice/english/resources/definitions.htm>.

15. Srivastava B & Koehler J. *Web Service Composition – Current Solutions and Open Problems.* IBM Research Laboratories. Accessed 10th April 2004. <http://www.zurich.ibm.com/pdf/ebizz/icaps-ws.pdf>.

16. Farlax Inc. *OSI reference model.* 2004. Accessed 3rd May 2004. <http://encyclopedia.thefreedictionary.com/OSI%20reference%20model>.

17. Parnas DL. *On the criteria to be used to decomposing systems into modules.* Communications of the ACM, 1972, 15(12):1053-1058.

18. Architecture Board ORMSC. *Model Driven Architecture (MDA).* Ed: Miller J & Mukerji J. Object Management Group, 9th July 2001. Document Number:ormsc/2001-07-01. Accessed 3rd May 2004. <http://www.omg.org/docs/ormsc/01-07-01.pdf>.