Service-Oriented Architectures for Network Enabled Capability

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Abstract

Network Enabled Capability (NEC) is the UK Ministry of Defence's response to the rapidly changing conflict environment in which its forces must operate. This paper introduces a part of the EPSRC and BAE Systems jointly funded project NECTISE (NEC Through Innovative Systems Engineering) that aims to address NEC issues using Service-Oriented Architecture (SOA). SOA is a network-enabled solution that has the potential to combine assets (software resources, people, equipment, processes) to provide capability; that is, the ability to achieve a mission objective. This position paper introduces the problems that NEC faces that can be addressed by SOA, and highlights some of the outstanding issues not address by SOA that form research directions within the NECTISE programme.

1. Introduction

NECTISE aims to define what NEC means to BAE Systems, the UK's largest defence provider, its supply chain, and its customer, the UK MoD. The project tackles four main topics of Through-Life Systems Management, Architecture for NEC, Decision Support, and Control and Monitoring. This paper concentrates on describing the research issues in the Architecture for NEC topic, showing areas where computer systems architecture will be used to provide flexibility, quality of service evaluation, and evolution of systems with high degrees of scalability and dependability for dynamic large scale integration.

The advances in worldwide communications that have spawned recent yet universal services such as the World Wide Web have been seen as an enabler to improved battlespace capability. In the USA, the move towards Network Centric Warfare (NCW) is gathering pace with vast databases being assembled to support universal connectivity between assets. In the UK and elsewhere such as Australia and Sweden, this trend is being repeated but on a smaller scale. The UK MoD has adopted the same underlying principle and called it Network Enabled Capability (NEC). JSP777 (UK Ministry of Defence, 2005a) defines NEC but in essence it is about getting the right information to the right people at the right time. However, the impact of NEC will not be confined to the battlespace or operational arena. MoD and their supply chain are preparing to work in partnership from concept, through technology insertion to final disposal, to delivering military capability (UK Ministry of Defence, 2006). Industry will be expected to be involved in the early requirements phase and in supporting assets in the field. NEC exists in an operational context, in the battle space where real-time connections create capabilities that contribute to a mission objective. NEC also exists in the organisational context, which includes military planning, acquisition, and supply. These loose boundaries for operational and organisational become blurred as NEC promotes loose coupling, so that late binding and late acquisition occurs during operations in real-time and planning must be at a higher level, with an overview of how assets (equipment, services, personnel, process) contribute to a capability.

Currently, defence customers demand systems that exhibit a high degree of integration to increase functionality. This leads to more complex interdependent system solutions, and consequently integrated operational concepts, causing more complex approaches to procurement and supply and to the operational use and through-life management of systems. Systems engineering has demonstrated that separation of functionality into independent systems with connectivity standards can achieve reuse of components in different contexts, aiding better management of resources and identification of requirements to achieve objectives. NEC addresses this by the connectivity of functional components to achieve capabilities.

NEC requires the following characteristics:

- Armed Forces to be flexible, ready and rapidly deployable.
- Application of controlled and precise force, to achieve realisable effects, that include

diplomatic and political aspects (effects based operations).
- System integration without interdependence.
- Evolvable, responding to changes in environment, situation, supply, information and ongoing development.
- Dependable, managing system changes, to tolerate faults and through-life evolution in a secure manner.
- Cost effective, by efficient use of assets and supply.
- Connecting industrial and defence environments, and connecting pan-defence environments.
- Increased use of data and information, securely managing information and control.

Practical evidence shows that system architecture is the most important factor that affects both a system's functionality as well as its non-functional aspects, such as scalability, flexibility, and dependability. Architectural models should therefore be the starting point for any development of NEC systems. Numerous studies have demonstrated that system architectures are effective in assisting the understanding of broader system concerns by abstracting away from the details of a system (Shaw and Garlan, 1996). This is achieved by employing architectural styles appropriate for describing systems in terms of components, the interactions between the components – connectors, and the properties that regulate the composition of components – configurations. Systems and components may be human beings, hardware, software, communication equipment, as well as other resources, including those that describe the Defence Lines of Development (DLoD) (UK Ministry of Defence, 2005b). In particular, architectures for NEC systems must consider the viewpoints of all capability stakeholders; connectors between independent components/systems must describe their interoperability; and configurations describe the evolutionary acquisition of capability through successive system development cycles.

This paper presents issues on flexible architectures for NEC, suggesting which issues can be addressed by SOA, and positioning the outstanding issues that require further research to improve the abilities of SOA. The next section describes the requirements for NEC systems, followed by areas that SOA addresses, in particular web service and grid service technology implementations. The final section introduces the research topics for NECTISE to extend SOA for NEC. At the end, there is a glossary of acronyms.

2. Architectural Issues for NEC

To achieve NEC requires network enabling by connectivity, information sharing and networking people, assets, and procedures for network enabling; and capability requires identification of networks of people, assets and procedures to fulfil mission objectives. In the NEC battlefield, the architecture needs flexibility to address the following issues:

- Evolvable system, which can cope with dynamic changes of the runtime system and design of an architecture to manage changes in the future.
- Availability. Whether a Service is present and ready for use.
- Accessibility. Represents the degree the Service is capable of serving a request.
- Integrity. Maintaining the correctness of any interaction.
- Performance. Produce a high throughput but low latency system.
- Reliability. Capability of maintaining the service and service quality.
- Regulatory. Service corresponds to rules, laws, standards and specifications.
- Security. Includes access control, privacy and confidentiality.
- Maintainability. Ability to undergo modifications and repairs.
- Scalability. Ability to maintain available services under increasing demands.
- Resilience. Capable of tolerating faults.

Physical Attributes of Services, include:

- Integrability. How easily a system component can be integrated (such as conformance to interface standards).
- Upgradability. How easily a system component can be improved within the system.
- Constructable. How easily a component or system can be built and deployed.
- Reconfigurable. A measure of the scope a component or system can be changed once deployed.

The biggest challenge is taking the areas of SOA that have arisen specifically from computing and applying them all to hardware, procedures and people in the NEC context.

3. Service Oriented Architecture for NEC

One of the possible solutions for NEC architecture is Service Oriented Architecture (SOA). The nature of SOA lends itself to NEC, offering flexible approaches to distributed

systems engineering with quality of service and evolution characteristics applicable to NEC.

The main part of SoA is its decentralised middleware (Alonso et al., 2004). By ensuring the middleware is not implemented in a single place it allows individual services to be independent of other components within the system. A decentralised middleware implementation would avoid a single point of failure and tend to force vendor specific tie-in. However, decentralised middleware requires replication of functionality at each location a service is deployed. This overhead is justified by the flexibility provided by the following characteristics:

- Loose Coupling is an architectural property exhibited by services that makes them independent from other components in the system.
- Defining services by interface, including data exchange and behaviour (pre/post conditions). This allows implementations to be interchangeable, offering dependability, availability and scalability by replication of services.
- Interface definitions also support late binding of services and resources, which supports evolvable systems by changing implementations to improve performance such as speed and accuracy.
- Reusable services. Loose coupling promotes the reuse of services in new contexts not previously envisaged.
- Inter-organisational. By using a loosely coupled system, an application or process would be able to use services developed outside organisational bounds.

The integration of services is achieved through the definition of procedures and workflows. This can support ultra-late binding, by selecting services implementations at the point of service execution.

In the context of NEC, acquisition of equipment for the MoD is on a platform basis, with subsequent maintenance and upgrade contracts. By introducing SOA, platforms are no longer the acquired products, delivery is based on the achieved effect, and consequently acquisition and delivery are on-going. This permits the underlying platforms to be maintained and evolved, improving dependability and flexibility, and opening the opportunity to achieve new effects.

4. Research Issues

Current SOA technology, such as web services and grid services, offers incomplete solutions to SOA for NEC. The unanswered questions include a wide range of problems, some of which will be investigated during NECTISE, such as:

- How to define the granularity of a service and how it relates to hardware platforms,
- How a service is defined by its components, responsibilities and attributes (quality of service),
- How does a service contribute to capability,
- If late binding is used, what parameters does a broker require, to select by availability, quality of service, security and usage policies,
- What are the quality of service attributes required for NEC,
- How is change managed in an uncertain NEC environment,
- What is the cost of middleware for NEC platforms, where overheads for communications bandwidth and processing resources may be limited,
- How does the cost of communications contribute to implementing SOA using web services, given the additional overhead compared to CORBA (Elfwing et al., 2002),
- How do you measure the correctness of SOA for NEC?

The last issue of measuring SOA is a separate research topic within the NECTISE programme, being addressed across the programme, but also specifically within the architecture topic to produce evaluation criteria for architectures.

NECTISE has completed a 6 month Definition Phase, which has produced a baseline report detailing current state of the art in the topic areas, a statement of the current understanding of network enabling and capability, a review of the BAE Systems requirements across the different business units, and a confirmation of the project vision. This paper highlights the start of one area of NECTISE that will investigate the importance of SOA in addressing the network enabled capability.

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Glossary

DLoD	Defence Lines of Development are rooted in the MoD approach to providing capability. The DLoDs are listed here by name: Training; Equipment; Personnel; Information; Concepts & Doctrine; Organisation; Infrastructure; and Logistics (UK Ministry of Defence, 2005b)
MoD	UK Ministry of Defence
NCO	Network Centric Operations
NCW	Network Centric Warfare
NEC	Network Enabled Capability
NECTISE	Network Enabled Capability Through Innovative Systems Engineering
SOA	Service Oriented Architecture.

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