nehta

Interoperability Maturity Model

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Executive Summary

Capability maturity models guide organisations in continuous process improvement, ensuring increasing levels of capability delivery to fully realise their business objectives. They describe an evolutionary path from ad hoc, immature processes to disciplined, mature processes with improved quality and effectiveness [CMMI]. Capability maturity models have been applied to many different disciplines including software development, systems engineering, integrated product and service development, and acquisition.

In the health sector, e-health services often involve multiple collaborating healthcare providers, individuals or organisations. Their ability to interoperate will significantly influence their capability to deliver safe, reliable, efficient and convenient healthcare services. The role of ICT systems is an important enabler for this capability and the term *e-health interoperability* is used to signify an overall capability of all participants to interoperate, spanning information, technical as well as organisational perspectives [IF].

This mix of interoperability perspectives is inherently complex and is further exacerbated by a need for a *continuous state of readiness* for adoption of new technologies, better information quality and new clinical/administrative processes and policies. Towards a similar outcome, capability maturity models are applied in other industries to drive quality practices in complex fields of endeavour. This is equally desirable in the health IT community. In fact, it is recognised that there is a pressing need for an *e-health interoperability maturity model,* a comprehensive model for defining a managed path towards increasing e-health interoperability, including the assessment of that ability [Rubin].

This document presents an e-health interoperability maturity model proposed by NEHTA, aimed at helping e-health organisations[1] improve their ability to use or deliver interoperable e-health systems[2], with the ultimate goal of increased healthcare benefits - in particular improving safety, quality and effectiveness in delivery of healthcare services.

This e-health interoperability maturity model (IMM) leverages a generic and widely used Capability Maturity Model Integration (CMMI) approach [CMMI] as a reference model for expressing levels of e-health organisation capability on their path towards delivering better interoperability outcomes. Each capability level represents a process improvement, referred to as an organisational maturity level. Consequently, each maturity level requires attaining the previous maturity levels, while incrementally adding new capability and bringing new benefits. There are five maturity levels identified, namely Initial, Managed, Defined, Measured and Optimised.

Further, the IMM identifies a number of *interoperability goals*, classified in terms of organisational, information and technical perspectives, according to the NEHTA Interoperability Framework (IF). These goals were identified through analysing interoperability in the context of the national e-health community as well as other ICT domains. They may also be applied in the context of enterprise e-health interoperability with appropriate realignment of priorities and mapping to organisational requirements, such as those that apply to state and territory health organisations.

Interoperability goals relate to the interoperability concepts and patterns described in the Interoperability Framework v1.0. Pattern families were identified to group common interoperability approaches and these support one

[1] Examples of e-health organisations are ICT departments within jurisdictions, vendors involved in delivering e-health systems and services, and various standards development organisations or other associations concerned with the design, development and use of e-health systems.

[2] Informally, an e-health system is a solution within the health sector that, to different levels, relies upon ICT capabilities.

or more of the interoperability goals presented in the IMM. Some such as governance have a one-to-one correspondence to interoperability goals while others such as Service-Oriented Architecture support multiple interoperability goals. So in summary, each pattern family includes a number of related interoperability patterns. Patterns are built from some common basic concepts. Interoperability goals identify characteristics of patterns that have been put forward as common issues of concern.

Interoperability goals should guide organisational practices that in turn create work products that reflect those original interoperability goals. Interoperability goals can be used to analyse an e-health system such as a specification or service through a *work product interoperability assessment* providing insight into interoperability support. This analysis identifies those aspects of the solution or specification that support each interoperability goal. A lack of interoperability support within the organisational work outcomes indicates that the underlying organisational interoperability practices need attention. It is then appropriate to conduct an *interoperability maturity assessment* to determine appropriate steps in interoperability process/practice improvement.

Effectively, the IMM provides a set of guidelines for setting organisational process improvement goals in delivery of interoperable e-health solutions and a point of reference for appraising an e-health organisation's interoperability through the respective interoperability systems or work products.

The IMM proposed in this document can be applied to any e-health organisation delivering e-health systems and to e-health systems where interoperability has been identified as a required system characteristic, whether within community, enterprise or local contexts.

The use of IMM delivers a number of benefits to e-health organisations:

- The IMM provides a managed and repeatable approach for guiding organisations in incrementally improving their interoperability. This is because it provides a method for analysing, defining and assessing interoperability according to internationally recognised maturity improvement practices.
- It allows e-health organisations to use it in combination with various benefit realisation approaches so optimum interoperability adoption targets can be selected based on the relative importance of each interoperability goal in the context of organisational requirements. This ensures the positioning of e-health interoperability within the broader economic models concerned with benefits realisation and allows for strategic planning and informed investment.
- It identifies which activities, processes and efforts are required by an organisation when a certain maturity level has been attained and future levels are desired. This knowledge allows e-health organisations better predictability when incrementally rolling out new practices across the business.
- It allows benefit flow-on from interoperability learning within community (national) and enterprise scopes as broader issues and approaches filter into local efforts yet continue to reap the broader benefit. Choosing to leverage capabilities in more restrictive contexts enables future use within the national or enterprise context. This prepares any local efforts to be more aligned with potential future community interoperability requirements. It allows for more sustainable, predictable, and repeatable system interactions at all levels.

1 Introduction

The first step towards getting somewhere is to decide that you are not going to stay where you are.
— John Pierpoint Morgan

1.1 Background

Improved e-health interoperability within and between healthcare organisations requires the application of a repeatable model for defining and evaluating interoperability. This model must deal with the incremental nature of interoperability maturity planning and help organisations define and evaluate interoperability improvement options. Similar observations have also been made by several international e-health experts, most notably Ken Rubin, highlighting the need for 'an independent framework against which interoperability solutions can be objectively measured [KR]'. Such a model should apply consistently across organisational, information and technical interoperability perspectives on e-health interoperability.

This document presents the NEHTA *e-health interoperability maturity model* (IMM), as foreshadowed in the NEHTA Interoperability Framework 1.0 [IF]. This model will allow the analysis of both work products and organisational practices supporting interoperability and provides tools for identifying programmes to improve interoperability maturity.

The IMM consists of the following components:

- five maturity levels, inspired by the widely used Capability Maturity Model Integration (CMMI) framework [CMMI];
- a set of interoperability goals, based on e-health and more general ICT requirements[3] in the Australian context; and
- an assessment framework.

This IMM will form a component of NEHTA's Interoperability Framework (v2.0), to be released in mid 2007.

1.2 Purpose

The purpose of this document is to present:

- the Interoperability Maturity Model including its applicability to the national, enterprise and local contexts;
- the business benefits of this model for health organisations striving to enhance their e-health interoperability; and
- tools for applying the model for analysing e-health systems and organisational practices.

1.3 Intended Audience

This document is intended for ICT specialists in health departments, vendors and standards organisations – in particular:

- E-health strategic planners involved in producing ICT strategy and deciding about optimum interoperability investments;
- Enterprise and solution architects involved in e-health projects;

[3] Note that although the IMM was developed with the e-health domain in mind, many of the interoperability characteristics are of more general nature, allowing support for interoperability in cases where the health sector needs interaction with other government and commercial sectors – these requirements were highlighted in the NEHTA Interoperability Framework [IF].

- CIOs and CTOs in jurisdictions, e-health system vendors and related organisations.

1.4 Scope

This document defines a maturity model for interoperability aspects of e-health systems and organisational practices from a *national* perspective. Although much will also be applicable within an enterprise context, NEHTA has specifically identified issues that will foster interoperability within the national e-health context.

The document does not address the maturity of other aspects of e-health systems such as security, messaging, etc. However, by adopting a similar CMMI-based maturity approach to these other aspects, it will be possible to aggregate multiple characteristics (i.e. interoperability and others) in a common model.

1.5 Document structure

The next section describes the key components of the IMM, i.e. five maturity levels, a set of interoperability goals, an assessment framework and the benefits to be obtained from the IMM.

This is followed by a description of a methodology for applying IMM for the development of interoperability maturity models for specific e-health systems and organisational practices.

The document also includes two examples of applying the IMM, firstly to the interoperability support within a particular e-health system and secondly to the organisational practices that support the generation of appropriately interoperable e-health systems.

A detailed description of the distinction between community, enterprise and local interoperability domains is given in Appendix A. Appendix B presents a discussion on maturity models, their purpose and existing approaches.

2 Interoperability Maturity Model

The IMM defines an iterative process by which e-health organisations can assess and increase their ability to interoperate, internally or as part of a national e-health community. The IMM allows organisations to identify potential interoperability maturity programmes, to which a cost-benefit analysis can then be applied to determine the preferred means for reaching a desired level of interoperability.

In developing the IMM, the following factors have been considered:

- existing maturity modelling approaches, as described in Appendix B.2, to leverage the best practices, experience and solutions established within these approaches;
- the "separation of concern" principle set out in the IF, to support an expression of interoperability capability across organisational, information and technical perspectives; this was further augmented by considering interoperability activity domains, i.e. community, enterprise and local, as described in 0;
- e-health characteristics, such as those identified and discussed in the Health Care Information Exchange and Interoperability (HIEI) model in Appendix B.2, with specific considerations for the current Australian e-health context, both at national and jurisdictional levels.

The IMM closely follows the CMMI reference model and consists of the following IMM components:

- *interoperability maturity levels*. There are 5 levels, namely: Initial, Managed, Defined, Measured and Optimised. Reaching each of the four latter levels requires the attainment of the previous levels;
- a set of *interoperability goals,* identified within an e-health context (i.e. regional, state or national level). These goals are separated into interoperability perspectives; and
- an *assessment framework,* to measure the maturity level of an e-health organisation or to assess the interoperability of an e-health system[4].

The application of CMMI is a process of continual improvement that links goals, practices, and work products as described in Figure 1. Goals influence organisational practices that in turn are demonstrated in the work products that are produced or procured. A work product interoperability assessment ensures the products do indeed reflect desired goals and interoperability maturity assessment checks organisational practices are delivering interoperable outcomes. The IMM is based on the same improvement approach as CMMI and the dependencies between these sequential steps should be kept in mind throughout the rest of this document.

[4] Note that, although the assessment of e-health systems interoperability is likely to reflect the maturity of processes established to deliver interoperability, this assessment can be done independently, for purposes other than defining process improvements.

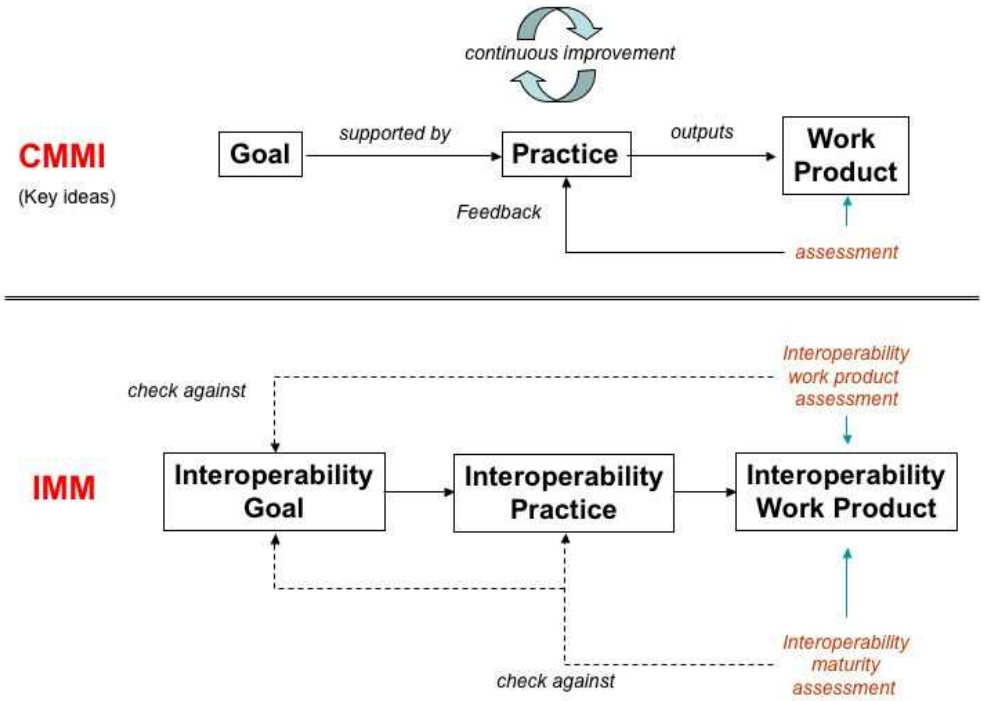

Figure 1: The CMMI and IMM continuous improvement processes

These IMM components are discussed as follows.

2.1 Interoperability maturity levels

In order to provide a standard and consistent way of talking about e-health interoperability maturity levels, the widely used CMMI approach was applied.

E-health interoperability[5] is defined as *a continual ability of an organisation or a system to use or offer business/technical services from or to another organisation/system and accordingly, exchange information with other organisations/systems to achieve a specified purpose in a given context.*

CMMI was chosen as a reference framework because of its general applicability to any problem domain (or target) for which maturity models are to be developed[6].

Accordingly, the five levels of maturity (see Figure 2) define a maturity of practices that can be aligned with the following levels.

- *Initial*: There is an early awareness of e-health interoperability requirements and characteristics and perhaps some early e-health interoperability solutions adopted, typically localised within certain clinical or administrative domains (as these provide environments with limited complexity).
- *Managed* (or under development): An organisation will begin accomplishing some interoperability goals, such as the adoption of specific e-health standards while gaining an early, shared understanding

[5] This definition was developed based on consideration of many e-health concerns. NEHTA's observations suggest that many e-health interoperability concerns have much in common with ICT interoperability concerns in other sectors. The e-health specifics are reflected in the semantics of information exchange, policies that constrain access, use and modification of information and stringent quality, safety, and reliability requirements for ICT.

[6] Although CMMI is used in this document to focus on the interoperability goals of an e-health system, it can be also applied in a broader e-health context, covering other e-health system characteristics such as feature set, quality and change management.

of data, services or internal processes as well as initial governance established to ensure repetition of earlier successes.

- *Defined*: An organisation has defined a set of guidelines for the adoption of e-health standards for data, services and processes, according to the lessons learned from previous maturity levels. These are further augmented with explicit focus on policy and legal compliance. Governance is well defined and defined levels of organisational readiness for interoperability outcomes are established. Communication standards for interaction with internal and external partners are established as are the supporting organisational structures facilitating a shared understanding across technical and semantic issues.
- *Measured*: An organisation has established processes for appraising and measuring e-health interoperability. This can be done before the system is deployed such as through conformance and compliance activities or during the operation of the system, i.e. run-time monitoring.
- *Optimised*: The organisation has implemented processes to support continuous interoperability improvements, driven by feedback from monitored processes, with the aim of improving overall e-health interoperability capability.

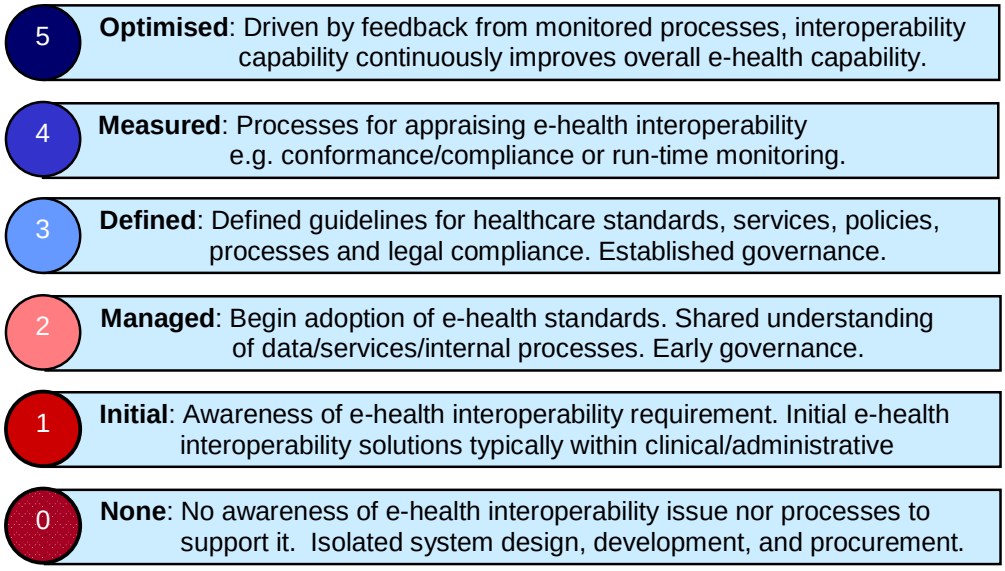

Figure 2: Interoperability maturity levels

The consistent use of this approach supports a *shared understanding* of maturity between organisations. Each of the levels in Figure 2 defines an increasing level of maturity that can be used to define specific interoperability maturity goals that in turn can be analysed in terms of practices that need to be established to provide continuous improvement in interoperability (see Figure 1). In order to measure the success of interoperability outcomes, one must have already defined the standards for that success.

It is important to note that above level 1 (Initial) each maturity level requires the accomplishment of goals defined in previous levels.

These maturity levels have general applicability and can be further refined to reflect the specific context for analysing interoperability, namely the community, enterprise or local interoperability domains (these are described in 0). Figure 3 describes examples of different interoperability practices within the three different domains. For instance, it shows how service oriented architectures (SOA), enterprise architectures (EA) and community architectures are used within different domains to address respective interoperability challenges. This may range from efforts of early champions to

adopt some technical or information interoperability within an enterprise boundary to an established certification programme and monitoring of Service Level Agreements (SLAs) governing rules within the e-health community. For more details on these domain-specific practices, see Appendix A.

Note that some cells within the local domain are left empty, as it is not clear that higher levels of maturity have a cost-benefit value at this granularity.

	Local	Enterprise	e-Health Community
5		Continuous interoperability improvement Enable organisational goals Inward and outward: EA as a binding process	Continuous interoperability innovations Enables Community/Social goals Emergence, dynamics, adaptation
4		Impact of EA/SOA on organisational goals Identify interoperability weak points	Established Certification program Community SLA monitoring
3	Local standards governance Early architecture principles	Enterprise-wide standards/governance Generic EA principles augmented with SOA Early organisational interoperability	'Community' architecture Interoperability governance defined Governed use of open standards
2	Shared early interoperability experience ICT standards adopted	Some defined EA processes Business and IT committed to EA	Interoperability frameworks Community/National collaboration Governance in development
1	Technical integration efforts Ad-hoc solution architecture	Individual champions for technical and information interoperability Efforts underway for executive EA buy-in	Community interoperability vision Policy makers delivering social benefits Ad-hoc use of standards
0	Isolated design/development Siloed procurement	No interoperability awareness No processes to support EA	No processes to support cross-organisational interoperability

Figure 3: Interoperability maturity: different domains

2.2 Interoperability goals

This section describes a number of characteristics that are identified as key interoperability goals for increasing the level of national interoperability. Goals have been identified for each of the organisational, information and technical perspectives. In addition, common goals have been identified which are also to be applied to each perspective. The goals were identified through analysing interoperability in the national e-health community context, but they are also relevant to enterprise or local domains, including state and territory health enterprises.

Although the goals identified below are comprehensive, it is anticipated that e-health organisations may wish to tailor these for their own use, or identify additional goals reflecting their own enterprise interoperability concerns. This should occur during the establishment of an interoperability maturity programme, as outlined in section 3.3.

Interoperability goals relate to the interoperability concepts and patterns describe in the Interoperability Framework v1.0. Pattern families were identified to group common interoperability approaches and these support one or more of the interoperability goals presented in the IMM. Some such as governance have a one-to-one correspondence to interoperability goals while others such as Service-Oriented Architecture support multiple interoperability goals. So in summary, each pattern family includes a number of related interoperability patterns. Patterns are built from some common basic concepts. Interoperability goals identify characteristics of patterns that have been put forward as common issues of concern.

2.2.1 Common goals

There are common interoperability goals that apply to each of the organisational, information and technical aspects of interoperability. Thus, the following should be considered in concert with the respective interoperability goals presented in sections 2.2.2, 2.2.3 and 2.2.4.

The common interoperability goals identified by NEHTA are:

- *Reuse:* Leveraging previous solutions or knowledge, ensuring consistency between past and new solutions, and mitigating different interpretations and/or duplicated solutions of the same problem or concept. Examples include the reuse of role descriptions (organisational perspective), reuse of standard clinical information concepts (information perspective) or reuse of system services supporting authentication, demographics management or user interfaces (technical perspective).
- *Evolution:* Treating change as an integral part of design including versioning and extensibility points.
- *Standards basis:* A special kind of reuse reflected in the adoption and implementation of nationally recognised and agreed open standards supporting a set of alternative, but standards-conformant implementation options.
- *Scope:* A clear delineation of system boundaries, i.e. what is part of the problem space and what is not. This then enables development of processes and technologies to interoperate across this boundary in well-defined ways.
- *Scalability:* Allowing for growth beyond initial capacity through identified mechanisms for capacity increase.
- *Configurability:* Support for elements of a specification or system that may change over time (e.g. enterprise or regulatory policies) as opposed to those more foundational elements (e.g. well established healthcare processes and services).
- *Explicitness:* Ability to clearly isolate design artefacts (or implementation choices) representing specific concerns, to enable replacement, reuse, and evolution. Examples are the explicit differentiation of the content of e-health messages from their communication protocol structure; an explicit definition of technical services in a technical architecture (each of which implements a clearly identified piece of technical functionality); or an explicit expression of key business services (in a business architecture).

These common interoperability goals will have many interpretations across the interoperability perspectives described below. Their intent is to capture many fundamental ICT interoperability goals.

2.2.2 Organisational

The organisational interoperability goals identified by NEHTA are:

- *Business focus*: Clear description of a business problem, followed by a set of business requirements, and subsequent traceability to technical solutions (as opposed to a technically focused approach), allowing for possible later changes in business requirements.
- *Governance:* Separate governance for design, implementation, production and procurement processes for ensuring pro-active adherence to interoperability principles.
- *Overhead to change:* Recognition of processes and associated costs for solution de-provisioning including implications of integration points and other dependencies, so that it is possible to determine an optimal path

for solution replacement, as well as costs associated with maintenance and commissioning.

NEHTA's Interoperability Framework highlighted the organisational issues that underpin interoperability. They are most critical in the multi-enterprise nature of the e-health community.

2.2.3 Information

The information interoperability goals identified by NEHTA are:

- *Data format vs. semantics:* A clear distinction between data representation (syntax) and model (semantics), allowing alternative data formats for implementation.
- *Meta-data:* Common definitions for the structure and description of information associated with data artefacts allowing for the context of information to be shared and commonly understood. For example this may include schemas defining data structures (XML Schema) or descriptions of author, creation date, or document version.
- *Ownership and rights:* The clear separation of permissions, rights and ownership of information to allow for the controlled and predictable creation, use and modification of information.
- *Common building blocks:* A special kind of reuse within the information perspective, supporting aggregation and association of data from different sources and encouraging shared use by different systems.

Clinical information specifications have always been a strength of e-health and their support for interoperability is enhanced through their strong reuse as well as independence from any technical implementations.

2.2.4 Technical

The technical interoperability goals identified by NEHTA are:

- *Interface specification:* Describing technical functionality independent of implementation, to enable change of technology options, while keeping the independence of the system boundary intact e.g. change in the underlying database or platform implementing Web Services.
- *Functional decomposition:* Appropriate separation of solution components providing the building blocks for future evolution, aggregation, and reuse, through new compositions or abstractions.
- *Communication Protocol*: Independence of communication protocols from business logic allowing for support of new interaction paradigms, as they emerge, e.g. event oriented protocols.
- *n-tier architecture:* Explicit separation of at least user interface, business logic, and data stores.
- *Technical policy separation:* Enabling independent specification of policy from solution interpretation (i.e. separation of policy from mechanism), so that, over time it is possible to change or use more sophisticated policy solutions for policy enforcement.

Technical issues are also often referred to as architectural goals in that they describe fundamental solution constraints that enable future interworking of independently developed work.

2.2.5 Summary

The interoperability goals defined in this section allow for future interoperability in a way that is both more predictable and cost-effective. Each application of these goals should map them into their unique context and

highlight the use of specific interoperability standards, e.g. SNOMED-CT. Table 1 below summarises the interoperability goals presented in this section.

Goals	
Common	Reuse
	Evolution
	Standards basis
	Scope
	Scalability
	Configurability
	Explicit
Organisation	Business focus
	Governance
	Overhead to change
Information	Format and semantics
	Metadata
	Ownership and rights
	Common building blocks
Technical	Interface specification
	Functional decomposition
	Communication protocol
	N-tier architecture
	Technical policy separation

Table 1: Interoperability goals

2.3 Interoperability assessment

Organisational practices supporting each of the interoperability goals presented in the previous section can be assessed in terms of the maturity levels from section 2.1. For example, an organisation may assess its ability to use standardised data formats as at maturity level 1 (Initial level) or its ability to support reuse of organisational processes as maturity level 3 (Defined). An understanding of interoperability goal support is the basis for an interoperability improvement program.

To assess interoperability practices a number of tools and techniques can be used, such as interoperability scorecards. Scorecards can be structured to reflect important interoperability goals including and beyond those specified in the national interoperability set described above. Two types of scorecards are proposed in this document as described in more detail in section 3.5.

The assessment results determine the current maturity state and this can then be used as a basis for specifying an interoperability maturity programme.

NEHTA's assessment approach closely follows the CMMI assessment recommendations, based on the use of Practice Implementation Indicators (PIIs). The PIIs are defined by the Standard CMMI Appraisal Method for Process Improvement (SCAMPI). PIIs represent 'footprints' of implementation of a specific practice, i.e. objective evidence of its implementation, usually through work products such as documents, files, products, parts of a product,

services, specifications and process definitions [CMMI]. In terms of the IMM, a work product can be an e-health system specification or an e-health system itself.

There may be different assessment options applied to the data captured in scorecards to determine an overall level of maturity. Two such possible methods include:

- Calculate an average maturity level of all goals. This provides a single interoperability measure but may not adequately represent the required interoperability support.
- Calculate a statistical distribution, i.e. how many goals (in percentages) have been realised at each maturity level, across the goal set. This provides a richer data set but is also more difficult to track maturity trajectories over time.

A work product interoperability assessment analyses systems or specifications created or procured by an organisation to determine their support for selected interoperability goals. This can be expressed in terms of strong, average, or poor support.

Work product assessments do *not* use the CMMI maturity levels described above, as they do not analyse the underlying processes that created or procured the systems. Work product assessments identify the impact of organisational interoperability practices and hence the need for conducting interoperability practice reviews. Practice maturity assessments are expressed in terms of CMMI maturity levels ranging from initial to optimised levels of maturity.

Strong support for interoperability goals within systems does not preclude the need for practice assessment, as these outcomes may not be representative of repeatable nor systemic practices. The combination of interoperability system and practice reviews provide a strong basis for overall organisational interoperability understanding and application

2.4 Benefits

The IMM delivers a number of benefits to e-health organisations:

- The IMM provides a managed and repeatable approach for guiding organisations in incrementally improving their interoperability. This is because it provides a method for analysing, defining and assessing interoperability according to internationally recognised maturity improvement practices.
- It allows e-health organisations to use the IMM in combination with various benefit realisation approaches so optimum interoperability maturity targets can be selected based on the relative importance of each interoperability goal in the context of organisational requirements. This ensures the positioning of e-health interoperability within the broader economic models concerned with benefits realisation and allows for strategic planning and informed investment.
- It identifies which activities, processes and efforts are required by an organisation when a certain maturity level has been attained and future levels are desired. This knowledge allows e-health organisations better predictability when incrementally rolling out new practices across the business.
- It allows benefit flow-on from interoperability learnings within community (national) and enterprise domains as broader issues and approaches filter into local efforts yet continue to reap the broader benefit. Choosing to leverage capabilities in more restrictive contexts enables future use within the national or enterprise context. This prepares any local efforts to be more aligned with potential future

community interoperability requirements. It allows for more sustainable, predictable, and repeatable system interactions at all levels.

3 Applying IMM

This section provides a sequence of steps for applying the IMM to address specific organisational requirements for improving interoperability.

These steps constitute a recommended interoperability assessment methodology for applying the IMM to the problem of national e-health interoperability, as depicted in Figure 4. Note that this methodology can also be applied in the context of enterprise interoperability.

The first step is to clearly identify the *interoperability target* of interest. Usually, this is an e-health organisation for which an interoperability maturity model is to be developed, but this can also be an e-health system for which interoperability assessment is to be carried out. These two interoperability targets are typically intertwined as part of a comprehensive interoperability maturity programme, but they are described here as two applications of the IMM.

This is to be followed by identification of the *interoperability* domain for the target, i.e. community, enterprise or local domain. The domain highlights the boundary condition for issues of relevance and ensures issues of a broader context are appropriately balanced against local needs.

These two steps are followed by identifying relevant *interoperability goals* for the target within domain, using the national interoperability goals identified in section 2.2 as a starting point. Note that not all goals have the same importance and individual importance weightings should be assigned (e.g. high, medium, low) to each goal. These weightings can be used to focus the assessment on important goals first, or to select priority organisational practices for interoperability maturity programme planning. In the second case, the selection process could be driven by the results of a lightweight cost-benefit analysis, undertaken for the purpose of assessing costs and benefits of interoperability or for broader e-health benefits realisation purposes. This is beyond the scope of this document.

In the case of a maturity assessment for an e-health organisation, the IMM also requires that the *interoperability practices* used to accomplish the interoperability goals be defined and assessed. That is, each interoperability practice should be explicitly linked to a set of interoperability goals, and the interoperability assessment should identify the success or failure of these practices in attaining the interoperability goals typically by assessing outputs of those practices.

Maturity assessments of either organisations or e-health systems will typically identify the need for an interoperability maturity programme (see right hand side of diagram in Figure 4).

These steps are described in detail in the next sections.

3.1 Define target

The first step is defining the targeted problem area to which the IMM is to be applied. This can be:

- an *e-health system* such as a general practitioner (GP) system, Patient Administration System (PAS), or those work products developed by a project group including specifications, services, or solutions (this includes NEHTA initiatives). In this case, the IMM is used to identify support for the interoperability goals and assess their level of support. The interoperability assessment of the target is done relative to a chosen domain and the needs of the stakeholder for whom the assessment is undertaken (i.e. whether for a GP as an end-user or a product developer).

- an *e-health organisation*, such as an IT department within a state or territory health department, or a vendor organisation. In this case the IMM will be applied to the improvement of organisational processes supporting interoperability outcomes. This would initially involve identifying the products or services to be produced, their interoperability goals to be achieved and consequently the work practices to be implemented to support these goals.

3.2 Define domain

In this step an organisation should clearly identify relevant boundaries that will characterise the domain of their interoperability efforts, whether a community[7], enterprise, or local domain or any combination of them. Note that it is usually a mix of national, enterprise, and local goals that are all given relevance but priorities will change depending on the local context. For example, a GP practice will have high priorities given to local or enterprise interoperability issues where systems require little interaction outside the GP practice, while those requiring interconnection with external providers will require community interoperability commitments.

In the case where an organisation identifies more than one relevant domain, such as when an organisation is a community in its own right (e.g. a jurisdiction comprising semi-autonomous regions), it should conduct multiple maturity exercises, one for each domain, as the interpretation of goals may vary and are not necessarily the same. The organisation can then assign appropriate levels of importance to local, organisational or community interoperability relative to their business objectives. Examples include a PAS within a hospital, PASs within the e-health community and health departments within the e-health community.

[7] Community scope can reflect regional, national or international contexts.

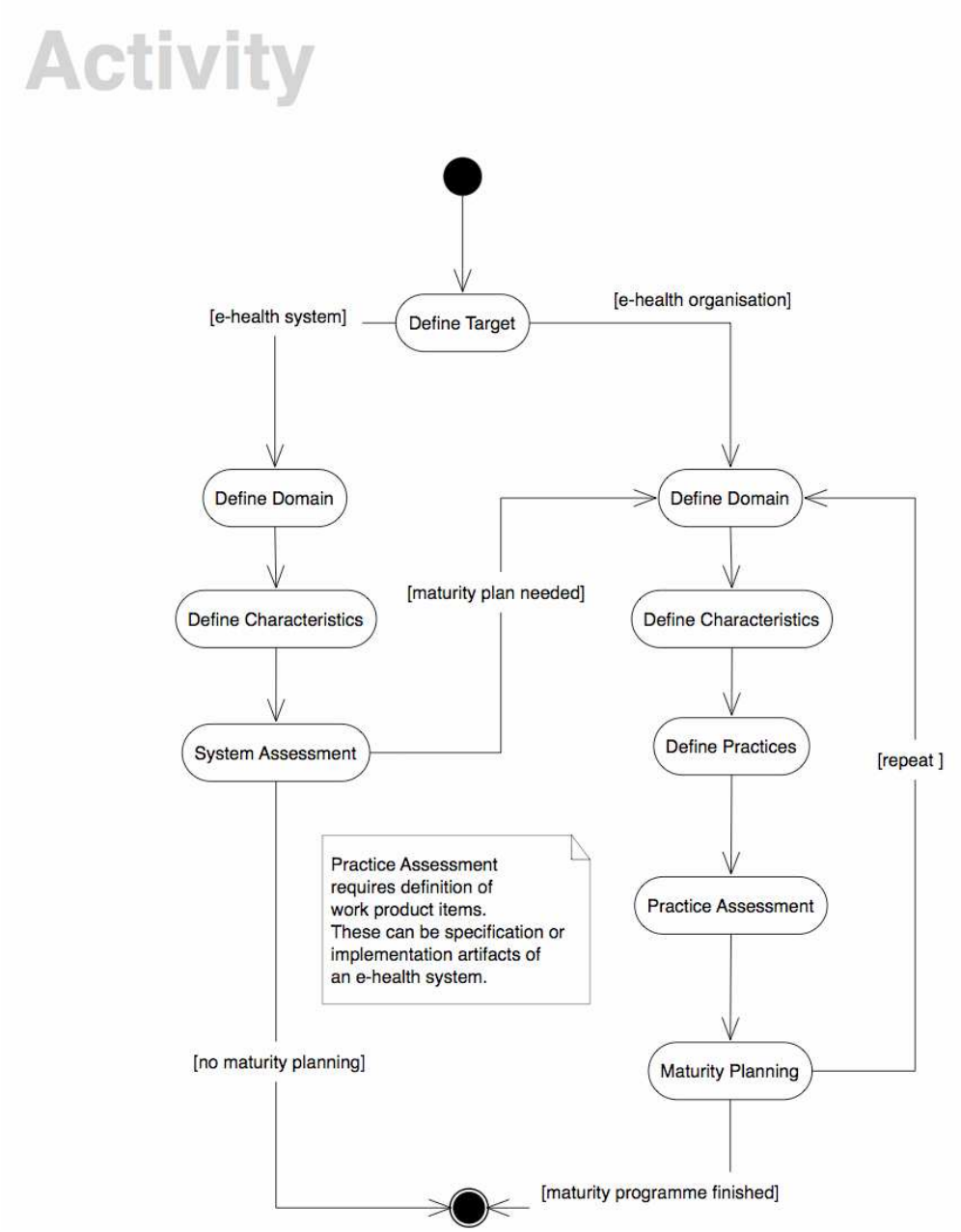

Figure 4: Applying the IMM

3.3 Define goals

In this step an organisation should identify the interoperability goals covering common, organisational, information and technical goals as introduced in section 2.2. Recall that those goals were identified with national interoperability in mind. It is likely that each organisation will select their own interpretation of these goals, reflecting concrete interoperability practices or solutions that have been adopted, increasing or reducing the goal set as required. Note that the same set of goals should be used as a basis for both the e-health system and the e-health organisation assessments.

3.4 Identify practices

This activity is undertaken for assessments of e-health organisations only, and is aimed at identifying those interoperability practices that are needed to support interoperability goals. Examples include regular updates of new architecture patterns within a reuse repository as part of enterprise

architecture processes; or root-cause analysis practice to react to certain undesired circumstances, such as privacy intrusions of patients in special care.

Note that while this document has identified a number of interoperability goals, it does not identify a similar set of interoperability practices. Through ongoing interoperability assessment of work products, supporting organisational practice requirements will emerge when work products and system requirements are assessed.

These organisational practices are likely to include the application of architectural governance, targeted education programs, shared organisational infrastructure, and new organisational teams to support interoperability outcomes. Each organisation will identify practices to reflect their own policies, processes and culture. As the IMM is applied, NEHTA will capture more detail of these common organisational practices.

3.5 Assessment

In this step an assessment of interoperability goals is made by gathering evidence and using assessment tools such as scorecards, as described below. These scorecards provide separate assessment approaches for e-health work products and organisational practices that produce the e-health systems. It is important to note that the maturity assessment measures, expressed in standard terms of the CMMI maturity levels, apply to organisational practices and not interoperability goals of work products. There are no such standardised approaches for assessing e-health work product interoperability and for the purpose of this document we use rankings of strong, average and poor interoperability support.

Not all goals are of relevance for different e-health organisations or work products, consequently the scorecards do not have to include assessment for all goals.

Several assessment approaches can be undertaken. This document presents an approach in which the common interoperability goals are collectively considered, addressing each of their organisational, information or technical perspectives. This approach is also reflected in the format of the scorecards presented below, as well as in the description of two examples discussed in section 4. Alternatively, common goals may not be treated as a separate group but could be included as part of the three interoperability perspectives, i.e. organisational, information or technical perspectives. Accordingly, the scorecards may have slightly different format but essentially the same content.

3.5.1 E-health work product interoperability support

E-health work product assessments measure the support for interoperability in a specific e-health system. E-health work product assessments are used to objectively measure the effectiveness of organisational interoperability practices as they manifest in work outcomes such as system features. Poor interoperability support in a system implies that improved maturity is required within an organisation to achieve interoperability; while strong interoperability support cannot distinguish one-off project success versus ongoing and repeatable interoperability support.

The Work Product Interoperability Scorecard should describe particular system features or capabilities supporting the identified interoperability goals. This is not an assessment of maturity of an e-health system; rather it is assessment of the interoperability features of that system. The scorecard provides a subjective ranking of the level of support; strong, average, and poor.

An e-health work product interoperability assessment should be done in tandem or as a precursor to an organisational practices interoperability

assessment and interoperability maturity planning (see section 3.6 and Figure 4).

Goals		*Work Product Capability*	*Ranking*
Common	Reuse		
	Evolution		
	Standards basis		
	Scope		
	Scalability		
	Configurability		
	Explicit		
Organisation	Business focus		
	Governance		
	Overhead to change		
Information	Format and semantics		
	Metadata		
	Ownership and rights		
	Common building blocks		
Technical	Interface specification		
	Functional decomposition		
	Communication protocol		
	N-tier architecture		
	Technical policy separation		

Table 2: Work product interoperability scorecard

3.5.2 E-health organisation practices

An e-health organisation interoperability maturity assessment looks at the practices employed by an organisation to support the generation of interoperable solutions through all phases of the software development lifecycle. The Interoperability Maturity Scorecard should describe particular organisational practices that support the inclusion of the identified interoperability goals in project outcomes. These practices are graded according to the maturity levels, as identified in section 2.1.

Organisation evaluations are particularly focussed on practices that support the creation of interoperable outcomes but require subsequent work product evaluations to determine whether these objectives are being met. Hence organisation and work product evaluations should be conducted in cooperation.

Goal		*Organisational Practices*	*Maturity Level*
Common	Reuse		
	Evolution		
	Standards basis		
	Scope		
	Scalability		
	Configurability		
	Explicit		
Organisation	Business focus		
	Governance		
	Overhead to change		
Information	Format and semantics		
	Metadata		
	Ownership and rights		
	Common building blocks		
Technical	Interface specification		
	Functional decomposition		
	Communication protocol		
	N-tier architecture		
	Technical policy separation		

Table 3: Interoperability maturity scorecard

3.6 Interoperability Maturity Planning

The assessment of organisational practices will define a set of processes that support the creation of interoperable outcomes by an organisation. These practices can be summarised according to organisation, information, and technical areas (note that common processes should be allocated to their corresponding perspective). The maturity planning worksheet will include this static organisational evaluation and will then define additional practices required to take each of the organisation, information, and technical interoperability areas into the future with higher levels of interoperability practices, effectively defining the organisation's interoperability maturity programme. It can be useful to present the maturity planning worksheet as a series of three tables, each allocated to one of the interoperability perspectives.

Maturity Level	*Organisation*	*Information*	*Technical*
5			
4			
3			
2			
1			

Table 4: Maturity planning worksheet

4 Examples

This section provides two illustrative examples of the application of the IMM.

The first example is concerned with the interoperability assessment of a GP system. We have chosen this example because of its relatively constrained functionality scope and the key interoperability role GP desktop systems play in the health sector.

The second example provides a high-level description of an organisation implementing improvements in delivering interoperability. It gives an idea of how an organisation can structure its own organisation, information and technical maturity models, as part of the overall IMM.

4.1 GP system

This section provides an example of the application of the IMM for a theoretical GP desktop system. The example is structured in terms of the activities of the IMM methodology shown in Figure 4 while using the scorecards presented in section 3.5.

The *target* of this application of the IMM is a fictitious GP desktop system, it is being considered from a national e-health interoperability perspective and from the perspective of an end user of the system[8]. In order to interoperate with other providers, NEHTA is interested in interoperability support for current and future ICT integration partners that contribute to the delivery of a national e-health environment.

Initial considerations have shown that the interoperability goals identified in Table 1 were sufficient to meet the system context and there was no need to define any new interoperability goals. Note that common goals are further qualified ('org', 'inf' and 'tech' attributes) to address the interoperability perspectives of concern.

The results of the assessment are summarised in the Table 5 below.

[8] Note that a different assessment of the same system could be made from the perspective of other stakeholders, e.g. a vendor.

Goal		Definition	Work Product Capability	Ranking
Common	Reuse	Leveraging previous solutions or knowledge, ensuring consistency between past and new solutions, and mitigating different interpretations and/or duplicated solutions of the same problem or concept.	The application is a standalone clinical information system in which no components of the solution are available for use outside this application (tech)	Poor
			The product does support the reuse of information within the application by reducing the need for repetitive data entry across modules (inf)	Poor
	Evolution	Treating change as an integral part of design including versioning and extensibility points.	Application is replaced as an entire system and information can be migrated between different versions with little intervention (tech, inf)	Average
			No capability to support subsequent extension points, in particular for project areas or subjects of special interest without vendor involvement (org)	Poor
	Standards basis	A special kind of reuse reflected in the adoption and implementation of nationally recognised and agreed open standards supporting a set of alternative, but standards-conformant implementation options.	Includes many fields and forms that conform to clinical measurement standards; a number of fields or codesets do not conform to national standards or provide migration toward these standards (inf)	Average
			Supports standards-based messages for communications to third parties (inf).	Poor
	Scope	A clear delineation of system boundaries, i.e. what is part of the problem space and what is not. This then enables development of processes and technologies to interoperate across this boundary in well-defined ways.	Adequately covers the scope of what is required for a clinical information system used by a General Practitioner	Strong
	Scalability	Allowing for growth beyond initial capacity through identified mechanisms for capacity increase.	Can deal with an appropriate scale of expected patient numbers (org)	Strong
			Administration of technical services, e.g. networking, database becomes increasingly difficult as user numbers increase (tech)	Poor
	Configurability	Support for elements of a specification or system that may change over time (e.g. enterprise or regulatory policies) as opposed to those more foundational elements (e.g. well established healthcare processes and services).	Supports some different workflows and user preferences (org)	Average
	Explicit	Ability to clearly isolate design artefacts (or implementation choices) representing specific concerns, to enable replacement, reuse, and evolution.	No definition of supported business processes and technical integration points (org, tech)	Poor

Goal		Definition	Work Product Capability	Ranking
Organisation	Business focus	Clear description of a business problem, followed by a set of business requirements, and subsequent traceability to technical solutions (as opposed to a technically focused approach), allowing for possible later changes in business requirements.	Tightly directed towards the needs of the General Practitioner	
	Governance	Separate governance for design, implementation, production and procurement processes for ensuring pro-active adherence to interoperability principles.	The governance of the system changes is purely controlled by the vendor. The local installation and the user accounts and configuration or governed by the local IT Staff	Average
	Overhead to change	Recognition of processes and associated costs for solution de-provisioning including implications of integration points and other dependencies, so that it is possible to determine an optimal path for solution replacement, as well as costs associated with maintenance and commissioning.	No documentation of extraction of information or migration to other platforms.	Poor
Information	Format and semantics	A clear distinction between data representation (syntax) and model (semantics), allowing alternative data formats for implementation.	Some code sets and fields are not standards based; supports some standards-based HL7v2 messages	Average
	Metadata	Common definitions for the structure and description of information associated with data artefacts allowing for the context of information to be shared and commonly understood.	No independent definition of metadata schema utilised. Non-uniform metadata maintained for different information artefacts.	Poor
	Ownership and rights	All data has an owner responsible for its integrity. Users can have a range of access and update rights to protect integrity and limit access as appropriate.	The application supports to an extent the ownership of information and the ability to restrict to access information by other users. The application also is role based to prevent users without appropriate credentials performing certain functions such as prescribing	Average
	Common building blocks	The structure and description of the information built using discrete components so that individual components can be used in new or changed environments.	Proprietary system with no apparent design to use common semantic structures	Poor
Technical	Interface specification	Describing technical functionality independent of implementation, to enable change of technology options, while keeping the independence of the system boundary intact.	Explicit but proprietary interfaces to allow third party integration with practice management applications; no explicit interfaces into the clinical components of the application	Average
	Functional decomposition	Appropriate separation of solution components providing the building blocks for future evolution, aggregation, and reuse, through new compositions or abstractions.	System acts as a tightly integrated solution; no modularity support	Poor
	Communication protocol	Independence of communication protocols from business logic allowing for support of new interaction paradigms, as	No independent protocol supported; External communications occur through third party applications	Poor

Goal		Definition	Work Product Capability	Ranking
		they emerge.		
	N-tier architecture	Explicit separation of at least user interface, business logic, and data stores.	Does not appear to separate between user interface, business logic and data. The UI appears often to be tightly coupled to data especially where extensions to the application have been made	Poor
	Technical policy separation	Enabling independent specification of policy from solution interpretation (i.e. separation of policy from mechanism), so that, over time it is possible to change or use more sophisticated policy solutions for policy enforcement.	No evident support.	Poor

Table 5: Analysis of a theoretical GP desktop system

The system above provides relatively poor support for interoperability. It has adapted a variety of standards for its own use but supports little in the way of implementation independent representations of service elements or data structures. Integration with the system is ad-hoc through bespoke adaptors being latched into implementation components. There is no independence of access control and hence is limited in its capacity to work with other enterprise systems.

The interoperability assessment reveals that an interoperability maturity programme is required, either by the GP practice to acquire products with improved support for interoperability; or by the product vendor to ensure that points of interoperability are maximised in subsequent product developments.

4.2 E-health organisation

This example provides some insights into how an e-health organisation in the Australian context and with national reach can define its target interoperability maturity levels to drive improvements in delivering interoperable outcomes across organisational, information and technical perspectives.

4.2.1 Establishing the maturity model and undertaking the initial assessment

The example begins with a selection of interoperability goals for the organisation based on those identified in section 2.2 and the capture of a number of interoperability practices that currently exist in the organisation, in support of these interoperability goals. These two interoperability factors are shown in the two leftmost columns in Table 6 below.

In this example, the organisation:

- Currently implements the same authentication service across different systems, thus supporting technical reuse.
- Supports evolution of technical solutions, by employing agile software development practices.
- Supports organisational evolution by extracting changeable aspects of the business architecture design into a set of business rules which can evolve as required.
- Supports information standards by establishing a Standards Catalogue constraining reusable information components such as structured documents or clinical report templates.

The assessment in the Maturity Level column is subsequently undertaken as shown in the third column of the table. This assessment is based on the guiding characteristics given for each goal type and according to a mapping of maturity concepts into organisational practices, from simpler to more complex, as provided indicatively in Tables 7 to 9.

Goal		Definition	Interoperability Practices	Maturity Level
Common	Reuse	Leveraging previous solutions or knowledge, ensuring consistency between past and new solutions, and mitigating different interpretations and/or duplicated solutions of the same problem or concept.	Reuse of authentication service (tech)	2
	Evolution	Treating change as an integral part of design including versioning and extensibility points.	Implement agile software development (tech) Extract business rules (org)	3
	Standards basis	A special kind of reuse reflected in the adoption and implementation of nationally recognised and agreed open standards supporting a set of alternative, but standards-conformant implementation options.	Standards Catalogue (inf)	3
	Scope	A clear delineation of system boundaries, i.e. what is part of the problem space and what is not. This then enables development of processes and technologies to interoperate across this boundary in well-defined ways.	Isolated practices in documenting requirements; no established notation (org, inf, tech)	1
	Scalability	Allowing for growth beyond initial capacity through identified mechanisms for capacity increase.	External Web Server facility supporting incremental load changes (tech)	2
	Configurability	Support for elements of a specification or system that may change over time (e.g. enterprise or regulatory policies) as opposed to those more foundational elements (e.g. well established healthcare processes and services).	Isolate business rules from business process (org)	3
	Explicit	Ability to clearly isolate design artefacts (or implementation choices) representing specific concerns, to enable replacement, reuse, and evolution.	Isolate data content from carriage (inf, tech)	2
Organisation	Business focus	Clear description of a business problem, followed by a set of business requirements, and subsequent traceability to technical solutions (as opposed to a technically focused approach), allowing for possible later changes in business requirements.	Adoption of SOA principles	2
	Governance	Separate governance for design, implementation, production and procurement processes for ensuring pro-active adherence to interoperability principles.	CIO approval and organisational adoption of an EA programme	3
	Overhead to change	Recognition of processes and associated costs for solution de-provisioning including implications of integration points and other dependencies, so that it is possible to determine an optimal path for solution replacement, as well as costs associated with maintenance and commissioning.	Statement required in all tender responses	3

Goal		Definition	Interoperability Practices	Maturity Level
Information	Format and semantics	A clear distinction between data representation (syntax) and model (semantics), allowing alternative data formats for implementation.	Local support for a variety of XML interchange formats	2
	Metadata	Common definitions for the structure and description of information associated with data artefacts allowing for the context of information to be shared and commonly understood.	Definition of organisational metadata standard	3
	Ownership and rights	A special kind of reuse within the information perspective, supporting aggregation and association of data from different sources and encouraging shared use by different systems.	Access control dealt with in each application space	1
	Common building blocks	A special kind of reuse within the information perspective, supporting aggregation and association of data from different sources and encouraging shared use by different systems.	Measured reuse of information specifications from information schema registry	4
Technical	Interface specification	Describing technical functionality independent of implementation, to enable change of technology options, while keeping the independence of the system boundary intact.	Wrapping of legacy applications	1
	Functional decomposition	Appropriate separation of solution components providing the building blocks for future evolution, aggregation, and reuse, through new compositions or abstractions.	Decomposition practices localised in solution delivery teams	2
	Communication protocol	Independence of communication protocols from business logic allowing for support of new interaction paradigms, as they emerge.	Support multiple transport protocols, e.g. WebService, Secure FTP, ebXML, email	2
	N-tier architecture	Explicit separation of at least user interface, business logic, and data stores.	Supports model-view controller approach	2
	Technical policy separation	Enabling independent specification of policy from solution interpretation (i.e. separation of policy from mechanism), so that, over time it is possible to change or use more sophisticated policy solutions for policy enforcement.	Not utilised	0

Table 6: Organisational interoperability practices

The organisation should reflect upon the above-identified strengths and weaknesses in supporting interoperability outcomes. A combination of e-health work product and practice interoperability assessments will provide the organisation with an opportunity to identify target interoperability practices to take into account in a maturity planning programme, structured in terms of organisational, information and technical perspectives.

Maturity planning requires an identification of target interoperability practices that need to be implemented to meet an increasing level of maturity for selected interoperability goals.

4.2.2 Maturity planning

Tables 7 to 9 below provide illustrative examples as to how maturity improvements are planned relative to the assessment undertaken in Table 6, taking into account assessment outcomes. The tables are populated through a combination of documenting activities associated with maturity levels already met and then planned activities identified to increase maturity to new levels.

In the above example (see Table 6), in terms of governance, the organisation already has the CIO's approval to establish an Enterprise Architecture programme, which is an important practice from an organisational perspective at the Defined maturity level. This, along with other organisational practices identified at the Defined level (level 3) in Table 6, provides a necessary condition for subsequent increases in maturity to the Measured level (level 4). Thus level 4 as a target is achieved through enabling the governance of procurement processes to require explicit links between business requirements and the technical architecture through management of project funding. These planned activities are documented in Table 7, Table 8, and Table 9.

In similar vein to governance, the organisation has defined maturity planning with other interoperability goals, as shown in Table 7, by identifying a high-level set of interoperability maturity practices from an organisational perspective[9]. These identify part of an interoperability maturity programme for an organisation populated through the analysis of current capability and planned future capabilities. Recall that these practices map onto the organisational goals identified in section 2.2.2 as well as the common goals relevant to each of the technical, information, and organisational perspectives.

As Table 7 shows, the organisation has started with isolated business requirements capture and the use of certain ad-hoc processes, e.g. independent solution architectures (Initial level). This organisation can then increase its interoperability maturity through informal internal processes for capturing common business requirements, as well as developing individual champions to support local policy adherence (Managed level).

After this level of maturity is attained (verified through internal or external assessment), the organisation can progress its maturity programme through the development of a business architecture as part of enterprise architecture programme, as well as standard business requirements capture processes (Defined level).

Once the Defined maturity level is reached, it becomes possible to establish additional practices. For example within the governance of procurement activities, one can measure adherence of technical solutions to identified business requirements and use this as a basis for project funding. Another example is the inclusion of decommissioning measurements within the

[9] Note that the specific practices in the example are based upon a number of established best practices in software engineering and project development and some specific practices recommended by NEHTA.

procurement cycle along with commissioning and maintenance costs (Measured level).

Upon reaching this level of maturity, the organisation is ready to begin supporting continuous interoperability improvements (Optimised level) to, for example, modify business requirements methodology and optimise a collection of common organisational business requirements.

Maturity Level	*Organisational Practices*
5 Optimised	Continuous interoperability improvement through modification of business requirement methodology.
4 Measured	Governance of procurement processes to explicitly link business requirements to technical architecture through project funding. Measurement of decommissioning.
3 Defined	An agreed business architecture as part of Enterprise Architecture programme. Standard business requirements methodology and repository. Templates for policy capture.
2 Managed	Informal internal processes for business requirements capture. Individual champions supporting policy adherence.
1 Initial	Isolated business requirements capture. Use of manual, ad-hoc processes.

Table 7: Maturity planning: organisational goals

Similarly, the organisation has developed its information and technical maturity planning programmes, as shown in tables 8 and 9.

The interoperability maturity assessment in Table 6 has revealed that the organisation has local support for a variety of XML interchange formats (i.e. a variety of local syntactic formats for pathology messages while taking into account their semantic underpinnings). This is identified as a Managed maturity level (level 2) and this is a prerequisite for identifying information models as an important component of an information architecture, and at a later stage, renewal of these models. The organisational interoperability maturity assessment has revealed no support for information ownership and rights beyond individual applications and work is needed to establish a similar maturity plan for this goal. The maturity planning table should include the important interoperability practices as building blocks for maturing organisational interoperability capability. We have not followed each issue through in this example.

Table 8 provides an example of maturity states from an information perspective based upon the information interoperability goals. This information maturity programme starts with a focus on machine transportability, then provides additional practices towards supporting shared semantics and ultimately delivering continual semantic alignment across clinical information and services through updates of the information model for consolidation and renewal with new standards.

Maturity Level	*Information Practices*
5 Optimised	Updates of information model repositories for consolidation and renewal. Check for new data standards.
4 Measured	Data quality review board. Architecture review of semantic and syntactic reuse. Check independence of data models and implementations.
3 Defined	An agreed information architecture as part of Enterprise Architecture programme. Metadata standard and schema

	repository. Well-defined data quality standards. Publication of semantic information relationships.
2 Managed	Local Agreement on common syntactic formats. Limited semantics support. Isolated data quality processes established.
1 Initial	Domain-centric data formats utilised. Machine transportable data. Isolated information repositories.

Table 8: Maturity planning: Information goals

In terms of current technical interoperability maturity the assessment has shown maturity levels for the most part at level 2, Managed. The logical maturity progression is to move to a Defined state where a technical architecture can provide guidance as part of an overall Enterprise Architecture. As with all maturation, previous levels of attainment must be included when progressing to higher levels.

Table 9 provides an example of this organisation's technical maturity plan based on the technical interoperability goals described in section 2.2.4.

Maturity Level	*Technical*
5 Optimised	Policy-driven configuration of existing business services. Replacement of underperforming services. Reconfiguration of services. Federate to new business partners.
4 Measured	Architectural governance committee. Measure links to business architecture. Analyse infrastructure reuse.
3 Defined	An agreed technical architecture as part of Enterprise Architecture programme. Adherence to a Service-Oriented Architecture. Published interface specifications.
2 Managed	Tiered architecture analysis for local solutions. Implementation of standards-based approaches.
1 Initial	Isolate technical delivery from information content. Interfaces defined for some legacy applications. Integration services to map message formats.

Table 9: Maturity planning: technical goals

This organisation is utilising wrappers to capture legacy systems in a reusable fashion and has isolated the delivery of content from the information content.

This has provided a basis for further enhancements such as an ability to use n-tiered solution architectures and implement technical standards, such as Web Services, providing support for a Managed level of technical maturity.

Once this level of maturity is reached, the organisation can aim at higher levels of technical capability such the establishment of technical architecture as part of an overall Enterprise Architecture. At this stage it is also appropriate to put in place the building blocks for a Service-Oriented Architecture style of design enabling future reuse and evolution of solution components.

The accomplishment of this level of maturity (i.e. the adherence to SOA principles) in turn makes it possible to measure the impact of technical interoperability on business services (Measured level) and identify improvement points.

By reaching this level of maturity, the organisation is then in a position to implement policy-driven configuration to continually support composition of existing business services in response to the improvement points, including changes in architectural assumptions and support (Optimised level). For example, it may be desirable to enable an event infrastructure to sit alongside an overarching SOA environment.

4.2.3 Re-assessment

In a similar way to the initial assessment undertaken in section 4.2.1, the organisation will need to define a schedule for reassigning maturity levels at subsequent points in time and updating maturity planning documents.

Maturity analysis and planning is a continual process enabled through periodic analysis of interoperability support within systems, specifications, and other solutions. This may then trigger re-assessment of interoperability maturity and future planning.

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Appendix A Interoperability domain

The NEHTA Interoperability Framework 1.0 [IF] is a common reference point for facilitating a shared understanding of key interoperability concepts and patterns in the Australian e-health sector. In order to deal with the diversity of stakeholders involved, the Interoperability Framework (IF) covers a broad set of interoperability issues, from organisational, information and technical perspectives, as per definition below.

Interoperability is defined as an ability of an organisation or a system to:

- use business or technical services of another organisation or system,
- offer business or technical services to another organisation or system and accordingly,
- exchange information with other organisations or systems

In using services provided by others, or providing services to others, an organisation or a system participates in business processes that involve multiple autonomous entities, involving multiple steps.

It is important to note that interoperability always involves two or more entities, engaged in some form of interaction, whether supported by a business or technical transaction. Further, entity interoperability can be considered from different IF perspectives (organisational, information and technical) and from different domains that define a context for interoperability (community, enterprise and local), as described in the following section

Note that the scope of this document is limited to *e-health interoperability*, as there is an implicit assumption of an underlying ICT infrastructure that supports various business processes, e.g. clinical, administrative or operational processes.

In discussing an organisation's/system's ability to interoperate, it is important to consider the environment in which it operates and the respective environments of other organisations/systems with which this organisation/system interacts. This is because different environments imply different considerations that apply to the organisations/systems therein.

Examples of such considerations are:

- various types of governance rules, arising for example from privacy laws, national or international regulations, legal or organisational policies; these rules typically reflect social, economic or sometimes cultural conditions from the environment;
- limitations associated with the skills and capabilities of people involved, e.g. clinical knowledge or technical standards awareness;
- professional norms of an environment, such as an agreed use of certain clinical terminology with its own semantics and syntax;
- technology requirements, such as 24x7 connectivity, bandwidth and reliability, as well as physical and temporal constraints that vary from environment to environment.

These different considerations imply different interoperability goals.

NEHTA uses the term *interoperability domain* to refer to the boundaries enclosing a set of co-located constraints. NEHTA distinguish between community (more precisely, a healthcare community), enterprise, and local domains, as elaborated below and depicted in Figure A.1.

Note that, as far as interoperability domain is concerned, a specific organisation/system should be characterised by each of these boundary types simultaneously, e.g. a state health organisation is an enterprise in its own

right (enterprise domain), with many constituent units (local domain), but is also part of a national health community (e-health community domain).

Figure A.1: Interoperability domain

The sections below describe in more detail characteristics of these different domains of interoperability and typical approaches adopted to address interoperability challenges in each of these.

A.1 Community

A community domain denotes a boundary within which a number of enterprises or individuals interact, in order to fulfil some *shared goal*, while at the same time meeting their individual needs or individual/enterprise goals.

In healthcare, a *healthcare community* is typically centred on delivery of safe and reliable healthcare to individuals, while an *e-health community* is a healthcare community empowered by the use of ICT to improve safety, reliability and add convenience to healthcare delivery.

Note that the community domain has a far more open boundary condition as opposed to enterprise and local domains that tend to be more inwardly focussed. This implies that membership and relationships within the community are relatively unencumbered as the community responds to the needs for collaborative healthcare delivery and alternatives.

A shared goal is be defined by some authority, typically a government[10], with the aim of satisfying some social goal, or by the members who are establishing the community, to satisfy their mutual benefits, as in many mutual agreements and business contracts.

As in the case of enterprise domain, a community goal will define policies, such as privacy policies, that govern interactions in a community, to ensure predictability, fairness and trust.

[10] A good example for setting such a social goal is the decision of the Australian Government in 2004 to progress an interoperable e-health environment in Australia to satisfy the broader healthcare goals for Australian population. Interoperable e-health can be regarded as a shared goal for the Australian health community and NEHTA has been tasked to facilitate the accomplishment of this shared goal.

A.1.1 Goals

While interoperability within an enterprise domain is 'inward' focused, interoperability in a community is concerned with the interactions between enterprises and crossing jurisdictional boundaries.

For example in supporting chronic disease management for a patient, information may need to be exchanged

- among many healthcare organisations and systems;
- within primary, secondary and tertiary sectors;
- involving both the public and private sectors; and
- involving international entities, in certain extreme cases.

Such an exchange of information needs to respect policies and guidelines set by a chronic management community, e.g. privacy policies, continuity of care guidelines for chronically ill patients, or even policies governing interactions with non-government organisations.

Within the community domain, community members change more often and have more differentiation than those within an enterprise.

Within the community domain, governance is typically established by following the principle of *federation*, which recognises the existence of *independent domains* governed by their own authorities, while providing agreed interaction standards between these domains (see Figure A.1). These agreed approaches are either specified through a set of policies established by national or international authorities or by agreements between authorised representatives from these domains. Note that each of the domain's authority provides governance for that domain. For example, a domain's authority can define funding policies covering conditions under which healthcare services in this domain are to be delivered by the providers in the domain, including required accreditation and reporting policies. Both, the domain authorities and federation agreements contribute to community governance.

A community domain can thus be characterised by division of power between 'local solutions' and community governance, where 'local solutions' (to interoperability problems) could be either related to the enterprise or local domain.

A.1.2 Approaches to interoperability

In order to address challenges associated with interoperability within a community domain, several possible approaches could be adopted, including:

- the adoption of open standards published by Standard Development Organisations or community standards that are agreed by individual communities, augmented by clearly defined certification processes and governance at the community level (national or international);
- the establishment of a clear policy framework covering regulatory and legislative policies or business contract policies that ensure satisfaction of community goals, and ensuring compliance of each of the member of community with such policies;
- the establishment of a 'community architecture' programme, consisting of an agreed set of concepts and principles which, when respected, will provide a consistent architectural approach at the community level, as a necessary condition for community interoperability.

A.2 Enterprise

An enterprise domain denotes a boundary of a single organisation, recognised as a legal entity, irrespective of its size, organisational or geographical structure. Examples are:

- government-funded healthcare organisations, such as public hospitals, community centres, outpatient clinics, as well as state or territory jurisdictions as a whole; note that some larger organisations can consist of many units or departments, which define their own enterprise domain
- Private health organisations, such as private hospitals, pharmacies, pathology providers, dental services, or GP practices;
- Non-government organisations.

A.2.1 Goals

Each of these organisations is created to achieve certain *enterprise goals*, which in turn influence organisation's policies, processes and structure. In the health sector, an enterprise goal may be mainly driven by social objectives as in public hospitals, or it may be a combination of commercial and social goals as in private hospitals.

As opposed to local boundaries, where the interoperability is typically driven by individual efforts (or small teams) with a focus on a limited problem domain, enterprise domain requires a more coordinated approach. This is because it is driven by a collective effort, involving *team work* while being focused on a problem of enterprise-wide significance. For example, if a hospital is the enterprise in question, an example would be multidisciplinary teams that contribute to the holistic care of patients within a particular speciality, e.g. immunology. Note that the enterprise boundary can be of a broader domain, such a whole state health department or as narrow as a hospital or a General Practice.

Governance structures in enterprises are typically *hierarchical*, with different strengths and depths of hierarchy, while keeping *guided local solution autonomy* when dealing with local interoperability problems (see Figure A.1). Thus a key characteristic here is the singularity of the point of control and in this respect the enterprise domain can be likened to an autocratic (i.e. hierarchical) system of government.

Note however that some organisations operate as a collective, with federation structures linking these points of control. Examples include a State health service that comprises of several area health services/districts who are all autonomous but report to a State health department, the Australian Federation of AIDS organisations or the Australian Federation of Disability Organisations, within national boundaries or the World Health Organization or the International Committee of the Red Cross at an international level.

A.2.2 Approaches to interoperability

In order to address enterprise interoperability challenges, several approaches can be taken, such as:

- Adoption of an agreed set of enterprise-wide standards, whether based on recommended principles and solutions from official standards, or defined by the organisation to satisfy its own requirements
- Establishment of an enterprise architecture programme to address various architectural concerns, covering business architecture, information architecture, application architecture, and technical architecture, as well as to establish enterprise architecture processes and governance

Note that such mechanisms are described as part of the *Supporting National E-Health Standards Implementation: Adoption, Uptake & Implementation* [Standards] document.

A.3 Local

A local domain exists within one or more enterprise or community domains and can denote a specific boundary type, e.g. geographical, organisational, clinical, and IT application domain boundary.

Some examples are:

- an organisational unit in a large healthcare organisation;
- a GP practice as part of a medical centre;
- an individual GP in a remote community (which in turn is part of a state/territory jurisdiction);
- a voluntary non-government organisation in a natural disaster area;
- day surgery unit as a part of a broader surgical department or a cardiology unit as part of a broader internal medicine department.

Note that the relationship between the three domains is not strictly hierarchical and the interoperability goals of a local domain reflect local concerns and impacts with little regard for broader issues. On the other hand, interoperability issues within a broader boundary (e.g. enterprise or community) are likely to influence local interoperability requirements.

A.3.1 Goals

There are a number of characterising features and solution approaches to interoperability within the local domain.

First, an individual, an organisation or a system in a local boundary is typically focusing on achieving *local goals*. There are varying (typically not high) levels of awareness or concerns as to how these goals might be aligned with the goals of a broader domain, as the following two examples illustrate:

- an IT manager in a hospital's audiology department is choosing and configuring a commercial hearing test product with new audio testing capability. There may be little concern for the needs and requirements of larger clinical information systems within the hospital environment. The local interoperability issue is often regarded as a closed world of applications needing to work together in a local context. It should be noted that the "closed world" view is unrealistic as most systems will exist simultaneously within a broader enterprise and community domain.
- on the other hand, a software integration team in a hospital may begin to use SOA principles to support existing system integration practices (e.g. the use of interfaces to separate functional definitions from implementation); although their focus is on integration between existing legacy systems, they will need to have an increasing awareness for needs of architectural alignment with other systems in the hospital.

These two examples demonstrate different dependency strengths between local and enterprise boundaries, both of which however exemplify *strong local solution autonomy*, although in the second example, taking into account enterprise-wide goals.

Second, the interoperability within a local domain may initially be championed by certain individuals, whether IT experts or clinicians, who initiate efforts in starting or improving interoperability with others. This *individual heroics*, if proven to deliver local goals, and when motivated by broader social or

economic goals[11], can be an important impetus towards repeating interoperability solutions in a broader, enterprise or community context, thus achieving enterprise or community goals. It is worth noting that such a change in perspective may be driven in this manner from bottom-up, or otherwise as a management imperative, top-down. This choice of approach (even a combination of approaches) is driven by the buy-in of the stakeholders themselves into the interoperability agenda.

Third, the local domain can be characterised by *isolated* or *limited central governance*. This can be due to an inherit nature of the boundary, as in established strong local governance of a GP practice within a medical centre, or due to organisational issues such as an increasing, though often undesired, strengthening of local control.

In many respects, the local domain, being characterised as strong local solution autonomy with isolated central governance, can be likened to a feudal system of government (see Figure A.1).

A.3.2 Approaches to interoperability

In addressing interoperability challenges within the local domain there are a number of possible approaches such as:

- Adoption of a locally agreed set of principles, rules and standards, to facilitate technical and information *integration* and broader set of local *interoperability* requirements[12], e.g. an adoption of sound architectural approaches, such as n-tier architecture or SOA
- An agreement on the best local common processes, standards and other local approaches developed to enable multiple systems to interact at a local level.

Note that where required (and possible) each of these approaches may need to take into account external requirements, either from the enterprise or community domain in defining the respective rules and standards. For example, if enterprise interoperability is adopted then it will impact on the set of existing local interoperability approaches. Further, these solutions can address interoperability challenges in short term, but may not be sufficient in long-term, when enterprise or community approaches need to be applied.

A.4 Summary

This Appendix has introduced a distinction between the community, enterprise, and local domains, because these boundaries define different characteristics of relevance for interoperability. However, these boundaries are often not so sharp and thus the separation of community, enterprise, and local domains forms a continuum. For example, one should apply community interoperability approaches (listed in section A.1.2) in an enterprise because the organisation operates as a collective rather than a strict hierarchy of control. The distinction of enterprise and community then becomes one of underlying environmental factors rather than simply applying an organisational moniker. In fact, some communities in name may in fact operate much like a typical enterprise due to their singularity of control structure.

It is also important to state that:

[11] Note that there is anecdotal evidence of pursing local goals at expense of enterprise or community goals, and the appropriate governance policies need to be established to address this problem.

[12] For the distinction between integration and interoperability refer to the IF document [IF].

- An organisation will need to address all these three different contexts at the same time, thus having a 'localised', 'inwards' and 'outwards' views on interoperability.
- Each of the community, enterprise, and local domain can be represented by the IF community concept, with distinct goals, governing policies, including conformance and compliance requirements and adopted processes and interactions.
- While local and enterprise interoperability have been addressed in the context of various technical approaches, including integration solutions and architectural approaches, community interoperability is becoming an increasingly important challenge, in particular in the domain of e-health.
- The cost of community governance is often higher than that of enterprise governance as more effort is required to facilitate a federated approach rather than a more efficient centralised point of control.

Appendix B On maturity models

B.1 Purpose

In general, maturity models are developed to help organisations better plan capability improvements in certain areas of their business. An improved organisational capability is then referred to as an increasing level of *maturity* of the organisation with respect to that aspect of business. This aspect for example can be related to organisation's software development processes, product or service development or procurement processes.

With a maturity model in place, organisations can define their target maturity levels over time against which they can measure their transition. This approach provides organisations a managed evolutionary path towards progressive increases in their capability, such as improvements in software development processes from a chaotic stage to more disciplined and methodological processes, ensuring delivery of quality assured software. The primary intention of maturity models is to provide an evolutionary path for improvement of organisational ability in certain aspects of their business. However, they can be also used to provide a benchmark for comparison between organisations regarding that specific ability.

The particular focus of this document is on presenting one such maturity model, developed to assist organisations in increasing and improving their capability to support interoperability in e-health. This Interoperability Maturity Model is aimed at providing guidance to e-health organisations in gradually increasing their ability to interoperate in the e-health community.

Note that interoperability is one aspect of maturity concern. Within different domains, other factors will come into play as to the importance put on this aspect relative to other characteristics (such as cost, features, change management required, etc).

B.2 Existing approaches

There are a number of maturity models that were developed to address certain specific problem domains. These are listed as follows:

- *Capability Maturity Model (CMM).* The CMM was the first maturity model, developed by the Software Engineering Institute at Carnegie Mellon University, USA, with the aim of helping organisations improve their *software development* processes [CMM]. The CMM defines the following maturity levels for software processes: initial, repeatable, defined, managed and optimised. Due to their generality, the principles, approach and philosophy taken by CMM have subsequently been adopted by a number of other communities, some of which are listed below.
- *COBIT Maturity Model.* This maturity model was developed and promoted by the IT Governance Institute, under the auspices of the ISACA (International Security Audit and Control Association). This maturity model is an *IT governance* tool used to measure how well developed the management processes are with respect to internal controls. The COBIT MM is based on the CMM and allows an organisation to grade itself from nonexistent (0) to optimized (5) [COBIT].
- *Capability Maturity Model Integration (CMMI).* The CMMI is a process improvement maturity model to help organisations improve their *development and maintenance processes for products and services*. It consists of best practices that address development and maintenance activities that cover the product/service lifecycle from conception

through delivery and maintenance [CMMI]. Note that SEI has retired the CMM model, and replaced it in August 2000 with the more general CMMI model.

- *Level of System Interoperability (LISI)*. LISI was developed to address specific requirements of C4I (Command, Control, Computer, Communications and Intelligence) domain. The LISI is a discipline and a process for defining, assessing, and certifying the degree of interoperability required or achieved between organisations or systems [LISI].
- *Health care information exchange and interoperability (HIEI)*. The HIEI was proposed to describe the capability of health organisations regarding health care information exchange and interoperability. HIIE framework consists of four levels.
    1. Non-electronic data: no use of IT to share information, e.g. mail, telephone.
    2. Machine-transportable data: transmission of non-standardized information via basic IT; information within the document cannot be electronically manipulated, e.g. fax/personal computer-based exchange of scanned documents, pictures, or portable document format files.
    3. Machine-organisable data: transmission of structured messages containing non-standardized data; (e.g.: e-mail of free text, or PC-based exchange of files in incompatible/proprietary file formats, HL-7 messages).
    4. Machine-interpretable data: transmission of structured messages containing standardized and coded data; idealized state in which all systems exchange information using the same formats and vocabularies, e.g.: automated exchange of coded results from an external lab into a provider's EMR, automated exchange of a patient's "problem list" [Walker]

- *IT Architecture capability maturity model*. This model was developed by the US Department of Commerce, with the goal of improving the success of IT Architecture by identifying weak areas and providing a defined path towards improvement. This is motivated by the view that as an architecture matures it should increase the benefits it offers the organisation. This maturity model is intended to be used annually by each Operating Unit and each CIO to conduct an assessment of the Operating Unit's IT Architecture capability and progress [DOC].
- *SOA maturity models*. There are several models developed to help organisations improve their Service Oriented Architecture capability. Examples include the service integration maturity model by IBM [IBM] and SOA assessment by HP [HP]. These maturity models should be positioned in relation to various enterprise architecture maturity models, to reflect synergy between SOA and enterprise architecture paradigms.