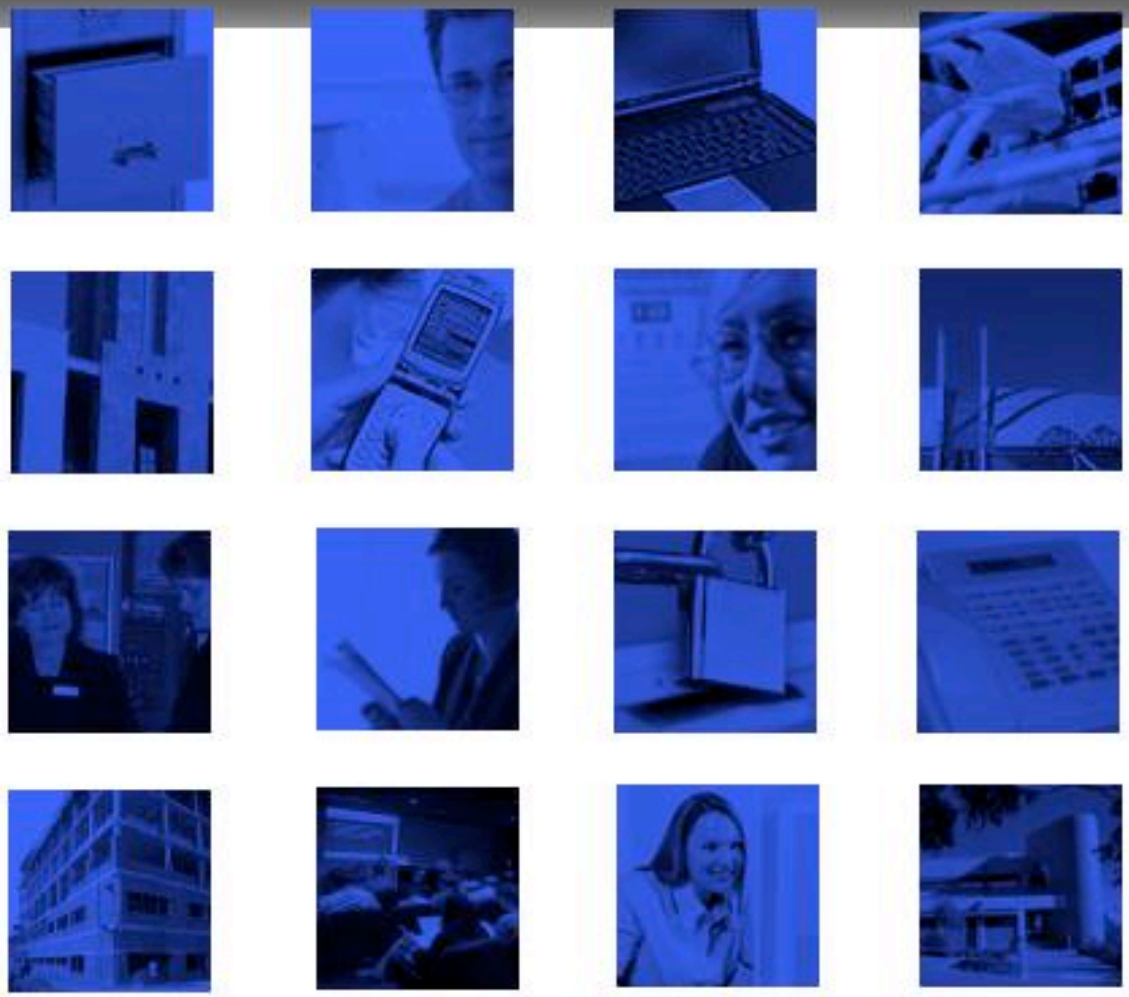
MONASH University

Monash University
Information Technology Architecture

2006 Edition



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1 Executive summary

1.1 Audience

This document has two major audiences – *senior management* (to understand the context driving technology decisions): sections 1-3 and *Information and Communication Technology staff* (to understand how to acquire, deliver and maintain systems that best optimise the balance between business benefit and cost at Monash): all sections.

1.2 Introduction

Enterprise architecture (EA) is the discipline of scientifically designing the technology elements of an enterprise, guided with principles, frameworks, methodologies, requirements, tools, reference models and standards.

The Monash Information Technology Architecture (MITA) articulates Monash best practice in services, processes and technologies. An organisation-wide approach allows for significant savings, as redundant or less efficient approaches are deprecated in favour of approaches that have a proven track record across the organisation.

Over 500 staff across Monash University are fully dedicated to working in Information and Communication Technology (ICT). Hundreds more contribute to the implementation and maintenance of ICT as part of their role. The goal of enterprise architecture is to focus this significant effort towards common, shared approaches that improve performance and reduce cost.

Two analogies are useful for understanding the scope and potential of enterprise architecture: the electrical grid and the surgeon's scalpel.

1.2.1 The electrical grid (Standardisation: A commodity solution for most users)

There are over a dozen different standards for electrical supply worldwide, varying in voltage and outlet (socket and plug) standards. A single standard would allow end-users to plug in their technology anywhere and would allow providers to share infrastructure and capacity easily. Similarly, shared standards in compute resources, storage resources, business logic and user interfaces allow both end-users and providers to use and share more easily and effectively.

1.2.2 The surgeon's scalpel (Customisation: A specialised solution for non-standard users)

There are probably several hundred staff across the Science and Medical faculties who use scalpels. Most of these staff are content to use standard scalpels acquired from a catalogue. A small number are actually interested in scalpel design, and need to be able to build their own scalpels or to customise scalpels they acquire. Building or customising scalpels is far more expensive than acquiring standard ones, but this expense is warranted when (a) a standard scalpel will not fulfil the required need or (b) researchers are investigating or teaching improved ways to build and customise scalpels.

There are two outcomes from this analogy:

(i) where a standard solution will not fulfil the required need, the *full cost* of the solution needs to be incorporated into the decision making process (i.e. not just the cost of the non-standard solution, but also the associated costs of managing and running the non-standard technologies required to deliver that solution).

(ii) research and education need to be supported, and this will require non-standard solutions. However, where researchers can use commodity solutions they will find significant

benefits, as central and faculty staff can deliver and maintain such solutions far more quickly and cheaply than customised ones. Thus customisation should focus as much as possible on the area of research, and not across all areas of technology in use.

1.3 Background

Monash University initiated the development of an enterprise-wide architecture in 2003, resulting in the first edition in 2004. That initial version laid the foundation and vision for the architecture, separating various components and promoting standardization. The 2005 edition refined this approach drawing on new trends and standards from industry. This edition (2006) provides explicit direction in key areas that have previously allowed duplication of approach across the University. It provides firm, well-defined principles and guidelines to guide ICT decision-making within Monash University.

1.4 Scope

This document aims to identify the best of existing tools, technologies and processes, as well as providing guidelines at a sufficiently high level to apply to new technologies. An effective architecture reduces the time and cost in acquisition, implementation and maintenance.

Architecture applies to the full life-cycle of technology, from project conception and design through implementation to service management and maintenance. It includes managing ongoing hardware refresh cycles and software and firmware upgrades until the eventual de-commissioning of the service.

Architecture focuses on the logical organization and management of applications and data as well as the underlying physical infrastructure. Architecture applies to the full hierarchy of technology from the network and platforms up to business and information architectures.

Architectural compliance is required in all new ICT projects across the University and its affiliates. It will also be rolled out retrospectively as existing services undergo major revisions and upgrades.

1.5 Structure of the Monash Information Technology Architecture

The Monash Information Technology Architecture is composed of three major sections – *the principles* (which inherit from University strategies and priorities and guide the architecture), *the architecture* (which describes specific priorities and recommendations) and *further detail* (provided in appendices or supplemental websites) which provide implementation information for people interested in specific parts of the architecture.

1.6 Governance

An Enterprise Architecture Board is being formed that will direct the ongoing strategy and implementation of the architecture. The board will identify gaps in current implementation, ensure ongoing currency and provide dispensations for exceptions. More information about the board, its membership and the review cycle for MITA will be available from the architecture website, http://its.monash.edu/staff/plans/architecture/.

Architectural governance sits below ICT governance, which operates both at multiple levels. Areas wishing to establish or improve their level of governance may like to refer to the *Control Objectives for Information and related Technology* (COBIT). COBIT is a framework for information (ICT) management in a similar vein to PMBOK for project management and ITIL for service management.

1.7 Review

The Monash Information Technology Architecture will be reviewed annually in consultation with faculties, divisions and other areas.

2 Principles

The Monash IT Architecture is established upon a set of principles (ss2.1 – 2.12) that are intended to guide university-wide IT decision-making and the planning and implementation of information systems. The principles draw upon the Information Management principles (http://monash.edu/staff/information-management/principles/) and are also informed by the ICT Strategic Plan (http://monash.edu/about/itsp/). The principles describe the characteristics of Monash's target IT architecture, and are ordered in terms of importance.

The principles (and the architecture) describe the best general case solution. Where conflicts occur two or more alternative solutions should be examined, a cost/benefit analysis conducted (incorporating flow-on implementation and operating costs), and a request for dispensation should be made (to the Enterprise Architecture Board) for adopting a particular solution above others.

2.1 University strategic objectives guide IT decisions

Information is stored and managed in support of the business objectives of the university. Information Technology is employed to assist University entities to achieve their objectives in the most efficient and effective manner. Technology decisions must take into consideration business drivers.

2.2 Systems are secure

Monash needs to protect its information. This requires careful attention to planning, implementing and managing a range of physical and logical measures across systems, system management and data.

- The university's IT Security Policy and IT Security Framework documents guide all activities relating to IT security. See http://adm.monash.edu/execserv/policies/Information-Technology-Policies/IT-Security-Policy.html
- Security of information, and breadth of access to information, must form part of the planning, development and operation for all systems;
- Appropriate data integrity provisions must be included in the planning for every system;
- Systems which access information in other systems must follow the business rules associated with that information in the original system;
- Security is the responsibility of all authorised users.

2.3 Designs target high availability and reliability

Core university activities depend on information services and systems. System planning and design should deliver systems whose reliability is matched to the importance of the service, the cost of disruption to the service, and the needs of the users. Tested business continuity and disaster recovery mechanisms appropriate to the business need should be in place at all times.

2.4 Systems safeguard privacy and intellectual property

In developing and implementing systems, staff should be sure to follow the relevant policies and laws (see http://monash.edu/legals/privacy.html) ensuring that information provided for a specific purpose is not used for other purposes without the explicit consent of the individual to whom that data refers.

The university is both a producer and consumer of intellectual property. As a producer, the university's information systems need to respect the university's intellectual property guidelines with respect to creation, storage, access, use and disposal. This includes provision of appropriate copyright and legal disclaimer statements to Monash owned/created intellectual property. Intellectual property guidelines and statutes are at http://adm.monash.edu/execserv/policies/Administration-

Policies/intellectual-property-framework.html and
http://monash.edu/pubs/calendar/statutes/statutes11.html#Heading202

As a consumer Monash purchases or licences use of intellectual property where this fits the university's goals and objectives. The university must store, use or provide access to this information according to the appropriate access and licensing arrangements. Rights management should use standard access mechanisms and should be devolved where possible. Intellectual property issues for the Internet and multimedia are at http://copyright.monash.edu/

For guidelines on protection of privacy and management of intellectual property, please refer to the Monash Information Management Strategy, http://monash.edu/staff/information-management/resources/

2.5 Systems use the authoritative source for data

One of the governing principles for management information systems is to maintain one primary source for each piece of data. There is a risk that data fetched from a non-authoritative source may be out-of-date or incorrect. Data should never be entered more than once. Other systems that need data should receive it electronically from a source traceable back to the master copy and not by re-keying the data. Where possible access should be via a live transaction to the master repository.

For guidelines on data sources, please refer to the data architecture (http://its.monash.edu/staff/plans/architecture/infoarch/dataarch/)

2.6 Open standards are used where possible

It is highly desirable that the University's information systems are built upon open standards. The adoption of such standards is expected to have benefits in:

- Protection against vendor lock-in;
- Ability to decouple client hardware and software from server hardware and software;
- Access to increased pools of expertise (given the global trend towards open standards);
- Access to increased functionality (developed by or co-developed with peer institutions)

2.7 A platform-independent user environment which is globally accessible

The University has an increasingly global focus, drawing in people from a diverse range of cultures and expertise. Most people, most of the time, should be able to access a common set of services that provide an intuitive interface for their needs, and these services should be accessible from a variety of platforms, from PCs running various operating systems through to mobile phones and PDAs.

To achieve the benefits of such a homogenous environment, architectural components should be sought that provide core, commonly used functionality through published interfaces (web services or APIs) and a unified, platform-independent interface (portal with multi-platform support).

Planning must include making services accessible to special groups, including those with a disability. See http://monash.edu/staff/web/quality/accessibility-standards.html

2.8 Purchased software is preferred to in-house development

Where an existing package is available that adequately fulfils requirements, it is preferable to purchase than to develop in-house. Purchased products should be chosen to complement existing products and services, and should offer a clear price benefit, quicker time to implement and reduced maintenance costs. Suppliers should be committed to principles similar to those in MITA, and be in a position to

support, maintain and upgrade the product. Where a suitable product is already licensed to Monash, it should be used in preference to buying a second product and licence. Projects should also review unimplemented functionality in existing licences (eg. SAP, Microsoft and Novell) before procuring new licences.

Customize applications only if necessary, as customized programs often require reworking on each vendor software upgrade or release.

2.9 Standard products and platforms are adopted to limit diversity

In order to reduce the cost of ownership, projects should select, whenever possible, from the set of preferred products published in MITA or in the University's standard operating environments (SOEs). Standardizing on IT environments reduces costs through:

- More focussed training for support staff and users;
- Increased flexibility and interworking of environments due to elimination of incompatibilities and harmful interactions; and
- Increased purchasing power.

2.10 Applications share resources

There is potential to save costs by sharing common resources (hardware platform, storage, data model, application framework, etc.) across applications. Resource sharing needs to be balanced against other business benefits and costs, including operational continuity, security and service/change/release management. Whereever possible, however applications should share resources to save costs.

2.11 Systems are structured for easy extension

When it is necessary to develop in-house applications the goal should be to build generic modules that may be reused or easily modified to cater for expansions and additions to the original specifications. Re-useable building blocks include elements from all levels of the architecture, from information through data models and business logic to procedures and templates.

2.12 Management of systems is easy to devolve

The size and structure of Monash calls for systems whose management can be devolved to Faculties and departments, and whose management interfaces are easy, fast and intuitive to use.

3 Architecture overview

The architecture ranges from overarching *information* and *business architectures* through *applications* and *application infrastructure* (application servers and frameworks) to *technical infrastructure* (network, storage and platforms). In the diagram below, the 'preferred' (recommended for general use) parts of the architecture are highlighted in green, the 'supported' (for specific areas of use) are highlighted in yellow and deprecated components are outlined with red dashes. The architecture is discussed in more detail in the following sections.

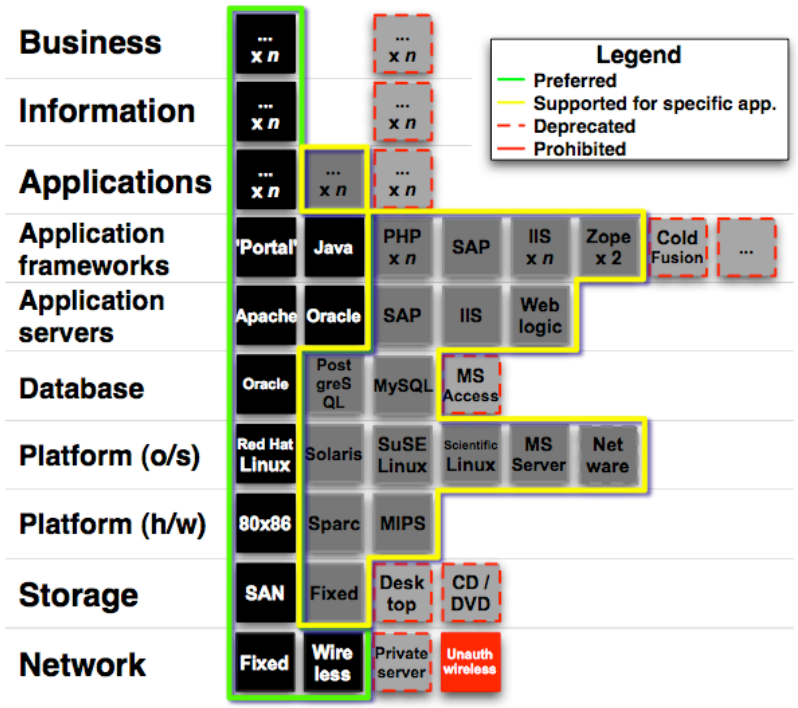

Figure 1: Overview of the architecture

4 Business Architecture

Monash has a structured planning process, in which *Monash Directions 2025* sets the overall institutional directions and priorities. Plans for key aspects of University activity (Research, Education, International and Support Services) provide additional detail. There are operational plans for faculties and support divisions and a number of enabling plans exist of which the *Information and Communications Technologies (ICT) Strategic Plan* is one.

The ICT Strategic Plan (http://monash.edu/about/itsp/) articulates directions and strategies that support university requirements for information systems and infrastructure that transcend faculty and departmental boundaries. The latest edition was published in 2006 and is reviewed annually on a rolling five-year basis. The annual review process also results in a portfolio of prioritised IT capital development initiatives that are directly aligned to the overall mission, strategies and operational needs of the University.

5 Information Architecture

The *Information Management Strategy* (http://monash.edu/staff/information-management/) describes a high-level architecture for information and information management at Monash University. The strategy emphasises the importance of information-centric technology solutions, focussed on the user and their information needs. Figure 2 represents this diagrammatically. At the top is the user and their

information needs. These are supported by services, delivered by applications, running on infrastructure. The Information Management Strategy deals primarily with the upper three levels of this figure. The ICT Strategic Plan deals with the lower two levels. The architecture focuses primarily on the lower two levels but broadly addresses all levels and their interrelationships.

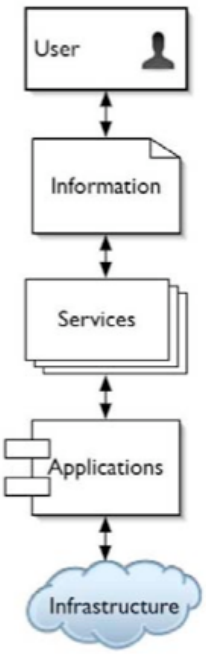

Figure 2: Info-centric technology

The Information Architecture addresses broad high-level issues relating to the generation, management, storage and dissemination of the University's corporate information, together with the technology used for these processes. In the broadest sense this corporate information may reference items not owned by the University, but widely accessed by members of the University in doing University business.

The categories of corporate information to be included within the architecture include:

- Highly structured information such as student records and financial transactions;
- Unstructured information such as email, lecture notes and research papers that may contain rich data elements such as animations, simulations video and audio clips.

All corporate information should be stored primarily on centrally managed systems. This architecture (MITA) deprecates the storage of data in secondary ('shadow') systems and on workstations or notebooks located in offices or staff members' homes.

5.1 Data models, data dictionary and data management

At a lower level, information architecture also incorporates the rules and structures around key pieces of business information. Fields such as ID numbers, organisational centre numbers, building and room numbers (and many others) all need clear rules of ownership, access and usage. These rules will ensure that such information is used for its intended purpose and managed in alignment with higher level business rules, procedures and policies.

6 Application Architecture

Integration between systems is a major cost in the implementation and maintenance of applications. The *Applications Integration Strategy* (http://its.monash.edu/staff/projects/info-systems/) provides a far more efficient and effective way of designing, building and integrating applications through a 'service-oriented architecture' (SOA).

The SOA focuses around discrete components of business logic ('web services'). Individual components can then be aggregated together in different ways to provide a broad range of user-centred workflows for different business processes.

A major objective of MITA is to encourage the development of discrete, reusable components ('web services') instead of separate application silos (that cannot share or re-use functionality). By focusing primarily on the 'value add' aspect of new business logic components, ICT staff allow the other layers of the architecture to become increasingly commodity resources:

- Enterprise systems become repositories of components and of associated data and information.
- Compute and storage resources can be accessed as required to execute and store the transactions.
- Users access consolidated workflows in one focused, personalised interface with consistent design and navigation

The structure of the target application architecture is depicted below. Important features are:

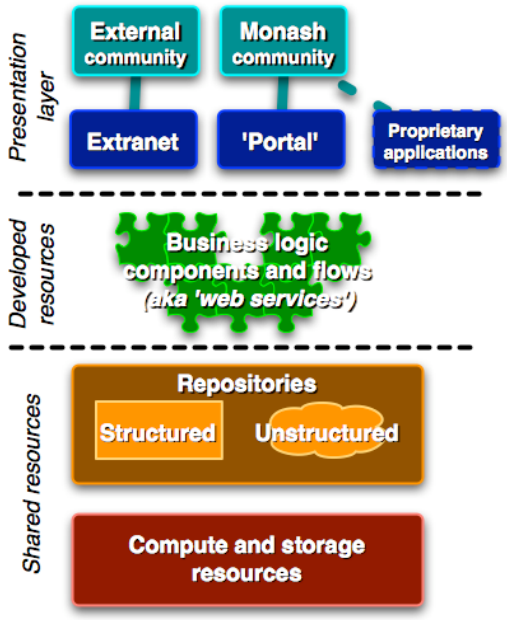

Figure 3: Application architecture

- A user-centred presentation layer directed toward specific audiences that permits access to information through a variety of interfaces and technologies;
- Business logic defined in discrete objects ('web services') that can be reused in different workflows, services and applications as part of a 'service-oriented architecture' (SOA);
- Structured and unstructured data repositories that encourage consolidated data models supporting dynamic access, modification and reuse of data in the above services;
- Compute and storage resources provided in a standardised form permitting flexible matching of resources to peaks in demand, continuing growth and effective disaster recovery strategies.

6.1 Presentation Architecture

It is advantageous to separate the presentation layer from the application. Different user classes are best served by different presentation methods:

- The University web strategy establishes the my.monash portal as the standard method of presentation to members of the Monash community, and offers a consistent interface to many commonly used services.
- The Monash web site is the standard method of presentation to the general public.

- Web-based interfaces to applications is the preferred presentation model, however proprietary presentation methods may be warranted in some cases to gain full access to all application features, or to address special needs. It is expected that proprietary methods will decrease over time as applications increasingly migrate to the web.

The "Monash Community" includes all who are eligible for an Authcate account, and may, in the future, be extended to include potential students and alumni. Outside users may access some services through registration in the External Directory Service (EDS).

Web presentation layers must meet branding, visual design, usability and accessibility requirements as specified in the Web Style Guide (http://monash.edu/staff/web/).

6.1.1 User-Centred Design

In the design of the presentation layer, a user-centred design methodology should be adopted to enhance the quality and usability of applications and websites. Users should be involved in all development phases (including requirements analysis) through activities such as contextual inquiry, interviews, focus groups, surveys and usability testing. Research has shown that a user-centred approach can dramatically improve return on investment through improved takeup and reduced support and maintenance costs.

6.2 Database Architecture

Oracle is currently the standard database management system for applications and repositories. Where possible, all structured data should be stored in a centrally managed Oracle database.

Element	**Database**	
Description	**Relational database management system (RDBMS)**	
Class	**Product**	**Notes**
Preferred	Oracle	Current version (preferred) and two previous versions (supported)
Supported	SQL server	Required for CRM, ESS and eCart/eCommerce gateway
	MySQL	Required for some PHP applications
	PostgreSQL	Required for some open-source applications
	Lotus DB	Required for Workgroup Collaboration Suite
Prohibited	MS Access or FileMaker Pro	Not for enterprise systems or corporate data. May be suitable for rapid development/prototyping/proof of concept. Oracle ApplicationExpress is recommended as a suitable alternative.

6.3 Application Development

6.3.1 Language

The primary priority in application architecture is the emergence of a service-oriented architecture (SOA). Thus, regardless of language, it is expected that the majority of development will happen around web services, with workflows aggregating services into 'business processes', defined in 'Business Process Execution Language' (BPEL).

A BPEL/SOA-based approach provides maximum agility in the face of ongoing business change. Technological implementation of processes can quickly be modified to reflect changes in the higher level business processes. This approach also provides for maximum re-use of business functions.

Most integration and workflow development (especially inter-system) is expected to be developed in BPEL. However, some workflows are highly domain specific (eg. only relevant to finance or student records). These domain-specific developments may continue to be developed in the native application.

6.3.1.1 Language lifecycle

Three environments are expected to become increasingly dominant at Monash: Java (developed and acquired), ApplicationExpress (developed) and .Net (acquired). Other languages are expected to be maintained at their current levels (with small incremental growth) and some are already in decline (Zope and ColdFusion).

6.3.1.2 Language consolidation

Although the primary focus is on a BPEL/SOA-based approach, consolidation around a small set of languages will provide a range of benefits. Central training and shared development of libraries, application frameworks and even major application functions will dramatically reduce development costs and the acquisition and maintenance of skills.

Element	**Application Development Language**	
Description		
Class	**Product**	**Notes**
Preferred	Java (on Oracle) (for enterprise applications)	Using Oracle toolset (i.e. JDeveloper, Oracle Application Server, etc.). Java offers advantages in enterprise integration.
	ApplicationExpress (for bespoke web applications)	ApplicationExpress is more agile for quick application development and maintenance
Supported	Perl	Required for CMS. Used in my.monash, IMS tools and a range of other applications and utilities
	Oracle Tools	Required for Callista and related systems. Tools include Forms, Reports, PL/SQL and JDeveloper.
	ABAP Tools, Iviews	Required for SAP systems. Includes SmartForms, EnjoyScreens, Objects, Sapscripts, WebDynpro and WebFlow.
	.Net	Required for MUTTS (timetabling)
	Zope + Python	Required for Statscout
Acceptable	PHP (for bespoke departmental web applications)	Allows less best practice re-use across the University, but provides for reuse/extensibility of existing open source solutions
Maintenance	Zope, Python	Decreasing in favour of Java and ApplicationExpress
	ColdFusion	Decreasing in favour of ApplicationExpress (or PHP)

6.3.2 Source code version management

A critical aspect of change and release management is an auditable, trackable source code management ('revision control') system. All software developed at Monash must be managed through an appropriate source code management system to comply with audit and risk requirements. This includes both application software and software used in the maintenance and development of other layers of the architecture (eg. management and update scripts).

Element	**Source code management**	
Description	**Repository to manage source code and track changes**	
Class	**Product**	**Notes**
Preferred	Subversion	Also known as 'svn'. Provides change tracking and supports release management *(free)*
Supported	Telelogic Synergy (for enterprise applications)	Offers aspects of configuration, change and release management for integrated application management *(per seat cost)*
	RevTrack	Revision tracking and release management for SAP
Maintenance	CVS	Decreasing in favour of Subversion

6.3.3 Automated testing (load, performance, functional and regression)

Manual and automated testing are critical to successful software deployments and ugprades. Where possible, all software should incorporate load and performance testing as part of new installations and major upgrade planning. As much as possible, developed software should incorporate automated test harnesses that report on unit test quality.

Element	**Automated testing**	
Description	**Testing of software to ensure adequate performance and resilience**	
Class	**Product**	**Notes**
Preferred	Mercury LoadRunner (load and performance for enterprise applications)	Leading automated testing product *(usage licence costs)*
	IBM Rational Robot (functional and regression testing)	Leading automated testing product *(usage licence costs)*
Acceptable	The Grinder (load and performance for bespoke applications)	Open source testing product *(free)*

6.3.4 Other tools and Utilities

The architecture website (http://its.monash.edu/staff/plans/architecture/) includes a repository of useful tools and utilities that can improve the agility and quality of software development.

6.4 Application Support Services and Standards

6.4.1 Identity Management

Identity Management involves establishing the identity of a user (authentication), and granting access rights to particular services or resources (authorization). Access controls can be managed individually or through groups, and can apply to one resource or a set of resources. Authentication and authorization should be achieved through the Monash Directory Service whenever possible. When purchasing application software it should be a specific requirement that the package has the capability to authenticate by calling an external LDAP directory and manage access control by LDAP groups (user-defined) and filters (dynamic).

Where possible, applications should maximise security and ease-of-use by supporting single-sign on and single-sign out through the my.monash portal. Where applications are not able to support single-sign on, they should register with the directory service manager to be recognised as an approved application. Registration enables improved monitoring for exploits and other forms of unauthorised use of Monash credentials.

Efforts are underway to develop a standard Monash identity architecture and single sign-on interface.

Element	**Identity management (including authentication and group management)**	
Description	**Methods or protocols for authenticating users and authorizing access to resources**	
Class	**Product**	**Notes**
Preferred	LDAP (to MDS)	Monash Directory Service (MDS) is the authoritative source for user credentials and identity information
Supported	Kerberos	Required for Linux desktops
	Novell eDirectory	Required for Novell Enterprise Workstation Services
	Application-specific user database	Only to be used when necessitated by business rules
Candidate	Shibboleth	Manage access through Monash Identity Provider (MDS) and SAML-based service provider agreements
	802.1X EAP	802.1X offers the option of permitting access to the network only after a user is authenticated. Access rights can be based on individual user or on membership of groups. Uses MDS to store user information.

6.4.2 Directory

The Monash Directory Service (MDS) is a collection of basic information about staff and students. The MDS is used as a central database by many other computer systems. Among other things they use MDS to authenticate users and find information about users (including what resources users have access to). This leads to powerful and universal Authorization and Group Management capabilities (see below).

Monash also allows controlled, devolved, and automatically-expiring entry of external users into the External Directory. This is combined with the Monash Directory to produce the Hybrid Directory. The Hybrid Directory is then used as an authentication source by a number of systems that wish to allow access by designated external users.

6.4.3 Application Integration

This area is currently under development. A competency centre is to be established that will further describe the approach and ongoing engagement with the various technologies and processes. It will address areas such as application integration, business intelligence, data integration and output standards.

6.4.4 Collaborative technology standards

The University is currently undergoing a significant revision of its collaboration technologies including voice, video, instant messaging, email, scheduling and team workspaces. Further information about standards for software, interfaces and integration will be incorporated as it becomes available.

6.4.5 HTTP (web) Server

Increasingly all applications are being deployed through web servers. Where possible, applications should support Apache or an Apache-based variant (both for consolidation and consistency of management).

Element	**Web Server**	
Description	**Software that provides HTTP services in sync with the current HTTP standards.**	
Class	**Product**	**Notes**
Preferred	Apache	Industry standard
Supported	Oracle OAS	Required for Callista, TARDIS, ROPES, Load Planning, FLSS and Evaluation systems
	SAP Netweaver	Required for SAP (HR and Finance)
	BEA WebLogic	Required for MUSO (online education)
	Microsoft IIS	Required for MUTTS (timetabling)

6.5 Desktop Applications

Desktop applications are those that reside on the client computer and are not dependent upon any particular application component on a server (i.e. not part of a client-server architecture). Desktop applications are part of the Standard Operating Environment (SOE) for staff and student laboratories (see http://its.monash.edu/staff/software/). ITS provides central desktop images that can be customised by faculties for lab deployment.

6.6 Client Applications

Client applications are the client part of client/server systems. Several important clients such as email, web browsers, and calendar clients are specified in the SOE (see above).

6.6.1 Web browser

Web browsers are increasingly becoming the primary working environment for staff and students.

Element	**Web Browser**	
Description	**Software for interacting with Internet-based services (primarily web-oriented content and services)**	
Class	**Product**	**Notes**
Preferred	Firefox (for general use)	Provides a more secure and Monash-customised environment
	Internet Explorer (for corporate applications)	Required for MUSO, Callista, SAP, the CMS and MURMS

6.7 Workstation Support Services

6.7.1 Shared Remote Print Service

The preferred printing model is that printers are

- Shared by members of a workgroup;

- Connected to their own network port;
- Associated with a print queue;
- Configured to use Internet Printing Protocol (IPP) or LPR/LPD.

Spooling print jobs on a server allows enhancements such as checking that the file is in a printable format, enforcing limits, queuing, accounting, and adding banner pages if required. General purpose print services are maintained primarily on Novell Netware servers (staff and student), but also on most Linux and Unix servers. All printers whose output is charged for should operate through print queues on servers where the accounting function is implemented (currently Netware servers).

Some enterprise applications (SAP and Callista) maintain separate print queues with access restricted to authorized users.

6.7.2 Remote File Service

Individuals and workgroups can store files on a remote file-store with appropriate data security, backup and archiving services. This should be the model for all information that is of value to the university. The Monash Information Management Strategy discourages storing files on individual desktop PCs, but where such data is stored off the network, it should be backed up and synchronised with server storage through iFolder (this is especially pertinent for laptops). The *Information Management Strategy* will be providing guidelines and recommendations for individual and group file management.

Shared or remote file-space for desktops is primarily provided through the Novell Netware servers. Access rights can be controlled down to the workgroup or individual, and can allow for read/write or read-only access. Networked file systems (NFS, AFS) provide another mechanism for file sharing, mainly on Unix and Linux systems.

6.7.3 Remote Management

These remote services should be uniformly available to all user desktops:

- remotely control and monitor workstation behaviour (within delegated authority) and remedy problems or identify breaches of the *Acceptable Use Policy* (Novell Zenworks for Desktops and eDirectory (NDS));
- deploy programs to single workstation on demand by user or administrator (Novell Application Launcher (NAL) or other methods);
- deploy programs, complete images or refresh an image to individual workstations or a group of workstations using multicast protocols, preserving user data where appropriate (NAL Zenworks);

6.7.4 Anti-virus, anti-spyware and spam filtering services

Desktop attacks can have a significant impact on individual performance. By default, desktops should only enable the services that are likely to be used. Up-to-date anti-virus, spyware and spam-filtering should be in place on the desktop and on servers.

Sophos Sweep Anti-virus provides protection with email and file storage (Novell Netware) as well as client-based desktops running Windows, Mac OS X, and Linux services (automatically updated when network connected). *(Note: currently under review)*.

Thunderbird provides user-informed spam filtering on client-based desktops (Bayesian filtering ‘learns’ junk) and SpamAssassin along with greylisting protects servers from spam.

A range of anti-spyware solutions are currently in use (eg. Adaware, Spybot, etc.). A University-wide solution is being considered as part of the anti-virus review.

7 Infrastructure Architecture

7.1 Client Platform Architecture

7.1.1 Staff Desktop or Laptop

Staff desktops, laptops and personal printers are standardised under a Monash IT Policy ITEC11, Standard Operating Environment for Staff Computers (http://adm.monash.edu/execserv/policies/Information-Technology-Policies/standard-operating-environment-for-staff-computers.html). Preferred hardware and software is published on the ITS web page Staff Standard Operating Environment (SOE) (http://its.monash.edu/staff/software/).

Desktop PCs, notebook PCs and printers should all be purchased or leased in accordance with Monash procurement policies from one of the endorsed suppliers published on the Procurement Services website (http://adm.monash.edu/procserv/suppliers/IT/).

7.1.2 Staff Handheld Computer

Handheld PCs and PDAs have been assessed by the Mobile Services Working Group and incorporated into the SOE and endorsed supplier list (http://its.monash.edu/staff/mobile/pda/) *(Note: under review as part of Workgroup Collaboration Rollout)*

7.1.3 Student Lab Desktop

Both Windows and Linux are supported in labs for different teaching needs. See the ITS website for information on the current state of the Student Lab SOEs (http://its.monash.edu/staff/software/).

7.1.4 Student Desktop or Laptop

As far as practicable, students should try to replicate or approach the Student Lab SOE in home machines or laptops. Laptops should include a built-in wireless card (802.11g preferred).

7.1.5 Student Handheld

Recommendations for handheld computers are under consideration by the Monash Mobile Devices Working Group, and will be included in the extended SOEs when available. *(Note: Pending completion of Workgroup Collaboration Rollout)*

7.2 Server Platform Architecture

Appropriate platform selection depends on the performance characteristics of the application. In general, the preferred Monash platform is an x86 (Intel/AMD) virtual server running Red Hat Enterprise Linux. For scalability, operating systems and hardware that support multiple-processor configurations and clustering are preferred.

7.2.1 Hardware

The performance and reliability of servers is determined by many factors that affect the selection and configuration of the hardware. High-availability services may include fully duplicated systems, others will have varying degrees of resilience in power-supplies, network cards, disk controllers etc.

Resilience and scalability is also achieved when a service is devolved to a "farm" of identical systems and an automatic load-balancing mechanism. A key driving factor in platform selection is support, i.e. the application and platform vendors' level of support for the proposed configuration.

Preference should be given to hardware configurations that reduce the installation and management burden. In this regard, blade servers and high-density rack-mount servers should be considered. SMP (symmetric multi-processor) configurations are available in rack-mount versions, and increasingly in blade configurations also. Where possible, virtual servers are strongly recommended as they provide maximum flexibility in rapid deployment, disaster recovery and upgrading.

Element	**Application Server, web server, file server, etc.**	
Description	**Included in this class are all general-purpose computers which provide a service to multiple workstations in the course of providing some corporate application.**	
Class	**Standard**	**Notes**
Preferred	80x86 (Intel or AMD) virtual servers	Rack-mount or blade, Intel/AMD high-end processors, SMP support providing virtual servers
Acceptable	Sparc	Mid-range and larger models preferred
Supported only for approved applications	MIPS	For data storage management

Element	**Database server**	
Description	**Database servers are characterized by their ability to sustain high rates of disk access; they are transaction processors rather than general computing engines.**	
Class	**Standard**	**Notes**
Preferred	80x86 (Intel or AMD)	SMP and expandable models
Acceptable	Sparc	Mid-range and larger models preferred

7.2.2 Operating System

Element	**Operating system**	
Description	**The operating system for server class computers**	
Class	**Product**	**Notes**
Preferred	Red Hat Enterprise Linux AS 4	To latest release (Update 4 as at Nov 2006)
Acceptable	Solaris 10	To latest release
Supported	OES Linux v1	To latest release. Required for Novell (print, file, anti-virus etc. services in student and staff environments)
	Scientific Linux 4	To latest release (Update 4 as at Nov 2006). Required for Lab PCs (AFS, etc.) and Grid computing
	Windows Server 2003	At least Service Pack 1. Required for eCommerce Gateway, eCart, CRC and Xcom
Maintenance	Netware	Decreasing in favour of SuSE (for Novell)
	Digital Unix, IRIX, BSD	Required for legacy systems
Prohibited	Windows NT, 2000	Not recommended because of high management/maintenance costs and security concerns (especially the high rate of patching necessary to close security vulnerabilities)

7.2.3 Server Consolidation

Server consolidation seeks to minimise the cost of acquisition, management and maintenance of servers while continuing to deliver the same level of business benefit (in line with principle 3.8, '*Applications share resources'*). This can be most effectively delivered through the use of a virtual server approach (as recommended in '*Server Platform Architecture*' above).

The selection of server capacity should be driven by the principles of limiting diversity, achieving high availability and re-using general purpose building blocks, while maintaining appropriate levels of performance, security, privacy and business agility. The aim is for the smallest practicable number of powerful platforms. It is to be expected that platforms will increasingly be multi-processor configurations, and that greater use will be made of clustering technology to reduce the number of managed entities.

Consideration should be given to the impact of service, configuration, change, release, incident and problem management. The pressures in these costs can be different for platform and application management, but effort should be invested to find the optimal point of minimum cost across all resource areas.

Consolidations at higher levels of the architecture will often enable consolidation at lower levels. Where possible, information architecture (eg. data models), application frameworks and applications, application servers and storage (eg. data repositories) and platforms should be consolidated. Fewer separate entities at higher layers will simplify consolidation efforts at lower levels, resulting in cost reductions across application and platform management.

7.2.4 "In-sourced" Hosting

Through the ITS Service Management Office, the division is standardising its delivery of hosted solutions. This will allow Faculties and Divisions to easily procure and deploy their services on ITS

infrastructure, providing savings both in infrastructure (because of virtualised deployment) and maintenance (because of standardised maintenance procedures).

7.2.5 Server Procurement

The normal procedure will be for application projects to list their server requirements and request Infrastructure Services (ITS-IS) to provide server facilities meeting the project specification. Infrastructure Services can provide a detailed questionnaire to guide selection. After discussion with the project team, a suitable hosting solution will be proposed.

7.2.6 Configuration

Operating system and related files including swap files normally reside on Direct Attached Storage (DAS). Applications and data reside on the Storage Area Network (SAN; see below).

7.2.7 Management and Monitoring

Monitoring is an essential preventative measure for highly available service delivery. An appropriate level of monitoring must be installed on all production services. Monitoring software should be configured with appropriate alarm hierarchies to notify service managers before or when incidents occur, and appropriate logging to allow for trend analysis, historical incident review and KPI reporting.

Element	**Monitoring**	
Description	**Software that logs activity and state across a range of measures, with alarm hierarchies for exception notifications**	
Class	**Product**	**Notes**
Preferred	BMC Patrol (per instance cost)	Required for ITS production systems (integrates into other ITS reporting mechanisms). Recommended where a high degree of service monitoring is required
Acceptable	Nagios	Open source equivalent (free)

7.3 Server Data Storage Architecture

In 2004 ITS moved to storage area networks (SAN) to decouple storage from physical servers. Benefits of network-based storage include improvements in efficiency, business continuity, flexibility and cost effectiveness.

Availability and performance of the SAN is critical to IT service availability. Suitable levels of resilience have been configured into the architecture to satisfy this requirement. IT servers classed as ‘mission critical’ must be configured with dual paths to the SAN to maximise availability.

Storage virtualisation (SV) is deployed in the standard disk storage product but has not been extended to the premium disk storage product. This is because our premium disk storage product supports many critical IT services and it is not clear whether SV is resilient enough to provide 24 by 7 availability. A review of SV products available on the market will be conducted in 2006 Q4.

For more information about ITS’ data storage management framework, governance and procedures, please see http://its.monash.edu/staff/systems/dsm/

7.3.1 Storage

Element	Server Data Storage	
Description	**The physical storage to store and protect information**	
Class	**Product**	**Notes**
Preferred	Infortrend SATA disk storage (for standard use)	Standard storage is based on SATA (Serial Advanced Technology Attachment) disk technology purchased from a smaller vendor. It is has no single point of failure, but has lower performance than FC. It is less expensive and appropriate for most Monash applications.
Acceptable	IBM DS4500 Fibre Channel disk storage (for premium use)	Premium storage is fibre channel enterprise class storage with no single point of failure, high performance and 24 by 7 support. It is expensive and should only be used for business critical services.
Supported	Direct attached storage (DAS)	In some cases direct attached storage may be the most appropriate storage solution.

7.3.2 Backup and Recovery

ITS also offers a centralised backup and recovery service via the Tivoli Storage Manager (TSM) system to any Monash server on a server subnet. The levels of data retention may vary as appropriate for the data but data is always stored at a geographically separated site to the original host.

Element	Data Backup and Recovery	
Description	**Backup, archiving and recovery of data**	
Class	**Product**	**Notes**
Preferred	Backup and Restore Tivoli Storage Manager	Data is always stored at a geographically separated site to the original host. In most cases copies of the data is stored at multiple locations.

7.4 Network Architecture

ITS is responsible for the operation and management of the network infrastructure. This includes all of the inter-campus and on-campus switching facilities, and all fixed wiring as far as the wall outlets (or the air interface in the case of wireless networks). Management of workstations, including the network interface card and patch lead, lies with the user (local technical staff).

ITS provides a range of methods to access the Monash network, including:

- Fixed (local wired access)
- Wireless (local air access, see http://its.monash.edu/staff/networks/wireless/)
- Remote access (modem access)
- VPN (secure access from other parts of the Internet, see https://secure.monash.edu/its/vpn/)
- GPRS/3G *(under trial)*

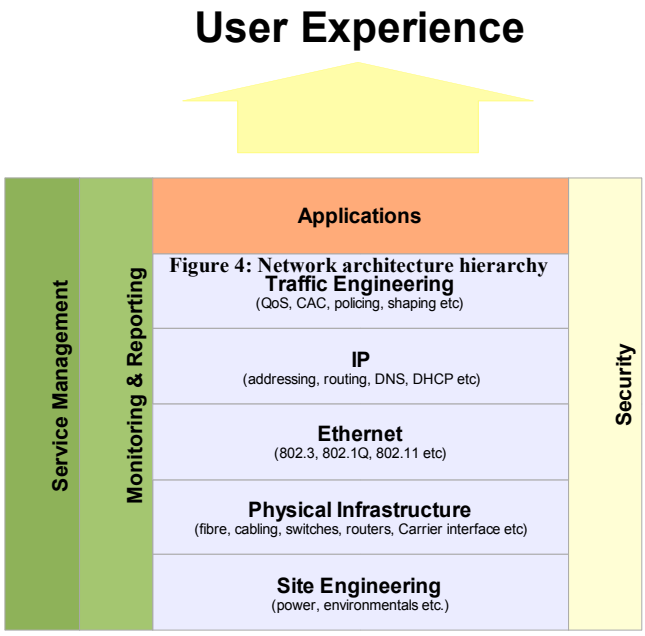

Figure 4: Network architecture hierarchy

The Monash network is based on universally accepted standards for the various interfaces and

protocols. Standards for some additional services (such as desktop video-conferencing) will be added in future editions of the architecture.

The network (access and capacity) is designed to enable and support research, education and administrative activity. Where users feel that the current network model does not effectively support their needs, they should contact the appropriate ITS staff to ensure that their needs can be effectively met.

7.4.1 Network Model

Monash University has a large and complex network consisting of more than 1,350 network devices servicing 20,000 data points in 150 buildings on 20 sites.

The network model at Monash consists of the following characteristics:

1. Resilience: Avoiding any single points of failure on network path or service
2. Reliability: Equipment used to provide network services must be enterprise grade equipment.
3. Self-Healing: The network should self-heal without requiring human intervention in the event of the failure of equipment or links.

It consists of multiple precinct networks linked together by a core network. Each precinct comprises a group of buildings based on a combination of campus geography and optical fibre distribution. Dual route switches provide resilient connectivity to each precinct and the central data centre. Each building has a distribution switch connected to edge switches. Edge switches provide gigabit/s connectivity to end-user desktops.

The multi-path network also provides geographically diverse paths, ensuring that a failure in any one location or path will not affect the rest of the network.

7.4.2 Network Protocols

The Monash network supports the TCP/IP suite of networking protocols. All new services must conform to this suite. Services should also allow for the effects of network access control policy (NACP). For example, inter-subnet communication is restricted for security purposes. This means that services cannot be configured to use protocols such as NetBIOS or NetBEUI.

7.4.3 Domain Naming

ITS manages domain names for Monash websites and non-Monash websites hosted within the Monash network. Domain names must be registered through ITS (see *Monash Domain Name Policy*, http://adm.monash.edu/unisec/pol/polres/itec09.html).

7.4.4 Device and subdomain administration

The Monash network is divided into various subdomains based on organizational, geographic and role-based groupings. Each subdomain should have a primary Subdomain Administrator. These administrators can be authorized to manage network registrations for devices under their control (see http://its.monash.edu/staff/networks/technical/notes/addhost.html). All devices must be registered in the AddHost system; end-user desktops should be configured to use DHCP. Registration must also indicate the purpose of the device, which ensures that the appropriate security and throughput settings are applied.

7.4.5 Servers, other non-end-user devices and network-intensive applications

If you are planning the use of any non-standard software or applications, you should take advantage of ITS Network Infrastructure Services' (NIS) software evaluation service to ensure that (a) the product's

configuration is optimised for the Monash network and (b) the network is appropriately optimised to ensure appropriate support for the product (eg. Quality of Service (QoS) management).

Similarly, if you are setting up any dedicated network resources (eg. standalone servers) you must ensure that they are (a) appropriately configured for their level of service (eg. machine room with UPS, see section 7.5 of this document) and (b) appropriately configured for network (see http://its.monash.edu/staff/networks/connections.html). This may include the use of dual network connections, load balancing (CSM) and SSL offloading.

Along similar lines, if you are looking at introducing Blade Centres (e.g. HP c-Class, p-Class or IBM eServer) as a means of consolidating on physical hardware, you must ensure that (a) the choice of data network and SAN switches are compatible with the existing network infrastructure, (b) that what is deployed sits well with ITS network design principles, guidelines, and is configured appropriately, including the use of dual network connections, and (c) all parties are aware of where the lines of demarcation and responsibility lie as far as ongoing support is concerned. If you are considering blade-based solutions, please contact NIS for details about the appropriate network design.

Where departments may be configuring their own large-scale storage resources, MITA strongly recommends pursuing equivalent configuration to the central SAN configuration to allow maximum interaction and integration. If you are designing such a solution, please contact NIS for detail about the appropriate network design.

7.4.6 Network Access Management

ITS is responsible for managing traffic flows across the Monash network and through to AARNet. This is largely achieved using Access Control Lists (ACLs) within network equipment.

ACLs are a part of a defence-in-depth information security architecture. Traffic control can be done with dedicated hardware firewalls, host-based software firewalls, or advanced router configuration. Because of the architecture of the Monash network and the difficulty in creating a single ruleset to satisfy every customer requirement, a centralized firewall service has not been implemented at this stage. Instead, Monash ITS offers a service where access control lists are used to apply the Network Access Control Policy and for individual service access requirements. Changes to ACLs must be requested through the ITS Service Desk (https://secure.monash.edu/its/helpdesk/webservice/).

7.4.7 Network Cabling

Monash University has a wired network that utilises a range of standards including those for multimode and single mode fibre and unshielded twisted pair (UTP) cables. Standards are provided for connecting PCs, video security devices, servers and networking equipment. There are also standards available for cabling, connections, labelling and racking. See http://www.its.monash.edu.au/staff/networks/cables.html for more details.

7.4.8 Wireless Network

ITS manages the 2.4 and 5.8 GHz wireless spectrum range within the grounds of Monash University, which means that wireless networks point must only be deployed by ITS. ITS can provide new wireless points on request, either permanently or temporarily (eg. conference purposes).

7.4.9 Multicast

Some applications such as video broadcasting over the network, and distribution of disk images to multiple workstations, proceed much more efficiently if the same information can be sent simultaneously to a group of destination workstations. ITS provides standards for the creation of such groups and the efficient distribution of data just to the specified recipients.

7.4.10 Telephony service

ITS manages a range of telephony-related services including:
- Voice
- Fax
- Mobile (including SMS)

For more detail about telephone services, please see http://its.monash.edu/staff/phones/standard-service.html and http://its.monash.edu/staff/phones/.

7.4.10.1 Device requirements (analog or digital)

Wall outlets are generally configured as analog or digital. Some devices require analog connections (eg. teleconference units and faxes).

7.4.10.2 Enhanced telephony processing (eg. call centre services)

ITS provides enhanced voice telephony services including call distribution system solutions suitable for call centres and other support purposes. For more information, see http://its.monash.edu/staff/phones/etps/.

7.4.11 Billing

There are three kinds of network billing – wall outlet (for data connectivity, includes wireless), voice outlet (for telephone handsets) and Internet (for Internet connectivity). Wall and voice outlets incur installation (one off), access (ongoing) and usage (pro rata) charges.

7.5 Environmental Infrastructure

The reliability of a service depends as much on environmental factors as on the reliability of the actual server hardware or software. Information systems providing corporate information services to more than a single workgroup are expected to have:

- Resilient air conditioning
- Resilient and conditioned power supply
- Server racking
- Physical security
- Appropriate fire protection systems
- A formal data integrity strategy
- A formal Disaster Recovery Plan (DRP)

ITS computer-room environments are designed to provide all of these features, properly maintained and provisioned.

8 Future Work

The development and adoption of an IT Architecture is an ongoing process. The Enterprise Architecture Board is being formulated and will meet regularly to review the architecture, its implementation and the impact of new projects. Major (annual) revisions will also incorporate

communications with all key stakeholders to ensure a current understanding of the enterprise-wide architecture and the benefits and processes for compliance.

9 Appendix I: Classification

Class	Description
Preferred	The product, or products, currently deemed to offer the best combination of value, features, security, etc for University-wide use. Usually there is a single "preferred" product, but occasionally there may be two, in which case each is preferred for a specific domain of usage. Generally supply and support arrangements will exist, and University-wide licensing may have been negotiated.
Supported	Adopting these technologies is likely to be more expensive than 'Preferred' solutions and these costs should be factored into budgets and funding proposals. The architecture is a balance of business benefit and cost, and there are a number of circumstances where a non-compliant product may provide compelling business benefits that warrant the increased expense. However, adopters should not regard these products as supported for use outside their proscribed domains, as support is quite limited and defined.
Acceptable	A product deemed to be less desirable in some sense than those in the "preferred" class, but may be used in cases when the preferred products are ruled out on the basis of business requirements. Generally adoption and support for 'Acceptable' solutions will be weaker than 'Preferred' solutions and adopters are encouraged to consider 'Preferred' solutions.
Candidate	A product not yet classified otherwise, but deemed to have sufficient merit for consideration as a potential preferred product. Candidate products are typically new products or technologies, and may be used in trial or pilot projects. These products will generally not be covered by existing supply or support contracts or by existing licences. Adopters interested in using candidate technologies are encouraged to register with ITS to inform future planning.
Maintenance	Products that are in use at Monash, probably in "legacy" applications, but are deemed to be less suitable than the best currently available. New projects should always use "preferred" class products (unless the EAB grants a dispensation). Where projects or services already use a "maintenance" product, its use may be continued until there is a major upgrade or redesign. At this point a switch to a preferred product should be considered. Supply, support and licensing, if they exist at all, may be subject to "sunset" clauses, so these aspects should be reviewed regularly.
Prohibited	Products that have serious defects or whose philosophy, structure, or resource requirements make them inappropriate to the Monash enterprise architecture. Should not be used in any sustained production situation.

10 Appendix II: Glossary

- **architecture:** the design, interconnections and underlying processes of the technical components that together provide Monash's information and communication infrastructure.
- **CMS:** The University's *Content Management System*, see http://its.monash.edu/staff/web/cms/
- **EAB:** Enterprise Architecture Board
- **ITIL:** The IT Infrastructure Library, see http://www.itil.co.uk/
- **MURMS:** Monash University Risk Management System, see http://comply.adm.monash.edu.au/
- **MUSO:** Monash University Studies Online – the University's enterprise learning and teaching systems environment, incorporating WebCT, InterLearn and Lex; see http://monash.edu/muso/
- **open standards:** collaboratively defined, publicly available specifications for interacting with, using and integrating technologies
- **PMBOK:** The Project Management Body of Knowledge, see http://www.pmi.org/info/pp_pmbok2000welcome.asp
- **rights management** (or 'digital rights management', DRM): technologies and processes to protect (restrict and manage) access to copyright materials

11 Appendix III: Frameworks and methodologies

Some frameworks and methodologies which have been found valuable at Monash, and which have been reference in the development of this architecture are noted here. Some of these relate to specific areas (eg. application development or identity management), while others are more general in nature.

- **COBIT:** The **Control Objectives for Information and related Technology** (**COBIT**) is a set framework for information (IT) management created by the Information Systems Audit and Control Association (ISACA), and the IT Governance Institute (ITGI) in 1992. The fourth edition was released in December, 2005
- **E2AF**: Extended Enterprise Architecture Framework
- **FEAF**: Federal Enterprise Architecture Framework
- **GERAM:** Generalized Enterprise Reference Architecture and Methodology (ISO IS 15704:2000)
- **ITIL:** IT Infrastructure Library for service management– see http://itil.org.uk/
- **RAD:** Rapid Application Development (RAD)
- **Thomsett:** Thomsett Project Management Methodology (a variant of PMBOK)
- **TOGAF:** The Open Group's Architectural Framework, see http://www.opengroup.org/togaf/
- **UCD**: User-Centred Design and Usability – see http://monash.edu/staff/web/users/
- **XP**: eXtreme Programming – see http://extremeprogramming.org/