ICT Architecture Principles for the Norwegian Higher Education Sector

Authors: Heidi Bergh-Hoff (UNINETT), Carl-Fredrik Sørensen (NTNU), Jan Erik Garshol (BIBSYS), Bård Henry Moum Jakobsen (UiO), Geir Magne Vangen (FSAT), Ørjan Dypvik Pettersen (HiN) and Johnny Hansen (UiT)
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The document's foundation and status

For several reasons, major changes are expected to take place in the higher education sector in the years to come. A range of new ICT services is driving the development of new approaches to research and education. In research, new tools enable increased data capture, allow researchers to access greater quantities of data, and increase analysis capacity. In education, lecture recordings and interactive tools enable learning anywhere, anytime and free up resources for more discussion and collaboration. Teaching staff can be continually updated on their students' activities and assessment results, which may be used to adjust the learning process throughout the course. The development of new approaches to learning worldwide has brought new services and service providers for "massive open online courses" (MOOCs). These services are a great resource for the higher education sector. In the long run, these services will also contribute to increased competition, a more rapid rate of change, rationalization and higher quality.

From an administrative perspective, replacing and updating the sector's administrative systems will offer more opportunities for rationalization, both locally at each individual institution, and through increased interaction and cooperation between organizations.

The Government has proposed structural reform in the higher education sector.[1] "The objective of this structural reform is for universities and university colleges to maintain a high level of quality in education and research, and to establish robust academic communities where resources are primarily allocated to core activities."[2] One of the recommendations from the white paper was the "establishment of a task force to develop a uniform strategy and recommend how academic and administrative systems can be applied and organized more efficiently". This task force will be established in collaboration with the Norwegian Association of Higher Education Institutions (UHR). It should comprise representatives from the sector and have a secretariat provided by UNINETT AS."[3] The task force should work to establish recommendations for shared systems for the entire sector, systems shared by groups of institutions, and systems each individual institution should handle on its own to preserve its character and competitive power.

Such sweeping changes across an entire sector require a comprehensive approach based on a common architectural philosophy that takes into account any requirements and changes necessary today, while building ICT systems that are geared toward the future, both technologically and organizationally. These ICT systems then, in turn, enable smoother, more flexible merger processes across the sector. Architecture management builds on common guidelines, expressed as a set of architecture principles. This document was commissioned by the university IT managers' forum and concretizes the architecture principles established by the Agency for Public Management and eGovernment (Difi) in the context of the higher education sector, focusing primarily on ICT. The sector's IT managers have decided to implement the architecture principles. This document may also be useful for the task force working on structural reform.

[1] Norwegian Parliament. White Paper no. 18 (2014–2015) Concentration for Quality - Structural Reform in the Higher Education Sector. Available digitally at: https://www.regjeringen.no/contentassets/86d1e31e78b44de6a3a15e913b092bf4/no/pdfs/stm201420150018000dddpdfs.pdf
[2] Ibid. Section 2.1, p. 16.
[3] Ibid. Section 6.3, p. 69.

About the principles

Introduction[4]

User orientation and cost efficiency are two important considerations within public services. To support this, the government has, by presenting the eGovernment Program – *På nett med innbyggerne* and Meld. St. 19 (2008-2009) - *Ei forvaltning for demokrati og fellesskap*, decided on seven overarching IT architecture principles. Difi's IT architecture principles[5] have been concretized for the higher education sector in this document, which represents a joint interpretation of the principles for the HE sector.

The principles will function as a set of common for the use of ICT in the higher education sector. They will help ensure that ICT solutions support education, research and dissemination activities in the sector, thereby enabling better and more uniform digital services.

In accordance with a circular regarding the coordination and management of ICT-related investment in the public sector, Difi's architecture principles are mandatory for government agencies[6]. The principles shall be applied when new ICT solutions are developed or when significant modifications are made to existing ICT solutions. If the principles lead to significant, undesirable consequences, they can be partially or completely waived. Deviations of this kind must be motivated and documented.

The relationship between the enterprise and the architecture principles

Enterprise architecture deals with how an enterprise is organized, how business processes and roles function together and how ICT solutions are utilized to support those processes. An enterprise architecture consists of principles, methods and models, which together describe this as a whole. A well-documented and unified enterprise architecture helps ensure that individual solutions are realized in a larger context, and not as separate processes. The purpose is to facilitate good alignment between business processes and ICT solutions, preventing the development of information systems that do not communicate with each other, so-called silos.

Difi has recommended that the overarching architecture principles are included in a common enterprise architecture for the public sector.[7] Difi is responsible for managing and developing the architecture principles. The respective sectors and public bodies are responsible for incorporating the architecture principles into their own architecture. This document concretizes the principles for the higher education sector.

Target audience

The target audience for the architecture principles is primarily those working with process change and ICT systems design, as well as enterprise and ICT architects. All of these people in practice work with enterprise and ICT architecture, and they must ensure that the principles are incorporated into policies and principles, and that they become part of the architecture of the enterprise. In practice, the actual work must take the form of change processes in current and future programs and projects, as well as major changes in existing services, such as product changes and major functional changes in basic services.

The principles are also relevant for technical consultants, process managers or systems administrators who own, manage or develop new, digital services. Employees in these roles must comply with the enterprise's guidelines and principles, and as such, will also uphold the

[4] Text in green is taken from Difi's overarching architecture principles. Text in black is a concretization of the content specific to the context of higher education.
[5] Agency for Public Management and eGovernment, 2012. Overarching IT architecture principles for the public sector http://www.difi.no/filearchive/arkitekturprinsipper-2.1.pdf
[6] Ministry of Government Administration, Reform and Church Affairs, 2011: Circular no.: P-11/2011—Coordination and management of ICT-related investments in the public sector
[7] The Agency for Public Management and eGovernment, 2010: Report 2010:17—*National common components in the public sector*

overarching architecture principles.

Enterprise architecture in the higher education sector

The HE sector comprises approximately forty independent institutions. Tighter integration is needed to improve quality, resource utilization and efficiency. The enterprises and the systems supporting them have a history, however, and they were not always designed to work together. The variety of technical support systems in use impede process collaboration. A harmonization of existing systems is therefore necessary to promote and simplify interaction.

The sector has made some progress in this field by implementing shared systems. BIBSYS, CRIStin, FS, SO and Feide are examples of resources used nationwide. There is, however, still a large potential for further harmonization. This applies to several aspects of the enterprise architecture, such as shared functions, processes, roles, terms, systems and data models. Standardization in these areas will free up resources that are currently spent maintaining unnecessary variation. These resources could be utilized more productively to strengthen and develop the sector's core activities: research, education, innovation and dissemination.

In taking an enterprise architecture approach to harmonization, the sector is well-placed to see the big picture and gain a better understanding of how the individual components of the institutions' operational models affect each other. A more accurate definition of the term enterprise architecture would be "the organizing logic for business process and IT capabilities reflecting the integration and standardization requirements of the enterprise's operating model" at institution and sector level.[8]

Figure 1 presents some analysis perspectives that typically form part of a description of enterprise architecture. The model is a simplified interpretation of the TOGAF model[9], which is widely applied in Norway. The purpose is to understand how different layers or levels in the enterprise interact, to ensure high-quality, relevant solutions and good interaction throughout. Since this document was commissioned by university IT directors, the bottom two layers have been described in more detail than the top two layers.

[8] Available digitally at http://cisr.mit.edu/research/research-overview/classic-topics/enterprise-architecture/; last accessed 19/08/2015.
[9] Available digitally at http://pubs.opengroup.org/architecture/togaf9-doc/arch/; last accessed 03/06/2015.

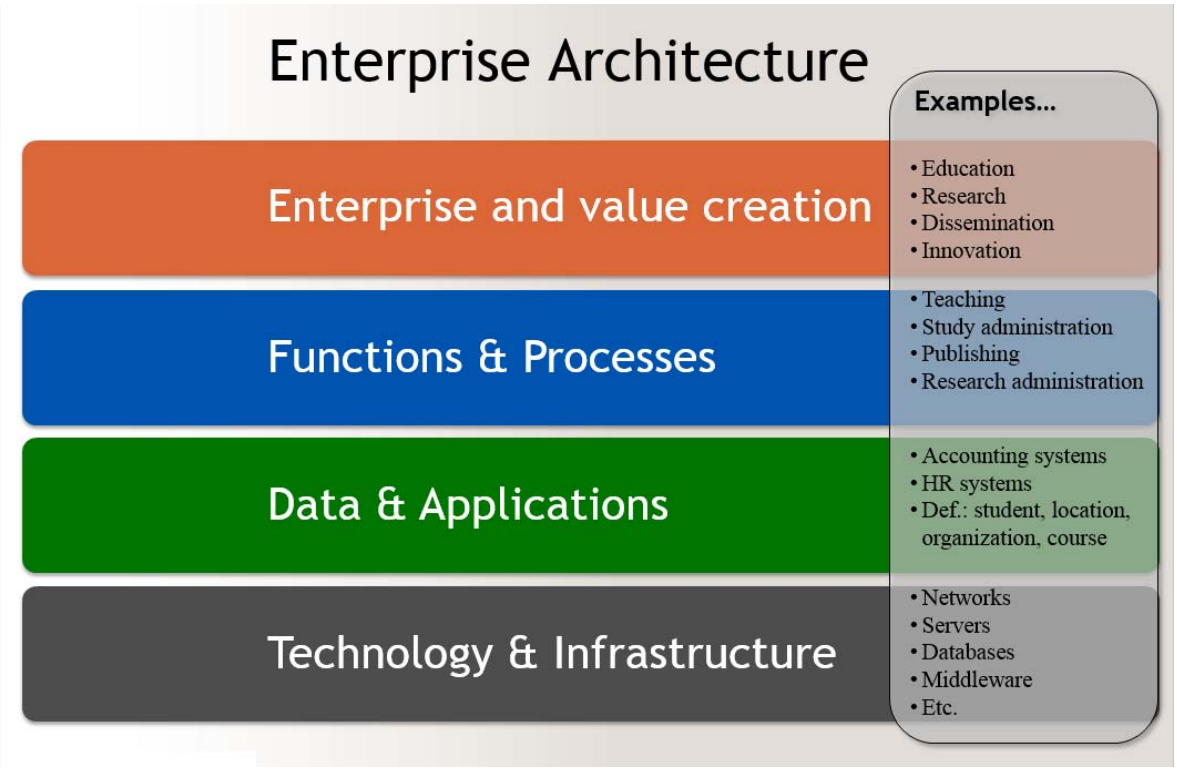

Figure 1: Simplified version of the TOGAF model for enterprise architecture

The principles describe requirements for how to define and realize the architecture in these layers. They may affect the development of individual institutions, in that they describe guidelines common to the entire sector. They may also be used as a "baseline" for requirements specifications in the procurement of ICT solutions. In a procurement process, the assessment of architectures in accordance with the architecture principles will give decision-makers an idea of how well a recommended solution meets the requirements of the sector's principles and models, as well as of the consequences of any non-conformity. Therefore, architecture principles contribute to the realization of a joint enterprise architecture for the HE sector.

An architecture process for the sector must include governance, where an architecture advisory board could play a central role. An architecture process is essentially a managed change process, suited to balance requirements related to shared functions, processes and systems in the sector with considerations of institutional branding, specialization and regional needs that may lead to non-compliance with these requirements. Architectural governance must include mechanisms for the design and implementation of architecture (including the architecture principles), compliance measurement and exception handling. This kind of change process requires an initial investment, but it offers considerable efficiency gains in the long run. Standardization, sharing and re-use reduce overall expenditures in the sector, but they also require local changes that may initially be perceived as disadvantageous if they are evaluated exclusively from a local perspective. Thus, a critical success factor in this process is to highlight specific advantages from increased division of labor, more and better shared services and increased re-use of solutions, in an effort to prevent sub-optimization at an institutional level.

Value proposition for different target audiences

A uniform and coordinated enterprise architecture for shared processes in the HE sector promote higher quality at institution and sector levels through increased interaction, knowledge-sharing and a stronger focus on specialization and the development of unique strengths. Access to accurate and updated information in decision-making processes leads to better-quality decisions, and improved cost-efficiency by re-using solutions. The portfolio of ICT solutions, work processes, roles and terms become less complex and more uniform.

The gains described above account for the value of a unified enterprise architecture for sector management. The value for other target audiences is outlined in Table 1 below. Students benefit from increased mobility and flexibility in tailoring their personal learning process. Educators are afforded better opportunities for specialization and in-depth studies. Researchers benefit from increased efficiency through better tools and access to more data. Support functions, such as accounting, HR and ICT may be able to increase their range of services, in that they become more cost-efficient by eliminating fragmented solutions and increasing division of labor.

Table 1: Value proposition from architecture reform in the HE sector by target audience

Target audience	Value
Students	Mobility Flexibility in course selections, even across institutions Flexibility in follow-up and supervision Personalized learning pathways, self-paced learning and geographic freedom New assessment forms
Teaching staff	Enables academic specialization Enables adapted learning pathways, real-time feedback and flexibility in terms of time and location Process streamlining, e.g. examinations and assessments Easy access to and increased opportunities for adaptation of learning objects New platforms for collaboration with business and industry partners in education
Researchers	Easy access to data and simplified data management Harmonization of tools—both research tools and tools in support of externally funded activities[10], such as project management
Management	Improved quality through increased collaboration, knowledge-sharing and specialization Improved quality in decision-making through improved management support and information Better utilization of resources through re-use and improved decision-making bases Elimination of needless complexity - reduced systems portfolio - process harmonization - role harmonization - term harmonization
Administrative staff and IT departments	Economies of scale as the result of service, process, role and term harmonization Reduced complexity Enabling division of labour Architecture expertise through best practice and consulting

[10] Externally funded activities include project-based activities funded by grants or other external sources.

Concretization of Difi's principles for use in the higher education sector

The ICT architecture principles for the HE sector is a concretization of Difi's overarching IT architecture principles for the public sector. Any text taken directly from Difi's principles is green in this document. Any black text in the document is either new to this concretization or the wording has been changed significantly from how it appears in Difi's principles.

Any distinction between ICT principles from enterprise principles is largely artificial, and there is a certain risk associated with defining ICT principles separately. We have sought to minimize this risk by taking into consideration the Dutch HE sector's principles for information defined at enterprise level.[11] We consider these principles to be largely transferable to the Norwegian HE sector. Input from other architecture principles, both in the Norwegian public sector and from other HE communities abroad[12][13][14][15][16] have also been taken into consideration.

Principles and policies must be implemented to be useful, and doing so can be challenging. To support this process, examples of implementation are presented in **ICT architecture principles for the higher education sector in practice.**

[11] SURFnet. Higher Education Reference Architecture, Information Principles; available digitally at http://www.wikixl.nl/wiki/hora/index.php/Principes_voor_informatievoorziening; last accessed 08/09/2014

[12] "Arena for sector architecture" in the field of health and welfare, Architecture principles for the field of health and welfare, 23/02/2011; available digitally at http://www.kith.no/upload/5834/Felles_Arkitekturprinsipper_publisert.pdf; last accessed 08/09/2014

[13] The Open Group, October 2008. The Open Group Architectural Principles, A Case Study prepared by Darren Hawley

[14] UNINETT, 27/02/2013. UNINETT Architecture Principles; available digitally at https://www.uninett.no/webfm_send/764; last accessed 08/09/2014

[15] The University of Adelaide, University ICT Architecture Committee. ICT Principles; available digitally at http://www.adelaide.edu.au/technology/governance/principles/; last accessed 08/09/2014

[16] University of Canberra. Policy: Enterprise Architecture Principles Policy; available digitally at https://guard.canberra.edu.au/policy/policy.php?pol_id=3235; last accessed 08/09/2014

Summary

This document presents the part of Difi's principles that are relevant for the HE sector, while also concretizing the principles for higher education to present a complete picture of the sector's architecture guidelines.

The document includes a page for each of the principles, outlining the principle, its explanation and consequences, as well as references and interdependencies. The principle briefly outlines its goals and objectives. The explanation outlines the purpose of the principle. Consequences are described on the basis of TOGAF's four architecture domains: business, application, data and technology. The consequences associated with an architecture domain are numbered for reference purposes. For example, the second item in the technology domain for service orientation may be referred to as "Service orientation T2". The consequence outline in these four domains offer more concrete guidelines than do Difi's architecture principles, and this underpins the understanding and application of TOGAF's architecture framework in the sector. Measures that may support and promote several of the architecture principles are only specified once to avoid repetition and to prevent ambiguity in principle references. When consequences are predicated on processes, functions, services, roles, definitions of terms or data models, these have been specified under "references and interdependencies". Regulations and standards central to the understanding and application of the principles have also been listed under "references and interdependencies".

A good user experience is central to the design of the sector's ICT solutions. In that the topic primarily is associated with the accessibility principle, it is first described there. This must not be interpreted as a dismissal of a user-centered approach; it is rather a consequence of the intention of adhering to Difi's guidelines. Difi has largely succeeded in describing architecture principles that address seven different system aspects that are relevant virtually everywhere, and their order is considered prioritized. This prioritization works well, with the exception of user focus and security. For that reason, we address the importance of a good user experience specifically here. Difi has addressed the tension between accessibility and security by stating that "the security principle may limit other principles if necessary to maintain the public's confidence in the public sector".

In order to promote a uniform interpretation of the architecture principles, a list of terms is provided toward the end of the document. We have sought to use established definitions of terms whenever possible. Sources are cited. TOGAF 9.1 terms have been applied insofar as they are relevant. However, the TOGAF standard, which is currently under revision, had prior to said revision not developed sufficiently in the area of service-orientation to meet our needs. We have therefore added supplementary terms from Archimate, a complementary and more recent open standard maintained by the Open Group. Other sources have also been used.

Service orientation

Principle	Functionality and performance should be the main considerations when developing IT solutions. ICT services that are necessary to support all or parts of one or several business processes, must be identified and realized for the purpose of re-using them. *Services* must be sought re-used whenever possible. If *shared services* do not meet the needs of a target audience, specialized *services* may be defined.
Explanation	By facilitating re-use of services and components in agencies and across the public sector, when appropriate, the principle of service orientation adds to faster and more cost effective development of digital services.
Consequences	*Business* 1. *Shared services* that meet the target audience's needs are used whenever they exist *Application* 1. Application services are sought re-used whenever possible 2. New *shared services* whose functionality overlap with existing *shared services* are implemented with a plan for phasing out the old solution. 3. *Application services* are designed in such a way that they can be used for new purposes in other *application services* *Data* 1. *Master data* have been made available through re-usable application services *Technology* 1. Resources are made available through common HE sector user identification and authentication mechanisms. 2. Authorization mechanisms granting access to *services* and *data* manage access on the basis of shared roles in the sector 3. Service delivery is sought realized through a shared *service delivery platform*
References and interdependencies	Shared mechanisms for access control and the retrieval of *shared services* must be established and maintained. All shared services must be retrievable and accessible through the same access point. Please cf. **ICT architecture principles for the higher education sector in practice** for examples of shared services and roles.

Interoperability

Principle	Enterprises in the HE sector and their IT solutions are able to interact at an expedient level to support higher education, research and dissemination. To some degree, the HE sector must also collaborate with relevant enterprises outside the sector. The principle distinguishes between three different types of interoperability: • Organizational interoperability involves harmonization of business processes, contractual frameworks and changes in organizational conditions necessary for interaction • Semantic interoperability involves clarifying the meaning of the information elements that are exchanged and a shared understanding of operations • Technical interoperability involves using technical standards that facilitate well-defined interfaces, transmission protocols and formats It is a prerequisite for interoperability that the interaction is not in conflict with legal regulations or privacy restrictions. Legal assessments are central as part of both organizational and semantic interoperability.
Explanation	The principle should facilitate for an efficient flow of information, and ensure that the overall ICT development in the sector underpins business processes and regulations, both within the individual enterprise and across the sector's institutions. Secondly, the flow of information should facilitate for the flow of students and staff between institutions. Silos must be prevented at every level.
Consequences	*Business* 1. Goals, processes, roles, responsibilities, and requirements must be clarified and aligned 2. Cooperating enterprises clarify regulations, financial models, operating agreements and any collaborative agreements 3. Shared processes, *information architecture* and roles are applied wherever they exist *Application* 1. Applications comply with the shared *information architecture* 2. Standardized application services are established and have priority *Data* 1. The shared *information architecture* is realized in a shared data model 2. The semantic meaning of *data* is clearly defined in the *information architecture* 3. All data have **one** *master data source* where all updates are made *Technology* 1. Loosely coupled mechanisms of integration are used 2. Shared solution for unique identifiers for familiar resources in the HE sector are used
References and inter-dependencies	The sector must define and maintain: Shared roles influencing the implementation of ICT solutions Shared *information architecture* and data model for the HE sector Shared and standardized *services* Shared and *standardized processes* whenever practical

Accessibility

Principle	Digital services are available when the users need them, easy to find, and with a user friendly and universal design.
Explanation	This principle should facilitate the accessibility of *services* by all relevant user groups, regardless of age, gender, functional ability and cultural and ethnic background. By promoting "digital first", the principle promotes a future-oriented development in the HE sector, which allows *services* to be accessible at any time or place. By classifying the criticality of the *services*, the principle facilitates for contingency planning.
Consequences	**Business** 1. User contributions are assessed and documented whenever new services are established 2. *Services* are user-friendly for the target audience 3. *The services* are available in a language the target audience can understand 4. Electronic services are easy to find and do not require users to be aware of how administration is organized. 5. Standardized access to all information owned or produced by the institution is secured by requirements. 6. Digital first. Processes are planned with the ambition of automating the process and facilitating for a digital option to be the first choice. 7. Organizational processes (e.g. shift rotations) may complement system robustness as needed **Application** 1. All application services must comply with the principles of universal design.[17] 2. *Application services* are available on the users' preferred channels. *Applications* with a broad user group are available on smartphones and browsers first. 3. Accessibility requirements are based on the criticality of the *service* (mission critical, critical for many users, limited use) during opening hours, which may be 24/7. **Data** 1. It is easy to find and access *data* one is authorized to access, in the right process and in a timely manner, usually electronic, 24/7, worldwide. 2. *All data* have a designated data owner and well-defined procedures for data management. 3. Requirements for *data quality* have been specified **Technology** 1. Infrastructure services are designed to support enterprise accessibility requirements. As far as possible, the interface of *services* is technology and platform independent, in order to avoid the need for specific solutions or products in order to use the *services*
References and inter-dependencies	Universal design: http://lovdata.no/dokument/SF/forskrift/2013-06-21-732 and http://www.difi.no/digital-forvaltning/universell-utforming, eManagement Regulations of 07 February 2014 establish the principle of digital first: http://www.regjeringen.no/upload/KMD/AIF/dokumenter/digital_komm_brosjyre.pdf

[17] Existing solutions must be compliant by 01 January 2021.

Security

Principle	The IT solution itself and the information processed in the solution, should, based on formal and risk-based requirements, be protected against breaches of confidentiality, integrity and accessibility. When essential for maintaining the public's confidence in the HE sector, the security principle can limit other principles.
Explanation	The security principle shall contribute to the sector's IT solutions being developed and managed in a secure manner, while at the same time ensuring that *information* and *services* are available to those who need them and/or have the right to use them. The principle shall contribute to the strengthening of the HE sector's competence, organization, culture and ability to comply with regulations concerning information security. The security principle is an important prerequisite for maintaining the public's confidence in the HE sector.
Consequences	**Business** 1. Confidentiality: *Information* shall only be accessible according to defined service levels and to users who are eligible to access the information. 2. Integrity: Information is adequately protected from accidental or unauthorized changes. 3. Accessibility: Cf. separate principle 4. The enterprise must test and document that security measures function as intended. **Application** 1. Risk analyses are conducted for all *services* upon implementation, and if changes with the potential to affect information security have been made, the risk analysis is revised. At least every two years, an assessment is made regarding whether such a change has been made. 2. *Information* and *services* shall have a defined security level based on a risk analysis and the specified categories. 3. The security level is documented for the user, and it must be possible to revoke rights. 4. *Services* implement access control that protects confidentiality, integrity and accessibility for the defined security level. **Data** 1. *Information* is classified and access to *data* is controlled to protect the defined security level* 2. Systems facilitate for compliance with regulatory requirements for the combination, storage and secure disposal of *data*. **Technology** 1. *Data* are protected through strategic implementation of measures, e.g. encryption, zoning, elevated access levels through authentication and authorization.
References and inter-dependencies	Section 13 of the Personal Data Act and Chapter 2 of the Regulations pertaining to the Management of Personal Data address information security. The eManagement regulations, Security Act, Health Research Act, Personal Health Data Filing System Act and others, in addition to regulations pertaining to confidentiality are also relevant. The guide to risk and sensitivity analyses, issued by the Norwegian National Security Authority (NSM) address risk analysis requirements. * UNINETT UFS no. 136, Guidelines for the classification of INFORMATION Mechanisms for access control must be defined and managed.

Transparency

Principle	The IT solutions' implementation and underlying data shall be accounted for. Transparency is supported by the use of open data and open interfaces for services.
Explanation	The principle shall support the rule of law by ensuring that the basis for decisions making processes is known. Data and services shall be available to the target audience without requiring them to use tools from a specific provider.
Consequences	**Business** 1. IT solutions are developed in a manner that facilitates transparent, documented and traceable decisions. 2. Selection of organizational, semantic and technical standards is based on the reference catalogue of IT standards in the public sector. Whenever this catalogue does not specify a relevant standard, *open standards (preferred) or* HE sector specific *open standards* are used. **Application** 1. *Open standard* interfaces shall be used whenever available, or if not, *open interfaces*. 2. *Application services* are chosen on the basis of providing the best solutions for the sector over time, without regard for the actions of individual providers. 3. *Open interfaces* and formats are secured by requirements. **Data** 1. Access to *data* shall be open by default. Access restrictions are implemented as needed. *Data* are formatted in accordance with open standards and are available through *open interfaces*. **Technology** 1. Standard interfaces and protocols are used whenever available 2. *Infrastructure services* shall be chosen on the basis of providing the best solutions for the sector over time, without regard for the actions of individual providers.
References and interdependencies	The reference catalogue of IT standards in the public sector. Section 22 of the Personal Data Act makes provisions regarding the right to information concerning automated decisions. Guidelines for publishing public data

Flexibility

Principle	IT solutions are designed in such a way that they do not pose as barriers against changes in business processes, content, organization, ownership and infrastructure.
Explanation	Updated practices and new technical solutions are utilized. The principle shall contribute to cost efficiency by ensuring that ICT solutions can be adapted to meet new requirements. The business needs of the agency shall be the main concern in the establishment of new IT solutions. The principle should be understood with that in mind, and is about developing ICT solutions that do not become inoperable or need excessive modifications if there are changes in business processes, content, organization, ownership or infrastructure.
Consequences	**Business** 1. The governance processes associated with IT solutions must be able to identify and handle needs for change. Decision-making agencies (prioritization boards) and their mandate are defined at function or process levels to meet the needs for change in their respective areas of focus. 2. Organizational conditions significant to the ICT solutions, for example service level agreements, licensing agreements or end user support, must be possible to alter when needed. **Application** 1. IT solutions and the components they consist of, must be sufficiently modularized, loosely coupled and must use well-defined *open interfaces*. 2. *Services* are designed and implemented to support multiple *distribution channels* (e.g. Browser, smartphone app) **Data** 1. *Master data sources* must offer sufficient flexibility within their semantic interoperability to enable diverse uses whenever necessary, including only using parts of the *master data*. **Technology** 1. Operations are taken into account when choosing systems: ease of maintenance, ease of incremental change, ease of monitoring, ease of procedures change and conditions specific to each individual institution and operator. 2. Integration mechanisms minimize the time from change to effect.
References and interdependencies	-

Scalability

Principle	IT solutions must be able to scale according to use.
Explanation	The principle shall contribute to awareness of the importance that IT solutions that still can be used, even though the degree of utilization changes. Changes can be related to the number of users, volume, response times or the life cycle of the ICT solution.
Consequences	**Business** 1. Organizational conditions relevant to managing changes in utilization or usage patterns, must be possible to scale up or down. Examples can be service level agreements, licensing agreements or end user support. 2. The governance processes associated with IT solutions must be able to identify and handle needs for up- and downscaling **Application** 1. Upscaling and downscaling must be possible after the ICT solutions are put into production, so that over time, they are able to deliver the required level of performance. 2. *Application services* shall be self-service whenever possible 3. *Services* shall, to the greatest extent possible, automatically adjust to the capacity of the underlying infrastructure. **Data** 1. *Data* shall be retrieved from the *master data source* whenever practically possible. **Technology** 1. It must be possible to increase or decrease resource allocation incrementally as needed. 2. I must be possible to relocate and re-establish resources as needed.
References and interdependencies	-

List of terms

Asynchronous communication: Exchange of information between sender and receiver without the use of a common clock or other synchronization signal. (Source: Wikipedia.org)

Application: A deployed and operational ICT system that supports business functions and services, e.g. payroll. Applications use data and are supported by, but distinct from, the technology components (Source: TOGAF 9.1). Applications can be said to implement business logic.

Application interface: A point of access where an application service is made available to a user or another application component. (Source: Archimate 2.0)

An **application component** is a modular, deployable, and replaceable part of a software system. that encapsulates its behavior and data, and exposes these through a set of interfaces. (Source: Archimate 2.0)

Application services expose automated behavior. An application service exposes the functionality of application components to their environment. This functionality is accessed through one or more application interfaces. (Source: Archimate 2.0)

An **artifact** is a physical piece of data that is used or produced in a software development process, or by deployment and operation of a system. An artifact represents a concrete element in the physical world that may, for example, take the form of a file, a data object or an application component. An instance (copy) of an artifact can be deployed on a node. (Source: Archimate 2.0)

Criticality: A classification of the need for uninterrupted availability of information or services. Criticality is often classified as a handful of categories for clarity.[18] Services delivered to the HE sector shall be assigned to one of the following three categories, depending on how critical they are to the institution's operations: 1) mission critical, 2) critical for certain processes or functions, and 3) causes discomfort

Data is letters and numbers without meaning. When we place data in a meaningful context, we call it information.[19]

High **data quality** means that the data are fit to support their intended uses. This means that they must satisfy criteria related to:

- Accuracy
- Completeness
- Timeliness
- Consistency

(Source: Wikipedia.no)

Distribution channel: the mechanism by which a business delivers value to its customers (Source: *Business Model Generation*, Osterwalder and Pigneur)

Enterprise: A collection of organizations with a common set of goals (Source: TOGAF 9.1).

Enterprise architecture is the organizing logic for business processes and ICT capabilities reflecting the integration and standardization requirements of the company's operating model at the institution and sector level. (Source: Adapted from MIT Center for Information System Research)

ICT System: A collection of components organized to perform a specific function or set of functions. (Source: TOGAF 9.1 and indirectly ISO/IEC 42010:2007)

[18] Applied, but not defined by ISO 27001 and COBIT. The definition is inspired by Tipton and Krause. 2007. *Information Security Management Handbook*, Sixth Edition.
[19] Gottschalk, P. 2004. *Informasjonsteknologi i kunnskapsledelse*. Universitetsforlaget, Oslo

Information is interpreted data [in a given context][19].

Information architecture is a model whose purpose is to structure information so that its composition and meaning is easy to understand for the user. An information architecture includes specific information elements, which are defined and described. The relationship between information elements in the model is also specified. (Source: Adapted from wikipedia.no)

I**nfrastructure services** are defined as externally visible units of functionality, provided by one or more nodes, exposed through well-defined interfaces, and meaningful to the environment. (Source: (Source: Archimate 2.0)

Master data source: A single source of common business data used across multiple systems, applications, and/or processes. If distributed copies must be made, the master data source is the only source of updates to the data. (Source: Adapted from wikipedia.org - *Master data*)

A **node** is a computational resource upon which artifacts may be stored or deployed for execution. (Source: Archimate 2.0)

Operating environment: The environment required to enable a service to operate as intended. (Source: the architecture principle task force)

Service: A service is a logical representation of a repeatable business activity that has a specified outcome. A service (including any contributing services) is self-contained and has a structure that is not [necessarily] known by customers. (Source: TOGAF 9.1).

Services are defined at three levels:

- Business service (for the business layer)

- Application service (for the "information systems" layer)

- Infrastructure service (for the technology layer)

(Source: Archimate 2.0)

Shared process: Everyone participates in the same process, e.g. the Norwegian Universities and Colleges Admission Service (*Samordna opptak*) (Source: the architecture principle task force)

Shared services: Services that will be utilized throughout the HE sector, and that have a shared context where any contributing services interact through the shared service, e.g. *Feide*. (Source: the architecture principle task force)

Standardized process: A uniform process across organizations or locations.[20] Those involved in the process carry out the same steps in the same order, but separately. (Source: the architecture principle task force)

Standardized services: Services that are identical for all institutions, but where the context of the service is specific to the institution, such as a shared payroll service for several institutions. (Source: the architecture principle task force)

A **business service** is defined as a service that fulfils a business need for a customer (internal or external to the organization). (Source: Archimate 2.0)

Open interface: An open interface has been published with the necessary documentation to execute the intention of the interface, and does not exclude anyone who has met published requirements for using it. (Source: the architecture principle task force)

Open standard: An open standard is maintained by a not-for-profit organization, its ongoing development occurs on the basis of an open decision-making procedure available to all interested parties, it has been published, it is made irrevocably available on a royalty-free basis, and there

[20] Richen, A. and Steinhorst, A. 2005. *Standardization or Harmonization? You need Both*. BPTrends, November 2005 Available digitally at: http://www.bptrends.com/bpt/wp-content/publicationfiles/11-05-ART-StandardizationorHarmonizationv-RickenSteinhorst.pdf; last accessed 13/10/2014

are no constraints on its re-use.[21]

Service delivery platform: Infrastructure suited to host one or more operating environments. (Source: the architecture principle task force)

[21] European Commission. 2004. European Interoperability Framework for Pan-European eGovernment services V 1.0. Page 9. Available digitally at http://ec.europa.eu/idabc/servlets/Docd552.pdf?id=19529; last accessed 15/10/2014.