Scotland's Digital Future: Scottish Public Sector Data Centre Virtualisation Guidance

Digital Scotland

The Scottish Government
Riaghaltas na h-Alba

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Introduction

Scotland's Digital Future: Delivery of Public Services set out an objective of developing a national strategy for the public sector's data storage focusing on consolidation and re-use. This reflected a recommendation of the Review of ICT Infrastructure in the Public Sector in Scotland report by John McClelland which suggested that significant efficiency and energy savings could be achieved through consolidation.

The Data Hosting and Data Centre Strategy for the Scottish Public Sector sets out how we will deliver on that overall objective and in particular how the public sector will adopt the following approaches for achieving significant efficiency and energy savings:

- cloud computing
- virtualisation
- co-location.

In assessing the current approach and environments for data hosting we found that organisations face many options in making arrangements for data hosting but:

- lack both an overall vision and information base for doing so, and
- need guidance on how the Scottish public sector can best utilise existing facilities for services that are not cloud ready e.g. legacy systems

The decision roadmap in the data hosting and data centre strategy sets out what organisations should consider in terms of new investment or change to the delivery or hosting of services. While externally hosted cloud computing is a priority option in the overall strategy, it may still be necessary in the short term for some organisations to manage their own data centres.

This document provides the guidance and principles for how Scotland's public sector can utilise virtualisation technologies.

Who is the guidance aimed at?

In line with the approach of and commitments in "Scotland's Digital Future: Delivery of Public Services", this guidance has been developed with and for the Scottish public sector and their partners to maximise the benefits of an aggregated approach to delivery. The sectors in scope are:

- Central Government including Police and Fire
- Local Authorities
- Health
- Further and Higher Education

The guidance will also be available to the third sector and in particular is appropriate where they are supporting the direct delivery of public services.

Wider strategic principles

- Cloud based solutions will be the dominant approach for the Scottish public sector
- The assessment criteria and guidance on the procurement and usage of cloud offerings will be adopted
- Utility and cloud computing is considered in assessing the appropriateness of current arrangements and future investment plans, and a shift to the cloud takes place when this is the most cost-effective option that delivers business requirements
- Internally hosted data centres should be virtualised where possible.

What is virtualisation?

Virtualisation can dramatically improve the efficiency and availability of ICT resources and applications in an organisation by moving away from a model of “one server, one application”. This enables underutilised resources to be dynamically applied to a number of machines.

Hardware virtualisation or platform virtualisation refers to the creation of a virtual machine (VM) that acts like a real computer with an operating system.

This is achieved by abstracting a physical server’s resources (CPU, Memory, Networking etc.) and presenting them to each virtual machine that is running on the physical host. By doing this, multiple virtual machines can share the same physical hardware but appear and run as separate servers in the organisation’s network.

These virtual machines are commonly known as guests, running on their parent hypervisor (the software or firmware that creates a virtual machine) host running Windows or Linux operating systems (dependent on Hypervisor).

Server virtualisation allows for a more efficient use of resources by removing multiple physical servers, for example Active Directory Domain Controllers and Exchange Servers which traditionally run on separate instances of Windows would not now require separate hardware platforms.

By removing the one to one relationship between a service or application and physical hardware a number of new possibilities are now available to an organisations environment. Services can now be moved as simply as moving a file from one location to another, disaster recovery in minutes rather than hours or days is now possible to achieve at a fraction of the cost it would have been with a physical environment.

To further enhance the basic advantages of less hardware and a flexible moveable virtual machine, virtualisation also brings other advantages for management. These

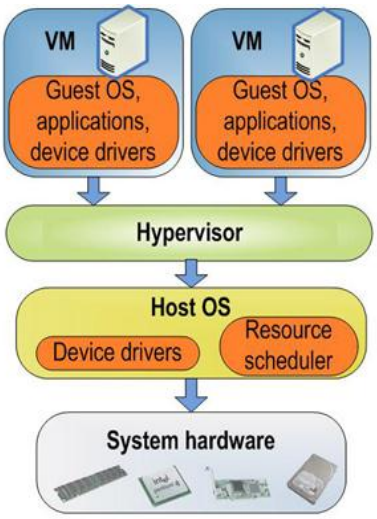
features vary dependent on which hypervisor has been used but features such as below are found in all the leading hypervisors:

- Ability to move virtual machines between hosts and storage whilst running.
- Ability to increase memory and CPU resources.
- Replication of entire virtual machine to another host either locally or remotely.
- High availability allowing for host failure
- Snapshots of running machines providing instant recovery
- Templates providing faster deployment of virtual servers.

These and more features are only possible because of the abstraction of the hardware and software layer that is provided in server Virtualisation.

How does server virtualisation work?

The **virtual machine (VM)** is a logical resource that defines a virtualised server, and includes all of the resources typically found in a server or desktop, such as RAM, a CPU, hard disks and network cards. Where the VM differs from a physical system, however, is that it exists as nothing more than a collection of files



The words host and guest are used to distinguish the software that runs on the physical machine from the software that runs on the virtual machine. The software or firmware that creates a virtual machine on the host hardware is called a **hypervisor** or Virtual Machine Manager.

In hardware or server virtualisation, the **host** machine is the actual machine where its **hardware** is used and on which the virtualisation takes place.

Types of virtualisation

The guidance in this document looks specifically at server virtualisation but for information other technologies in ICT from network virtualisation to storage virtualisation can be done. For information these can be summarised as below:

Virtualisation type	Description
Server Virtualisation.	You can use a single or multiple physical servers to host a large number of virtual machine servers running a hypervisor operating system. VMware vSphere and Microsoft Hyper-V are the leading hypervisors at present.
Desktop Virtualisation.	This is split in to client side (running on a desktop) and Virtual desktop infrastructure (VDI) where clients operating systems are ran on a server Virtualisation host. Citrix Xen Desktop and VMware Horizon View are examples.
User state Virtualisation.	This is where settings for applications and operating systems are centralised allowing users to logon to any device while retaining their settings. Roaming profiles and persona management products are examples of this type of Virtualisation.
Presentation Virtualisation.	More commonly known as Terminal services allows desktops and applications to run on a server and be displayed to a number of sessions on remote clients. Microsoft Remote Desktop Services and Citrix Xen App are examples.
Application Virtualisation.	Virtualises applications to allow them to be ran in or streamed to containers on the host operating system. App-V from Microsoft and Thin App from VMware are examples.

Virtualisation roadmap to the cloud

Deploying virtualisation technologies could be an organisations first step in preparing to move into cloud computing. With that end goal in mind, following the steps below will give organisations more flexibility in choosing how to host their services and infrastructure in the future.

Initiation: The first step should be defining your goals, and producing detailed requirements that outline exactly what you need. This includes an inventory and description of your current environment. This will help you figure out what your potential virtualisation use cases might be.

Plan & Design: This phase plans and designs how the server would be configured. If you're consolidating workloads, you need to also consider the network and storage needs for your virtual machines. Remember that you're going to be combining not only the memory and CPU requirements for each virtual server, but also the network and storage requirements.

If you're going to be consolidating existing workloads, you need to start getting baselines of those workloads if you don't already have them. At least 30 days if possible, and running at peak demand. Then start sketching out the hardware that you'll need, the storage requirements, management requirements and the possible solutions.

Build: This phase configures the virtual machine. Thus, the question that should be asked is as follows: How do I implement server virtualization to accomplish the goals?

Manage : It's easy to deploy new virtual machines and workloads, which means it's tempting to just fire up another virtual machine without necessarily considering all options. The machines may not require physical hardware, but they still need to be managed. Organisations should still follow policies for acquiring new "servers" and not change their strategies because it's suddenly easier to deploy new servers.

Migrate to cloud: once the data is decoupled from the hardware the move to the cloud becomes easier, organisations should now start considering organisational risks and look at assessing cloud computing as an option.

Virtualisation considerations

What and when to virtualise a service or application is not a simple answer and will depend as much on the environment it is being used in as the service itself.

A good example of this is SQL which VMware have advised on being virtualised for a number of years and although Microsoft supports SQL in a virtual environment they are considerably more caution when it comes to actually recommending it be virtualised.

The table below gives some advice on what should be virtualised on your journey through virtualisation on the way to the “Cloud”.

Ease of Virtualisation		
Easy	**Will require additional work**	**Stay Physical for now at least**
DNS	Exchange	Oracle (3)
DHCP	SQL (2)	Backup Media servers
Active Directory Domain server (1)	Servers in DMZ (5)	Servers with dongles
Management server (e.g. System Centre)	Legacy App servers	Dynamics
Monitoring servers		IBM software Applications (4)
Cisco management servers		Any servers not running X86 chipset will require specialist hypervisor
Web Servers		Video streaming
File and print services		

NB This list is by no means exhaustive and individual requirements maybe different

1. Active Directory servers can and should be virtualised, with the caveat of leaving one physical or at a minimum two DC's on different hosts. Microsoft Hyper-V actually provides a method of cloning DC's
2. SQL Will depend on size and profile of databases
3. Oracle can cost more unless virtualised on Oracle VM
4. IBM. A number of IBM back office products have a licensing model tied to physical CPU's and may be cost prohibitive when moving to a virtual environment
5. DMZ servers can be placed on hosts that also reside in the core network but use separate physical network connection. More of a concern is certain security models and certifications require total physical separation meaning dedicated hosts may be required in the DMZ.

Benefits of virtualisation

Virtualisation can centralise administrative tasks while improving scalability and overall hardware-resource utilisation. With virtualisation, several operating systems can be run in parallel on a single central processing unit (CPU). Using virtualisation, an organisation can better manage updates and rapid changes to the operating system and applications without disrupting the user.

For example an organisation running standard server applications Exchange, File and Print, DNS and Active Directory etc. on 20 physical servers would normally find this can be reduced to 3 virtualisation hosts with maybe 1 or 2 servers remaining physical, this would deliver a 75% reduction in hardware and an associated saving on power, cooling costs and management costs.

- **Supports Greener ICT**

Migrating physical servers over to virtual machines and consolidating them onto far fewer physical servers means lowering monthly power and cooling costs in the data centre. That means far fewer servers, less networking gear, a reduced number of racks needed, all of which translates into less data centre floor space required and a positive impact on Green ICT.

- **Faster server provisioning**

Server virtualisation supports deploying new services as well as scaling those that already exist because of virtualisation's intrinsic ability to rapidly deploy configurations across devices and environments.

- **Operational expenditure savings**

Once servers are virtualised, organisations can greatly reduce the ongoing administration and management of manual, time-consuming processes by automating operations, thus resulting in lower operational expenses.

- **Improved disaster recovery and increased uptime**

In the event that a server fails, an administrator can move a virtual server from one physical host server to another physical host server in minutes without interruption in availability of the virtual machine at that time.

- **Assists moving to cloud computing**

Virtualising your servers and abstracting away the underlying hardware is the same architecture that clouds are built on. Your data can then be moved more seamlessly into other environments.

Licensing and software implications when virtualising

Licensing is an issue for server virtualisation, looking at the 2 dominant hypervisors at present **vSphere** from VMware and **Hyper-V** from Microsoft they are licensed very differently.

VMware vSphere is licensed in a per CPU socket method, meaning that for every physical CPU in a host, a license must be purchased. An unlimited number of VM's are then allowed on that host. vSphere comes in a number of different versions, as far as licensing is concerned each containing more advanced features as the cost increases, with vSphere Enterprise plus being the current highest. In addition if you run Microsoft VM's you will also need MS datacentre licenses for each vSphere host.

Microsoft Hyper-V method of licensing is based on the edition of Windows server you are running, if you are running Standard edition, one VM may be created per host, after this, all additional VM's need to be licensed on an individual guest basis. If you have the Data Centre edition of server W2012 R2 then there is no limit on the number of VM's allowed on that host.

As with other products and applications various enterprise agreements and bundles do exist for both products and vary in price.

It is worth bearing in mind that although VMware Enterprise agreements will almost always work out beneficially, Microsoft ones depend on the amount and type of licences required. A typical Windows Data Centre license can host unlimited VM's, and with the advance in server and CPU technology this would mean all but the largest deployments will only need a handful of these. Although additional System Centre with VMM (Virtual Machine Manager) licenses are required to gain the most from a Hyper-V environment. A Microsoft Enterprise agreement should be looked at with a view to the entire organisation and not just server virtualisation and take into account desktop and office licenses too.

For Linux only, or very heavily biased organisations it may well be worth considering **KVM** the leading Linux server virtualisation product, although this does have support for Windows VM's it is some way behind Microsoft and VMware in this area.

Summary of pros and cons of server virtualisation

Server virtualisation has been one of the major trends in IT for the last decade and with somewhere between 50-65 % (figures vary) of X86 servers now virtualised across the globe it has proven itself a reliable and popular extension if not full replacement for X86 native hardware.

Server virtualisation should save you money but to answer the question of how much is not so simple it really depends on the number of servers you have and what resources they require. A number of tools exist to assess the current environment and to help gain more insight into how your virtual server environment might look.

From Microsoft there is Microsoft Planning and Assessment Tool Kit (MAP) which is free and client installable and from VMware there is Capacity Planner a partner installable tool, 3rd party tools also exist.

Apart from the obvious cost saving of having fewer servers taking up less space and less power, the benefits of easier and faster backups and disaster recovery as well as lower management and time to deliver a server/service need to be taken into account as these will have a longer term effect rather than just reducing the server numbers.

Not all applications/operating systems with license/support agreements permit virtualisation, in all instances you should check the license and support contract for anything before you virtualise it. You may find that you can't do that per the agreement.

Annex 1 – case studies

National Libraries of Scotland

In 2007 NLS purchased two 100TB Hitachi AMS1000 Storage Area Networks as part a project plan to ingest digital objects.

A pilot was set up to investigate the world of virtualisation by re-purposing two Dell 2950 servers to form a cluster running VMware Enterprise 3.5 utilising the new SAN as shared storage. Following a successful pilot a small number of general purpose servers were run from this platform.

VMware was not fully adopted in the Library until the original two Dell servers were replaced and relocated to our DR site running the VMware Site Recovery Manager solution with four powerful HP DL380 servers taking their place. And with upgrades to our tape library system the transition was made. All new server applications were deployed from VMware and a programme was embarked up to transfer the physical server estate into VMware accomplished without issue with minimal server downtime.

Today NLS have VMware ESXi host servers running over 150 virtual servers split into three clusters, Production, Disaster Recovery/Test Network and the NLS Digital Library System Node for the British Library each on their own SAN system. All manageable from a single location with the capability of failing over the most business critical elements to another building within an hour should disaster strike. All with the day to day benefits of manageability, responsiveness and reliability expected of IT systems today.

To sum up, the NLS production environment, excluding their DR, test/development and British Library environment, run ninety virtual machines [not including appliances that run VMware] on seven VMware ESXi physical hosts. With the capacity to run twenty virtual servers per host they can easily accommodate both their own and shared services partner's future growth. With the cost of a general purpose server for one application at around £3k vs. a server designed for our VMware implementation costing £13,500 this results in significant cost savings. Even factoring the cost of other equipment e.g. a SAN, the latest purchase was £42000 the virtual solution is vastly cheaper.

University of St. Andrews

The University of St Andrews underwent a data centre initiative to replace ageing legacy facilities with an efficient, reliable and scalable facility that would support its dedication to academic excellence for more than 8,000 students in around 160 buildings and with over 2,100 staff. At the time the University had 50 campus locations for servers with no fit for purpose server rooms.

A working party of internal stakeholders and external consulting engineers produced a business case for the construction of primary and secondary data centres in order to underpin reliable service delivery. At every stage of the process, energy efficiency was pushed and design decisions taken to minimize overall power consumption. Key parts of the design philosophy are free cooling, fully enclosed hot and cold air paths & ability to reuse the waste heat generated by the computing facility. The facility has a design for a full-load annualised PUE of 1.2. From an infrastructure perspective, the high efficiency of operation is underpinned by extensive telemetry of the datacentre, allowing optimisation of the equipment.

Running parallel with the population of the data centre, a path of increased virtualisation and use of shared and managed services to reduce the footprint was undertaken, with great success. The project delivered all the expected benefits and will deliver calculated savings against sector average of £1.4m over 10 years, a reduction of 6.8m kg CO2 emissions and is a stepping stone to the University's aspiration to Carbon Neutrality for Power.

Further improvement works are earmarked to optimise the PUE for part-load operations and reduce annual operating costs by a further £10K. The data centre has been awarded the BCS CEEDA Gold award.

Annex 2 – glossary

SaaS	Software as a Service
PaaS	Platform as a Service
IaaS	Infrastructure as a Service
PIA	Privacy Impact Assessment
ICT	Information and Communication Technology
NIST	National Institute of standards and technology
SLA	Service Level Agreement
DPS	Digital Public Services
BIL	Business Impact Level
ISO	International Organisation for Standardisation
Hypervisor	computer software, firmware or hardware that creates and runs virtual machines.

Annex 3 – related reading

Policy documents

- John McClelland's Review of ICT Infrastructure in the Public Sector in Scotland - published June 2011
- Scotland's Digital Future - Delivery of Public Services – published Sept. 2012
- Scottish public sector High Level Operating Framework (HLOF) – published June 2013
- Scotland's Digital Future: Data Hosting and Data Centre Strategy for the Scottish Public Sector – Published Apr. 2014
- Scotland's Digital Future: Scottish Public Sector Cloud Computing Guidance – published Aug. 2014

Technical documents

- Payment Cards Industry Data Security Standards Virtualization Guidelines – published June 2011

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