CitiPower / Powercor

Review of AMI IT Infrastructure Programme

11 February 2011

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11 February 2011

Our Ref: FS

Dear Renate

Re: Assistance with CitiPower and Powercor AMI Budget Application 2012-2015

Please find attached Deloitte's commentary and analysis of the CitiPower/Powercor AMI IT infrastructure environment and programme through to 2015.

Please contact myself on 0413 982208 if you have any questions regarding this document.

Yours sincerely

Franco Santucci
Partner

Enc: Review of AMI IT Infrastructure Programme

cc: Brent Cleeve, Paul Liggins

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1 Executive summary

Purpose

Deloitte has reviewed CitiPower and Powercor's AMI IT infrastructure programme to specifically comment on the extent of virtualisation and agility that will be delivered by the programme, and the level of virtualisation and agility in the current AMI IT environment. The scope of this review is the current AMI IT infrastructure environment and the CY2012-2015 AMI IT infrastructure programme.

The issue of virtualisation and agility in DNSP's IT environments has arisen as a result of the AER's draft decision on 2011-2014 distribution prices. In the draft decision the AER rejected a large proportion of distributors' proposed IT capex on the basis of advice from the AER's advisors, Nuttall Consulting. Nuttall had concerns around flexibility and agility and in particular the lack of use of 'cloud computing'.

CitiPower / Powercor (CP/PAL) AMI programme

The CP/PAL AMI programme is currently rolling out 1.2M smart meters across Victoria from 2010 – 2013. The roll out and subsequent operation of smart meters requires new and modified applications and IT infrastructure to manage exponentially greater volumes of data generated by the meters, and also support the provision of services associated with the AMI meters.

CP/PAL embarked on its AMI IT programme in 2006 to develop the IT capability to support the roll out and operation of its smart meters. The programme has upgraded existing application and infrastructure capabilities, and also implemented new capabilities. The remaining programme focuses on enhancing capabilities of the current environment as well as scaling it to accommodate the needs of the remaining roll out of AMI meters.

Key findings

Following our review of AMI IT programme documentation and interviews with personnel from the AMI programme, CHED Services, and relevant third party suppliers (CSC), the current AMI IT infrastructure environment has an appropriate level of virtualisation and agility to accommodate current and future requirements[1] of the AMI programme.

- 66% of AMI servers are virtualised using VMware and Sun Containers for software virtualisation. (69% of the non-AMI servers are virtualised).
- Hardware virtualisation is achieved with HP C-Class Chassis and Blade Server technology utilising HP Virtual Connect functionality.
- There is 610TB[2] of storage capacity on the Hitachi Data Systems (HDS) AMS2500 which is virtualised through the use of the HDS 9900V.
- A total of approximately 1.1PB[3] of possible storage capacity (from the AMS2500 and HDS990V) is currently available compared to a forecasted total capacity demand of 628TB[4] required by the end of 2015 – representing a 57% utilisation of storage forecast to be utilised at the end of 2015.

[1] Requirements, including storage capacity, have been reviewed through to 2015 – the last year of the programme. Demand for additional storage capacity is anticipated to continue growing until 2017.
[2] Assumes the AMS2500 is populated with 50% SATA and 50% SAS disks – which would represent a typical configuration.
[3] This capacity estimate is based on the assumption that the AMS 2500 will use 50% SATA disks and 50% SAS disks when fully populated – this would provide a total capacity of ~610TB, while the 9900V will use 100% fibre channel disks when fully populated – providing ~507TB. Maximum capacity sourced from *PAL AMI Hardware Capacity.xls* 25 January 2011, supplied by CSC.
[4] Estimated using 1) *AMI Storage Calculations v1.3.xlsx*, Deloitte January 2011 – the total forecast demand for additional storage capacity between 2011 and 2015 (556TB), and 2) CP/PAL data that ~72TB of storage is utilised for AMI data today.

- The degree of agility provided today could only have been achieved practically with the use of modern virtualisation technologies.
- The hardware architecture is scalable and is designed for high availability and flexibility to meet AMI service levels and other business requirements.

The maturity of current cloud computing offerings and the specific requirements of utility software environments mean that CP/PAL should further explore opportunities to increase agility in the AMI IT infrastructure environment but take a measured approach to adopting cloud offerings where appropriate.

Conclusion

The CP/PAL AMI IT infrastructure environment represents a good example of the implementation of new and upgraded hardware capabilities that have adequately supported AMI IT application requirements to date – this has been achieved by managing forecasted demand and also unexpected requirements that have arisen from the use of new hardware and software selected to accommodate the functional requirements of the AMI programme. It is consistent with that which a reasonable distribution business would exercise.

CP/PAL have worked closely with vendors to manage change and respond to defects and issues, and have adjusted the AMI IT programme to accommodate changing requirements. The level of virtualisation and agility in the IT environment has allowed CP/PAL to be able to do this. In our view, the combination of hardware architecture, platform technology selection, and AMI IT programme management have provided CP/PAL with an agile IT infrastructure environment that will accommodate increased demands generated by the remaining meter roll out through to 2013 and the forecast growth in data through to 2015.

2 Introduction

2.1 Scope of work

CitiPower and Powercor have asked Deloitte to review its AMI IT infrastructure programme and to specifically comment on the extent of virtualisation and agility that will be delivered by the programme, and the ability to support the requirements in the context of the regulatory framework.

The purpose of the review is to understand the ability of the IT infrastructure programme to support the remaining roll out of smart meters under the AMI programme, including the level of virtualisation and agility that has been achieved to date. The scope of this review is the current AMI IT infrastructure environment and the CY2012-2015 AMI IT infrastructure programme.

2.2 Background

The issue of virtualisation and agility in DNSP's IT environments has arisen as a result of the AER's draft decision on 2011-2014 distribution prices. In the draft decision the AER rejected a large proportion of distributors' proposed IT capex on the basis of advice from the AER's advisors, Nuttall Consulting. Nuttall had concerns around flexibility and agility and in particular the lack of use of 'cloud computing':

> *Given that historical capita spend has not matched the DNSP forecasts, we believe that all the DNSPs have IT infrastructures that are too static and not sufficiently agile. Whilst the individual projects proposed by the DNSPs may be justified as being prudent and efficient, the historical inability to deliver them indicates that the projects are hampered by the lack of flexibility of the underlying IT infrastructure. Examples include; a lack of computer power, space, cooling, data centre and storage capacity. Resolving these issues, either becomes increasingly complex, too expensive (because it is no longer prudent) or too disruptive to continue and thus the project ends up being deferred or abandoned.*
>
> *Whilst the DNSPs have provided numerous reasons for the deferment of individual projects, we believe that a fundamental and common issue is lack of "agility" in their IT infrastructure. This is evident with the large increase in the number of data centres. These data centres require large capital expenditures to design and build. Most DNSPs are intending to consolidate their data centres, which is also a large and costly undertaking, unless an agile IT infrastructure has been put in place.*
>
> *If the DNSPs are permitted to continue to operate in a "non-agile" way then DNSPs will be able to claim large scale expenditure for the next round of upgrades in the following regulatory period (2015-2020) and beyond. The DNSPs should be encouraged to adopt a flexible Computer and Storage platform, on which applications (databases, CIS, etc) can be added independent of the underlying Compute and Storage platform. This approach is referred to as IaaS ("Infrastructure as a Service") delivery.*

In relation to CitiPower, Nuttall noted that:

> *In our opinion, CitiPower has not fully considered the complexity of the totality of works that they are contemplating and the amount of change they can absorb, given the lack of agility in the IT environment.*

Similar comments were made for Powercor.

In a subsequent report to the AER following the draft decision, Nuttall provided more detail around the issues of agility, flexibility and virtualisation. Amongst other things Nuttall was concerned that the utilities were unable to articulate the rationale behind their various levels of virtualisation.

Ultimately, the AER did not accept Nuttall's recommendations, citing advice from Deloitte that the distributors had an appropriate level of agility. However it is possible the AER will consider the level of agility, flexibility and virtualisation when reviewing the upcoming budget submission. Presumably, if the AER was not satisfied with the level of agility, flexibility and virtualisation adopted by the distributors it could take the view that this represented a substantial departure from the commercial standard that a reasonable business would exercise in the circumstances.

This report therefore focuses on whether the level of agility, flexibility and virtualisation employed by CP/PAL in respect of their AMI project is either (a) consistent with that which a reasonable (distribution) business would exercise in the circumstances, or (b) a substantial departure from what a reasonable (distribution) business would be expected to do.

In order to comment on agility, flexibility and virtualisation we have considered a number of aspects of existing AMI IT capabilities including technology architectures and platform selection, as well as the broader aspects of the AMI IT programme.

3 AMI IT programme overview

The CP/PAL AMI programme is currently rolling out 1.2M smart meters across Victoria from 2010 – 2013. The roll out and subsequent operation of smart meters requires new and modified applications and IT infrastructure to manage exponentially greater volumes of data generated by the meters, and also support the provision of services associated with the AMI meters.

CP/PAL embarked on its AMI IT programme in 2006 to develop the IT capability to support the roll out and operation of its smart meters. This programme has implemented a number of applications some of which use new software from vendors (e.g. Itron's IEE software for meter data management). The programme has also implemented new capabilities into the application environment, in particular the Universal Services Bus (USB) using Oracle's Fusion software.

In order to develop, test and operate these applications CP/PAL approved a programme of work in 2008 to ensure there was sufficient capacity in the current IT infrastructure environment (AMI IT Infrastructure Programme). In addition, the pace of change in the CP/PAL development and test environments was relatively high given the iterative cycle of releases adopted by particular software vendors to address defects. This impacted the capacity of the development and test environments, which had to scale to accommodate multiple development and test cycles, and store various sets of data for testing.

The programme also provided new capabilities in the IT infrastructure environment to support AMI requirements, particularly in relation to service level availability. Specific infrastructure projects in the programme have delivered capabilities in the development, test, production and disaster recovery environments, as well as providing capacity for data conversion and future metre growth.

It should be noted that additional complexity was introduced into the management of the environment and overall AMI IT infrastructure programme as a result of vendors' acquisitions and product strategy decisions during the last few years. Most notably Oracle acquired Sun, and Sun no longer offered Hitachi Data Systems (HDS) products to its customers. The impact on CP/PAL was the need to renegotiate its maintenance contract for its storage platforms.

The capacity of the Market street computer room was also increased to accommodate the demands that new AMI IT infrastructure would create. A third party review and subsequent upgrade project were conducted in 2007 and 2008 respectively to increase physical floor space, rack space and power and cooling capacity.

The AMI IT programme will continue until the end of 2015. The remaining programme will enhance the capabilities of the AMI IT environment that exist today. Enhancements include establishing greater analytics capabilities, broadening the scope of the mobility and USB applications and scaling application and hardware platforms to support the increased demands created by the roll out of remaining meters.

IT infrastructure projects will deploy additional hardware devices such as blade chassis', storage disks, server management licenses, and network devices to scale the environment. IT infrastructure projects will also refresh (upgrade) existing devices that will approach end of life during the 2012-2015 period.

4 Technical assessment

4.1 Key findings

The AMI IT infrastructure has an appropriate degree of virtualisation and agility that accommodates today's requirements and also establishes a platform for growth as the meter roll out occurs over the next three years. Following a review of AMI IT documentation and data, and interviews with CP/PAL and third party IT personnel, in our view the AMI IT infrastructure environment has sufficient agility to accommodate the increased demand that the meter roll out will place on the environment. Specifically:

Virtualisation

- The AMI IT programme has extended the use of virtualisation from the non-AMI IT environment with server and storage virtualisation.
- Hardware and software virtualisation has been adopted by CP/PAL in a hybrid virtualisation model.
- 66% of AMI servers are virtualised using VMware and Sun Containers for software virtualisation. (69% of the non-AMI servers are virtualised).
- Hardware virtualisation is achieved with HP C-Class Chassis and Blade Server technology utilising HP Virtual Connect functionality.
- There is 610TB[5] of storage capacity on the HDS AMS2500 – contributing to storage virtualisation in conjunction with the HDS 9900V.

Agility

- The degree of agility provided today could only have been achieved practically with the use of modern virtualisation technologies.
- The hardware architecture is scalable and is designed for high availability and flexibility to meet AMI service levels and other business requirements.
- Based on the projected growth in data volumes (556TB[6]) (generated by the remaining meter roll out, AMI meter activity, and data archiving obligations[7]) and the additional capacity to be delivered by the AMI IT infrastructure programme to accommodate this growth (591TB[8]), the IT infrastructure is expected to have the *storage capacity* to accommodate data volumes until the end of 2015[9].
- The *processing capacity* of the servers can be scaled by adding components such as CPU cores, system boards, blade servers and memory to existing server infrastructure – in order to accommodate the growing demand that the meter roll out will place on the environment. *It should be noted that the increase in demand for extra processing capacity generated by an increase in meter data was not assessed during the development of this report*[10].

[5] Assumes the AMS2500 is populated with 50% SATA and 50% SAS disks – which would represent a typical configuration.
[6] *AMI Storage Calculations v1.3.xlsx*, Deloitte January 2011
[7] CP/PAL is obligated to archive data for seven years.
[8] *AMI Storage Calculations v1.3.xlsx*, Deloitte January 2011
[9] The data volumes are expected to peak in 2017 – the scope of this review is the current IT infrastructure programme which is scheduled to finish at the end of 2015.
[10] In order to reasonably assess server processing demand and capacity, vendor forecasts of processing power based on increased demand are required. Vendor forecasts are only available incrementally following each stage of the meter roll out.

4.2 Virtualisation

Virtualisation is a broad term that refers to the abstraction of a pool of data centre or infrastructure resources, enabling a single resource, either physical or logical appear to function as multiple logical resources.

Alternatively it can mask the complexity of a group of logical or physical resources to appear as a single logical resource. Although virtualisation is typically thought of only in terms of operating system instances, it can also be applied to physical servers, storage, networks and applications[11].

4.2.1 Servers

66% of CP/PAL's servers in its AMI IT infrastructure environment are virtualised[12], compared to 69% of servers in its non AMI environment. This is typical of the level of virtualisation we have observed at other Victorian DNSPs.

Specific server software virtualisation technologies utilised by CP/PAL are:

- VMware[13] for its Wintel and Linux servers.
- Solaris Containers[14] (which is Sun's operating system level virtualisation technology) on its Sun M5000 server (for development and test) and the Sun M9000 server (for production).

These technologies allow multiple environments to co-exist, reduce the amount of physical hardware required, and enable rapid deployment of new hardware equipment with minimum impact to operations.

The hybrid virtualisation model employed by CP/PAL provides the benefits of physical and virtual technologies – and minimises the limitations that are inherent in each. For example a completely physical environment would lead to higher hardware capital and operating costs due to the need to procure equipment each time new requirements arise or extra capacity is required. It would also take longer to deploy the new hardware due to the procurement process.

The downside of a completely virtual environment is the negative impact on support from software vendors that do not certify their product to operate on certain virtual platforms (e.g. Oracle 10g and 11g running on VMware), in addition to potential performance constraints[15].

CP/PAL have employed the hybrid model to virtualise where possible, and where performance requirements are not compromised. Therefore, the core AMI IT applications are running on virtual servers[16] except for:

- Silver Springs Network Management System (NMS) due to lack of vendor support for VMware.
- Oracle 10g and 11g databases which support the Universal Services Bus (USB) – the Oracle databases are currently not vendor certified to run on VMware[17].
- The Oracle USB application which requires real-time processing – a dedicated physical server is better suited to this application to support this performance requirement[18].

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[11] *Virtualization: The Reality of Virtualization*, Deloitte 2008
[12] *Powercor Environment Statistics.xlsx*, CSC January 2011
[13] *Clayton DRS and HA Design release 1.0* CHED Services, 21 October 2010
[14] *Infrastructure Technical Specifications (Development M5000 Servers) v1.6*, CHED Services, 7 December 2010
[15] It should also be noted that a 100% virtualised environment is not physically possible due to the need for physical servers onto which virtual servers are deployed.
[16] *Powercor Environment Statistics.xlsx*, CSC January 2011
[17] Source: *http://www.oracle.com/technetwork/middleware/ias/oracleas-supported-virtualization-089265.html*, viewed 31 January 2011
[18] While the 10g and 11g production databases and USB production application are deployed on physical machines, virtual machines are used for the 10g, 11g and the USB application for the development, test and DR environments.

In our view, CP/PAL have used server virtualisation technologies where appropriate to benefit from the advantages of the technologies, while accommodating the performance requirements demanded by the business and AMI service level objectives[19], and working within the constraints imposed by vendor support agreements. The advantages offered by the virtualisation technologies are discussed further in section 4.3 'Agility'.

Opportunities for further virtualisation may be realised by collaborating with software vendors, including VMware, to support efforts to certify application software that is not currently supported on VMware.

4.2.2 Storage

Storage is also virtualised in the AMI IT infrastructure environment using the Hitachi Data Systems (HDS) Lightning 9900V Universal Storage Platform (USP)[20]. The HDS 9900V has a 'controller' that consolidates storage from heterogeneous, physical storage devices, and routes data to the appropriate device.

In the CP/PAL environment, the controller consolidates storage capacity from the HDS 9900V device itself and also the HDS Adaptable Modular Storage (AMS) 2500 device. The AMS 2500 is a lower cost storage solution – it is used for development and test environments. The HDS 9900V is a more expensive storage solution with faster performance, and is used for production and disaster recovery data. Together the 9900V and AMS 2500 devices have a maximum capacity of approximately 1.1PB[21].

With the current number of AMI meters rolled out today (~250,000) 72TB of storage is utilised. Based on the CP/PAL forecast growth in storage demand, an additional 556TB of storage is expected to be utilised by 2015[22]. This growth in storage capacity demanded by the applications, and the capacity supplied by the AMI IT infrastructure programme is illustrated in *Figure 1*.

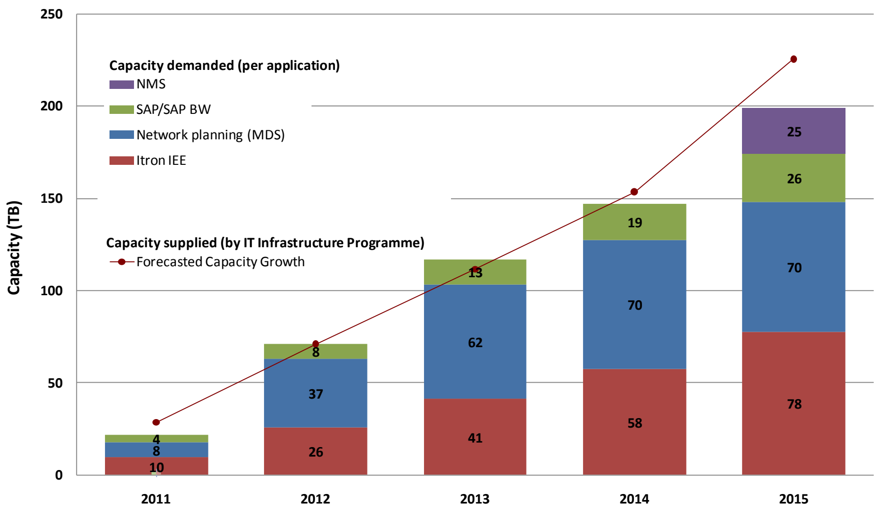

Figure 1: Additional storage capacity supply and demand[23]

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[19] *Minimum AMI Service Levels Specification (Victoria) Release 1.1* Department of Primary Industries, September 2008 http://new.dpi.vic.gov.au/energy/projects-research-development/smart-meters/service-levels viewed January 2011

[20] The HDS 9900V USP was procured from Sun (rebadged as the Sun StorageTek 9900V). As Sun no longer provides this product the maintenance contract has been transferred from Sun to HDS.

[21] This capacity estimate is based on the assumption that the AMS 2500 will use 50% SATA disks and 50% SAS disks when fully populated – this would provide a total capacity of ~610TB, while the 9900V will use 100% fibre channel disks when fully populated – providing ~507TB. Maximum capacity sourced from *PAL AMI Hardware Capacity.xls* 25 January 2011, supplied by CSC.

[22] *AMI Storage Calculations v1.3.xlsx*, Deloitte January 2011

[23] AMI applications represented on this graph are only those which are forecast to require greater storage as more AMI meters are rolled out. Capacity represents *additional storage* capacity required in addition to today's current storage utilisation – and does not represent *total storage* required.

The HDS Tiered Storage Manager (TSM) was implemented in late 2010[24] and is used to migrate data between different tiers of heterogeneous storage. The TSM makes it easier to migrate volumes[25] between storage devices (9900V and AMS2500) – CP/PAL can realise the benefits of virtualised storage by using the TSM to migrate volumes between the different tiers of storage to meet the AMI programme requirements. (e.g. storing application code on a lower tier, or relocating applications to a higher grade tier for performance).

The TSM and the virtualised storage environment provide a degree of agility and therefore the ability to respond to new or changing requirements (Agility is discussed further in section 4.3.). Additional storage devices from other vendors, and disks can be added to the environment.

Based on the technical documentation provided by PAL and CP[26], and following a number of interviews with IT personnel, in our view the storage virtualisation technology is appropriately utilised across the AMI IT infrastructure environment. The virtualisation of the current storage technology adequately provides the ability for the server environment and AMI applications to access a shared pool of storage resources, and therefore accommodate changing storage requirements.

4.2.3 Summary

Benefits such as cost reduction, increased hardware resource utilisation, and ease of maintenance have driven CP/PAL to 'virtualise where possible' across AMI and non AMI IT environments. Sustainability objectives have also driven the adoption of virtualisation technologies to support a reduction in power consumption and carbon emissions[27].

In 2006 CP/PAL embarked on a journey to adopt virtualisation technology beginning with the adoption of virtual servers[28] in the non-AMI IT environment. The AMI IT Programme has continued to utilise virtualisation technologies for servers, and has also adopted virtualisation technology for storage.

CP/PAL have achieved virtualisation with a hybrid virtualisation model, utilising a combination of software and hardware virtualisation technologies across the AMI production, development, test and disaster recovery IT environments. Based on CP/PAL's specific requirements, the extent of virtualisation across the AMI IT infrastructure environment is reasonable.

4.3 Agility

Agility enables IT infrastructure to scale and grow to accommodate future business requirements in a manner which is relatively less disruptive and costly to the business. It enables an IT infrastructure environment, and therefore a business, to respond relatively quickly to new and changing requirements – and hence provides a degree of flexibility.

Agility is achieved through a combination of hardware architecture design, and platform technology selection decisions that collectively allow the IT infrastructure environment to be agile and respond to new requirements (particularly capacity and performance related requirements) with relatively low impact and low cost.

An agile environment achieves this by allowing additional components and devices to be added to the existing IT infrastructure environment as demand necessitates – for example, additional memory can be added to blade servers, and additional disks can be added to a storage shelf.

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[24] Confirmed during interview with CSC Architect, January 2011
[25] A volume is an allocation of space from a pool of disks.
[26] A full list of documentation reviewed for during the development of this report can be found in Appendix A.
[27] *CP/PAL IT Carbon Footprint Plan*, December 2008
[28] *CP/PAL IT Strategy 2006-2010*, 2005

4.3.1 Hardware architecture

Within the AMI IT infrastructure environment, the HP blade server (C class chassis) architecture, the Sun M5000[29] and M9000[30] server architectures, the storage architecture[31], and the LAN network architecture have been designed to scale and therefore provide a level of agility in the environment.

In addition these hardware architectures reduce single points of failure across the server, storage and network layers of the environment – this provides flexibility in the event of a disaster, and supports load balancing in the event that all or part of the environment unexpectedly fails. These characteristics also contribute to the degree of agility in the environment.

The HP blade servers provide hardware virtualisation for PAL and CP's Wintel and Linux servers. HP's Virtual Connect is a hardware module that works with the adapters within each blade server. The server environment uses Virtual Connect to reduce the number of physical network connections required for LAN and SAN connectivity. Multiple blade servers utilise the configuration of one Virtual Connect module and this increases the flexibility of the server environment by increasing the number of virtual networks (VLANs) available.

HP blade servers are deployed across two chassis'[32] and VMware logically clusters the blade servers across the chassis' – making them appear as a single, logical VMware cluster with CPU and memory resources. These resources are then made available to the virtual machines that have been created within the cluster. In addition CP/PAL have also created resource pools to ensure that the resources of each cluster are not oversubscribed. Figure 2 illustrates these concepts.

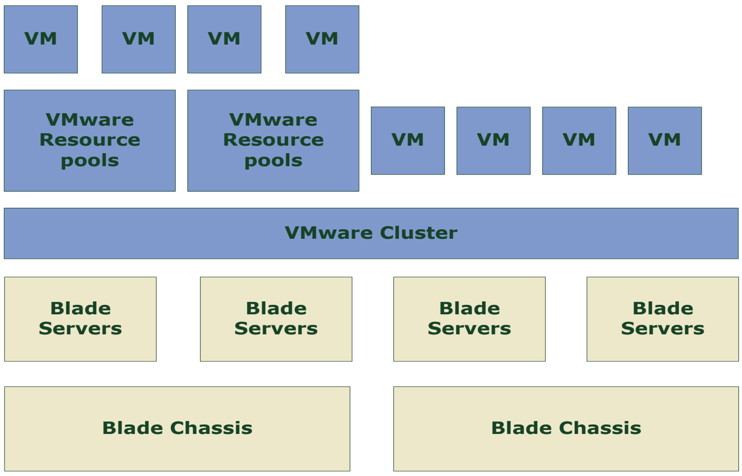

Figure 2: HP blade server and VMware conceptual illustration[33]

[29] *Infrastructure Technical Specification – Development M5000 Servers v1.6* CHED Services, 7 December 2010
[30] *Sun SPARC Enterprise M9000 Build Specification Document v1.4* Sun Microsystems, 27 November 2008
[31] The placement of the HDS AMS2500 behind the HDS Lightning 9900V USP was confirmed during interviews with the CSC AMI Architect in January 2011
[32] *Clayton DRS and HA Design release 1.0* CHED Services, 21 October 2010
[33] For the purposes of this report the VMware hypervisor and data centre layers have been omitted from this diagram – these layers illustrate the technical aspects of establishing the virtual server environment rather than the concepts discussed in section 4.2.2.

Five logical VMware clusters have been created to support the virtual environment. This architecture supports load balancing of virtual machines – which helps the environment to be agile and respond to increased processing demand. Load balancing is discussed further in section 4.3.2 'platform technology selection'.

The Sun server architecture supports agility in a similar way to the HP blade servers through the ability to add additional components such as CPU cores and system boards – this allows the processing power of the server[34] to be increased.

As discussed in section 4.2.2 the storage architecture allows additional disks and storage devices to be added – this capability provides a degree of agility to the storage architecture. Different types of disks with different performance and capacity capabilities also support the agility of the architecture. CP/PAL have incorporated four tiers of disk in their environment to distinguish between the different types of disks (Solid State, Fibre Channel, SAS, SATA).

The network architecture incorporates redundant devices such as firewalls, routers, load balancers and VPN concentrators which provide a higher level of service to the environment, maintaining service in the event that one device fails or a disaster occurs[35].

In our view when combined with platform technology selection that includes virtualisation, this hardware architecture spanning servers, storage and network components provides a level of agility in the AMI IT environment which is appropriate for the requirements of the programme.

4.3.2 Platform technology selection

The selection of platform technology also contributes to the agility of the IT infrastructure environment. Platform technology is largely applicable to the virtual server environment. As discussed in section 4.2.1 CP/PAL have selected VMware for Wintel and Linux server virtualisation, and Containers for Solaris server virtualisation.

Agility is achieved in the virtual server environment by using VMware's High Availability (HA) and Distributed Resource Scheduling (DRS) features[36]. When coupled with the VMware cluster architecture discussed in section 4.3.1, these features ensure that the VMware virtual machines are load balanced either across a cluster or a resource pool.

The HA feature protects against a physical VMware server failing in each cluster by reallocating the virtual machines to the next available physical VMware server in the cluster. DRS load balances the CPU and memory of each virtual machine and reallocates excess demand for resources to available physical servers within the cluster.

By dynamically applying CPU and memory in the cluster or resource pool to virtual machines as required, load balancing ensures resources are not over utilised. This therefore provides the environment with a degree of flexibility that allows it to quickly respond to changes in demand for processing capacity, with minimal impact to operations.

Agility is provided via live migration capabilities – vMotion is the technology used by VMware to provide live migration capabilities. vMotion is a mechanism used to move virtual machines between physical VMware servers allowing quick response to component failures or performance issues[37].

Solaris is inherently a flexible and agile platform. It allows multiple Containers within a single operating instance to run individual environments – this is effectively equivalent to running multiple virtual machines on a physical server. Additional Containers can be deployed when required and therefore providing a degree of flexibility.

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[34] Specifically the processing capacity of the system board is increased.
[35] *AMI NMS Logical Diagram v10.vsd*, CHED Services, 16 June 2009
[36] *Clayton DRS and HA Design release 1.0* CHED Services, 21 October 2010
[37] There is some variation in the degree of impact on the environment due to application specific characteristics.

Additional software that CP/PAL use to support agility in the environment are:

- VMware's Site Recovery Manager – ensures a standby environment is available for selected virtual machines, and can be utilised quickly in the event of a failure.
- HDS TrueCopy – replication software that allows data to be replicated between different environments (e.g. production and disaster recovery).
- Shadow Image – a third party product that allows a copy (clone) of an environment to be made. Agility provided by virtualisation is enhanced by cloning software (HDS Shadow Image) as it ensures new environments on virtual machines can be created quickly, or updated quickly.

In our view, CP/PAL have appropriately utilised platform technology to benefit from the advantages of virtualisation while also creating an infrastructure environment that has a good level of agility. The agility of the environment allows CP/PAL to adjust to new and changing requirements (e.g. modifications to development and testing cycles), scale the environment for longer term growth (e.g. from meter roll outs), and respond and recover to unanticipated events and disasters via redundancy that has been designed into the architecture, and is enhanced by the platform technology.

4.3.3 Data centres

In 2008 the Market street disaster recovery data centre was upgraded to accommodate the new IT infrastructure required to support the AMI applications. The upgrade addressed key issues identified in a review of the data centre that was conducted in 2007[38]. Upgrades were based on the recommendations from the review and included the data centre's floor and rack space, cabling, cooling and power[39]. The recommendations to upgrade the data centre were made based on a ten year life span and considered the demands created by IT infrastructure required to support CP/PAL's 1.2M AMI meters[40].

Taking into consideration 2011 plans to retire end of life equipment and unutilised rack space, the current utilisation of floor space at Market street is 74%.

The Clayton production data centre is operated by CSC. CP/PAL lease data centre floor space from CSC under the terms of their existing five year services contract. Under this contract CSC is obligated to provide adequate capacity to satisfy CP/PAL's requirements over this period. Renewal of the CSC contract is currently being negotiated by CHED Services – CSC has committed to providing adequate capacity to accommodate the increased demand at Clayton which will result from the support the remaining meter roll out.[41]

In our view CP/PAL have ensured that their production and disaster recovery data centres have sufficient capacity to accommodate the growth in IT infrastructure that the meter roll out will demand. This has been achieved via the planning and upgrade of the Market street site, and via commercial arrangements with CSC.

4.3.4 Cloud computing

Opportunities to achieve even greater agility in the environment are potentially available via cloud computing offerings. However the adoption of cloud requires careful consideration of data controls and ownership, back-up, retention and disposal, availability and reliability, disaster recovery, legal compliance, assurance, scalability, security and encryption, auditing and monitoring, and tax implications[42].

[38] *Comms Room Overview and Scope of Works,* Voss Group Consulting Engineers, 11 October 2007
[39] *PAL Market Street Computer Proposal Report Draft 2.0*, CSC, 20 January 2008
[40] Confirmed by CHED Services IT Infrastructure Manager, January 2011
[41] Confirmed by CHED Services IT Infrastructure Manager, January 2011
[42] *Cloud Computing: Considerations on the Road to Adoption,* Deloitte, April 2009

Prior to adoption of cloud computing these considerations must be analysed and assessed to avoid overspending on cloud computing initiatives and exposure to unnecessary operational and reputational risk.

For most enterprises, the pace of cloud computing adoption will map to the maturity of the cloud services on offer. The rate of adoption of cloud computing is tied to the levels of technical and functional maturity of the cloud offering, and the suitability to enterprise-class levels of performance, reliability, and resiliency.

Cloud computing is currently limited to commodity services that do not offer compelling value to utilities. Gartner surveys[43] indicate that utility software environments require heavy customisation to meet business requirements. Deloitte has previously recommended that organisations take on targeted pilot projects for specific services, and adopt a measured approach for adoption of cloud computing services[44].

Given this, CP/PAL should take a measured approach to assessing, trialling and implementing cloud computing offerings that may assist in creating further agility or enhancing AMI IT capabilities in the future.

4.3.5 Summary

CP/PAL's AMI IT infrastructure environment has multiple points of agility allowing it to scale vertically and horizontally. The use of software virtualisation technologies (VMware and Solaris) provides the ability to scale horizontally. The modular hardware architecture provides the capability to add components into existing infrastructure as required and therefore scale vertically.

In our view the environment has sufficient agility to accommodate the increased demand that the meter roll out will place on the environment. Based on a review of CP/PAL data and documentation, and interviews with IT personnel, the AMI IT Infrastructure Programme is expected to deploy sufficient storage capacity to accommodate increased data volumes. The modular architecture allows the processing capacity of the server environment to scale to respond to demand for greater processing power.

[43] Market Trends: Software Technology for the Utilities Industry, Worldwide, 2009, *Gartner Research*, 1 December 2009
[44] Cloud Computing: Considerations on the Road to Adoption, *Deloitte*¸ April 2009

General use restriction

This Report was prepared for CitiPower / Powercor for the purpose of assessing the level of virtualisation and agility in the AMI IT environment. In preparing this Report we have relied on the accuracy and completeness of the information provided to us by CitiPower / Powercor and from publicly available sources. We have not audited or otherwise verified the accuracy or completeness of the information. We have not contemplated the requirements or circumstances of anyone other than CitiPower / Powercor.

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Events may have occurred since we prepared this Report which may impact on it and its conclusions. We understand our report may be provided to the AER, however, we do not accept or assume any responsibility to anyone other than CitiPower / Powercor in respect of our work or this Report.

Appendix A

The following documents were reviewed to provide input into this report:

1. AMI Development Windows Servers Stage Plan V2.2.doc
2. AMI USB Production Infrastructure Stage Plan V1.0.doc
3. AMI-D066 4.7 CIC Presentation (Business Case).pdf
4. AMI-D067 4.7 Approved Project Charter V1.1.pdf
5. AMI-D068 4.7 Approved Stage Plan_Computer Room Expansion Market St V1.0.pdf
6. AMI-D069 4.7 Approved Stage Plan_WAN Infrastructure Upgrade V1.0.pdf
7. AMI-D070 4.7 Approved Stage Plan_Additional SAN Storage V1.1.pdf
8. AMI-D071 4.7 Approved Stage Plan_Clayton Backup Infrastructure Upgrade V1.2.pdf
9. Unix Development Infrastructure Stage Plan 30 May 2008 v1.doc
10. AMI Development DR Unix Server Memory Upgrade Stage Plan V2.1.doc
11. AMI IT Production Infrastructure 15 September Final.ppt
12. AMI Market Street Backup Infrastructure Stage Plan 2.1.doc
13. AMI Production Storage Infrastructure Stage Plan v2.1 .doc
14. AMI Production Unix Infrastructure Stage Plan v0.5.doc
15. AMI Production Windows Server Stage Plan V2.1.doc
16. AMI-D136 AMI Production Infrastructure Approved Project Charter V1.0.pdf
17. USB Performance Benchmark and Production Design Project Stage Plan V1.0.doc
18. AMI Application Migration Stage Plan v1.0.doc
19. AMI DR Infrastructure and Application Migration Project Charter v1.0.doc
20. AMI DR Infrastructure Stage Plan v1.0.doc
21. AMI IT DR and Migration Infrastructure March 2009 V7.ppt
22. AMI-F372 – AMI IT DR Project and Application Migration Support CIC Presentation March 2009.pdf
23. AMI IT 2010 Meter Growth Project Charter V 0.4.doc
24. AMI IT Growth September 2009 v11.ppt
25. AMI Meter Roll out Infrastructure (2010) Stage Plan v0.6.doc
26. AMI IT 2011 Meter Growth Project Charter V0.5.doc
27. AMI IT infrastructure 2011 Growth CIC Presentation.ppt
28. GIS-GST-ADI-PAL-AMI-LTM-mvanthof-1 February 2008 (Final) v2a.doc
29. Advanced Metering Infrastructure Overview.ppt *October 2010*

Appendix B

The following people were interviewed during the development of this report.

- Alastair Boustead – AMI IT Programme Manager, CitiPower/Powercor
- Ian Williams – IT Infrastructure Manager, CHED Services
- Rob Buckingham – IT Infrastructure team member, CHED Services
- Matthew Van't Hof – AMI Architect, CSC

The following people participated in reviewing and providing feedback during the development of this report:

- Brent Cleeve – Pricing Manager, CitiPower / Powercor
- Renate Tirpcou – Senior Regulatory Economist, CitiPower / Powercor
- Ian Williams – IT Infrastructure Manager, CHED Services
- Lyndel Sainsbury – IT Business Manager, CHED Services