Delivering Value
The Economics of ClearPath Forward Systems

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White Paper
When evaluating the cost of IT systems, and comparing alternative platforms and approaches, it is essential to consider all the economic factors. In many cases, this is not done, leading to a distorted picture of the true costs.

The paper examines the economics of ClearPath Forward® systems, considering four sets of economic factors: delivering IT services – provisioning and continuing operation of the systems; reliability, availability and security; developing and supporting applications; and the value of ClearPath Forward applications to the business.

When all these factors are taken into account, ClearPath Forward systems stand up well from an economic perspective, especially in mission-critical transaction processing.

This paper was first published in September 2009 and revised in 2012 and 2014. The 2017 edition contains a number of revisions, taking into account major new developments such as the ClearPath Software Series, which runs on Unisys or third party hardware.
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Summary
The economics of providing the IT services necessary for a business is always a prime concern for the management responsible. This paper provides an analysis of the economics for ClearPath Forward systems, in the context of the changes brought about by significant IT technology developments. Unisys’ response with ClearPath Forward Libra and Dorado systems, and the ClearPath Software Series, has given users new options for deployment, providing systems well-suited to today’s challenging IT environment.

A note on names: ClearPath Forward is the name for the ClearPath programme; ClearPath Forward Libra (ClearPath® MCP-based) and ClearPath Forward Dorado (ClearPath® OS 2200-based) are the names of systems that run in Unisys supplied hardware platforms; and ClearPath Software Series is the name for systems that may run in third party hardware. ClearPath System is used in this paper to refer to any of the systems, that is, ClearPath Forward Libra, Dorado or ClearPath Software Series. Any other use is clear from the context.

IT Directions
The three years or so since the previous version of this paper have seen a dramatic increase in the adoption of, and the disruption caused by, mobile device use, social media, data analytics and the Internet of Things. The consequences for organisations in both the private and public sectors include massive and unpredictable traffic fluctuations, and heightened security risks. Business models can also be undermined. For example, the amount of processing to sell a good may dramatically increase as consumers shop around. Understanding the true value of IT systems is therefore vital.

The rapid growth of cloud technology allows organisations to develop an architecture able to respond to the challenges: the hybrid IT architecture. External service providers have long been a feature of distributed IT environments. Cloud service providers offer new options for hosting an organisation’s applications: they may host some or all of them, and may provide an overflow capacity in the event of excessive demand on internal IT resources.

Assessing Economic Value
This paper argues that it is essential to consider all the factors affecting the economics of IT systems, not just the ongoing total cost of ownership (TCO). However, the relevant factors are not always taken into account when looking at alternatives. For example, the costs associated with enterprise-class systems such as ClearPath Forward are well understood and appear on someone’s budget. The true costs of many other systems are partially hidden, with people costs and security risks as significant examples.

The paper examines the economics of ClearPath systems based on four sets of factors, divided into two groups:

**Business as Normal**
1. Delivering IT services: the provisioning and continued operation of systems, with the necessary operations and system support staff, to meet the requirements of the business.
2. Developing and supporting applications: the cost of implementing new application services, including those associated with the integration of other systems and databases.

**Risk Factors**
3. Reliability, availability and security: how systems compare to industry standards for mission critical usage.
4. Applications exist to deliver value to the organisation using them. They can lose value as a result of unreliability or erratic performance, which may incur financial penalties and drive customers away. They can also lose value if they, and the infrastructure in which they run, are not kept up-to-date.
ClearPath Forward Strategy
All ClearPath Forward systems are now Intel-based, including those at the top of the performance range. To facilitate the move, Unisys implemented the reliability and security capabilities of the Unisys-designed processor technology in firmware. ClearPath Forward Libra and Dorado systems, which use Unisys-supplied Intel hardware with an optional fabric infrastructure, provide very high levels of performance, reliability, resilience and security. More recently, Unisys has begun to extend the range of ClearPath Forward with the ClearPath Software Series, which may run in Unisys or third party hardware. In this offering Unisys provides the operating environment and the firmware; the user chooses the hardware. (A reference architecture is provided to ensure the chosen hardware is able to meet requirements.)

Conclusions
As a platform for I/O intensive transaction and associated batch processing, especially in mission-critical environments, ClearPath systems deliver excellent value when all the relevant economic factors are considered.

Business as Normal
• Deployment flexibility. The ClearPath Forward Libra and Dorado systems, together with the Software Series, give clients an extended range of deployment options, well-suited to the implementation of hybrid architectures. ClearPath Forward Libra and Dorado may host mission-critical applications, typically with very demanding service-level requirements, within the private data centre. The Software Series allows clients to use a platform of their choice, either on bare metal or under the popular hypervisors VMware and Hyper-V. The first ClearPath MCP Software offerings are available to run entry and mid-range systems, and MCP development environments. Allowing ClearPath systems to share the same Intel server as other operating environments such as Windows may be an advantage if clients have a preferred supplier for servers. There is also potential for operating cost reduction as all servers come under a single systems management régime. The ClearPath Software Series has established a foundation for current and future deployment using cloud technology, in house and/or using external cloud service providers.
• System efficiency. The systems can handle multiple, critical applications of different types under a single instance of the operating system. The MCP and OS 2200 operating systems have always provided a protected virtual environment for applications. Processor loads of close to 100% can be sustained, together with high levels of security. The result is that the amount and complexity of equipment in configurations, and hence energy and space consumption, are low compared with alternatives.
• Pay-for-use. Unisys offers two ways for clients to pay for ClearPath systems: server based or consumption based. Server-based pricing is the traditional model in which the client purchases the operating environment based on the number of servers or cores on which system(s) will be deployed. Consumption-based pricing allows the client to pay based on the actual usage. In classic ClearPath platform releases consumption-based pricing is referred to as metering (Metered MIPS). In the newer ClearPath Software Series, it is Cloud Value Units (CVUs). In either case, the client has the option to choose the payment model that suits their business and computing requirements. Licensing with a pay-for-use business model can reduce costs while increasing performance significantly. Unplanned surges in demand leading to revenue opportunities can be accommodated immediately.
- **Automation.** The systems management tools enable very high levels of automation, not only for the ClearPath systems but for others in the data centre, including cross-platform automation. The tools increase operational quality for both normal operation and in the event of exception conditions by increasing the speed of response and reducing the risk of operational error, the primary cause of downtime. Efficiency benefits due to automation reduce the cost of operations staff. Automation, combined with cartridge tape libraries or virtual tapes, enables unattended operation.

- **Open development environments.** Applications running in ClearPath systems are able to move to new releases without change, a feature appreciated by users over many years. The use of open development environments substantially widens the pool of developers by reducing the need for specialised system knowledge. Enterprise Application Environment (EAE), Agile Business Suite (AB Suite), Business Information Server (BIS), ClearPath MCP Developer Studio, Visual Studio, Python integration and Eclipse Integrated Development Environment (IDE) allow rapid development of applications using familiar graphical tools, thus reducing training requirements. The Eclipse environment contains Unisys ClearPath OS 2200 and MCP extensions providing support for other languages, including COBOL. ClearPath fabric-based systems can optionally support Java environments, COTS Java Virtual Machines (JVMs) and application servers, and the Eclipse IDE. The Java environment enables the use of Java-based products in ClearPath systems, and provides access to a wide development community.

- **Integration technology.** The integration middleware available with ClearPath systems enables them to co-operate with other systems, using all the major technologies such as Web Services and message queuing. The tools can be used for a spectrum of requirements, ranging from providing a new channel to an application – mobile devices, for example – to participation in hybrid IT architectures.

**Risk Factors**

- **Reliability and availability.** System reliability, with fast recovery in the rare event of a failure, maximises availability. Component redundancy and high availability are standard configuration features of ClearPath systems.

- **Security.** Cybersecurity and how to provide cyber-resilience are at the top of the list of concerns for many senior executives, not just in the financial sector. The global ransomware attacks launched on 12th May and 27th June 2017 highlighted the threat all too clearly. Security is a key component of each level of the ClearPath Forward architecture. The high levels of security reduce the risk of any data vulnerability and consequent adverse economic effects to near zero.

- **Application value.** Given the mission-critical environments in which ClearPath Forward systems are used, the above factors significantly contribute to the value of applications by minimising the risk of erratic behaviour or security breaches. Upgrades to new system releases are simplified because no application changes are required to move to a new system level. The development tools and integration technology available facilitate application extensions, including participation in distributed environments.

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1 MCP and OS2200 environments were unaffected by the attack.
Integrated stack
Many of the advantages described above can be attributed to the way the systems are developed and released. The software and firmware are designed, developed and tested by Unisys and released together: the integrated stack. The approach makes for great efficiency and low systems programmer resource requirements. It minimises the need to apply fixes and reduces the time to implement new releases, and hence lowers cost and risk. The integrated stack also contributes significantly to reliability and security: the source and integrity of all the components are known.

Total Cost of Ownership (TCO)
The results of a number of TCO analyses from clients in North and South America, Europe and Australasia show that ClearPath systems compare well with global industry averages from Gartner for mainframes for cost of processor power and personnel. How do ClearPath systems compare with Unix, Windows and Linux systems? Unisys has performed a detailed analysis of a large, mission critical ClearPath environment and an equivalent environment running the same applications under either Windows or Linux. The TCO of the current environment was easy to calculate. The target configuration was derived using readily available industry data and comparison with similar environments. The ongoing TCO of the proposed new configuration was roughly comparable with the ClearPath system environment. However, the cost of moving would be substantial, and security would become a concern.
Introduction

Technological developments over the past few years have proved disruptive, significantly changing the way organisations function in both the public and private sectors. Understanding the economics of IT systems able to respond to the changes is therefore a central concern of senior management, especially the CIO. This paper argues that a wide variety of factors needs to be considered when evaluating the economics of IT systems. For the purposes of this paper, the factors have been divided into four broad categories, split into two groups:

Business as Normal

1. Delivering IT services
2. Developing and supporting applications

Risk Factors

3. Reliability, availability and security
4. The impact on the value of applications if they are not kept current or are unavailable for an extended period

The remainder of this paper is organised into the following sections.

• The next section summarises recent technological changes, which have had a profound effect on how organisations function. It goes on to sketch out an IT architecture for the future.
• The economic categories and why they were chosen are then discussed.
• Recent ClearPath Forward system developments are summarised.
• The economics of ClearPath Forward systems are examined using the economic categories as a framework.
• The paper concludes with a brief discussion of Total Cost of Ownership (TCO) analysis models and results of a number of studies.
• A brief explanation of the notion of the integrated stack is appended.

Pointers to sources of more information are provided at the end of the paper.
What’s Changing for IT?

The widespread availability of inexpensive processing power, storage and network connectivity have led to an explosion of innovation. New devices and applications exploiting them, together with the underlying connectivity, have radically changed how business works in the public as well as private sectors. This section discusses the most important technology developments, their impact – positive and negative – and the IT architecture required to thrive in this environment.

The Technology

**Mobility.** The number of mobile devices such as smart phones and tablets has surged, enabled by the increased coverage and speed of networks, and ubiquitous free WiFi. There are more mobile devices than people on the earth. Newer mobile technologies, such as wearables and virtual reality devices, will add to the numbers. The increasing level of intelligence in the devices has spawned an industry of applications providing access to services of all kinds. As a result, the load on centralised application systems has increased dramatically and is spread throughout the day; there is no quiet time. Organisations can keep in touch with their clients, sending them messages of various kinds, for example announcing promotions and notifications of events, often in combination with social media.

**Social media** companies have been among the fastest growing organisations. Apart from connecting people together, social media allow companies and public sector organisations to connect with their clients.

**Data analytics.** The quantity and diversity of data available to an organisation have led to the requirement for a wide variety of analytical techniques to turn the data into information. In the commercial world, understanding customer behaviour enables targeted advertising and other promotions. In the public sector, information can lead to a better understanding of trends and provide valuable evidence for policy formation. Analysing data in real time or near-real time allows systems to respond immediately to events.

**The Internet of Things (IoT)** covers a wide variety of technologies, including utility management such as water and electricity metering, domestic appliance management and intelligence in vehicles. The IoT raises the possibilities of a number of benefits, including more efficient management of resources, less waste, and lower consumer and business costs. The number of devices connected is likely to grow exponentially.

Associated Problems

Although these technologies bring a number of advantages, some of which have been sketched out above, they can also bring problems. The following are three examples.

**Cyber security** is perhaps the most significant concern. Hardly a day goes by without news of another security breach. Those responsible range from individuals to criminal gangs and governments or government-approved actors. The consequences can be significant, both for the victims and the companies or other organisations whose systems are hacked. For example, the average cost of a data breach in 2016 was USD 4 million, up 29% since 2013. Ongoing reputational costs may put a company out of business.

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2 The following links are just a small selection of sources providing statistics:
https://deviceatlas.com/blog/16-mobile-market-statistics-you-should-know-2016,

Security threats are not confined to hacking to steal or corrupt data. Attacks such as distributed denial of service (DDoS) can be very damaging. Many of the devices connected to the IoT have very limited security; low cost has been the goal of their manufacturers. A DDoS attack in October 2016 used malware installed in devices connected to the IoT to mount a massive assault on the Internet’s domain name system infrastructure⁴, bringing much of the US internet to a halt. The costs of the massive ransomware attacks beginning on 12th May and 27th June 2017 are still to be determined at the time of writing.

Traffic volumes. The huge number of mobile devices in circulation creates heavy and volatile traffic loads, making resource planning difficult. An additional complication is that social media can rapidly propagate news about events such as security breaches. Traffic volumes may then surge as people use mobile devices to check on personal data, for example bank balances. And false as well as genuine news can damage a company, requiring rapid counter action to limit the consequences.

Finally, existing business models may need modification. For example, those selling products online charge per item sold. The cost of the IT systems used is based on the number of system interactions required to sell an item; selling airline seats is an example. However, technology developments have enabled users to scan many providers looking for the best option, significantly increasing the traffic on systems without increasing the number of sales. Airlines have long been familiar with this problem, referred to as ‘look not book’.

Hybrid IT Architecture

Figure 1 is a schematic of an architecture able to respond to the demands placed on a typical organisation, referred to as Organisation X. The environment divides into internal and external domains. The internal domain is below the horizontal red line in the figure. It contains one or more internally-managed data centres housing the critical applications and databases. What is critical will depend on X’s business. As examples, a bank would include systems for account management and customer information, and a government income taxation service would include tax payer and account status systems.

The external domain is connected through one or more networks: dedicated private, industry networks such as SWIFT⁵ or SITA⁶, and the internet. Which types and how many such networks will depend on the nature of X’s business.

The external domain is divided into three parts: consumers of X’s services; providers of services to X, including cloud services; and devices connected to the IoT. Consider each in turn.

Service consumers include individuals using mobile and other devices, as well as employees of X, providing a call centre service for instance. Consumers also include other systems to which individual users may connect, for example price comparison applications.

The services provided by X may be delivered entirely by internal applications but are likely to include external service providers: the total service is a collaboration. Service providers include shared services, for example credit reference, payment and transportation systems. X may choose to keep some of its less critical applications externally, in cloud services. X could also use cloud facilities as overflow capacity in the event of excessive loads on its internal resources.

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⁵ Society for Worldwide Interbank Financial Telecommunication. For more information, see https://www.swift.com/
⁶ For more information, see http://www.sita.aero/
A start has already been made. See [http://www.nature.com/news/ibm-s-quantum-cloud-computer-goes-commercial-1.21585](http://www.nature.com/news/ibm-s-quantum-cloud-computer-goes-commercial-1.21585)

Figure 1: shows a hybrid architecture for a medium to large enterprise, referred to as Organisation X

The IoT represents a rapidly growing source of data from a wide variety of entities. Traffic may flow in two directions: from the IoT as status and other information and to the IoT in the form of control commands. For example, aircraft engines may send data on performance levels and receive instructions to optimise fuel consumption.

Data analysis raises interesting possibilities for external services. Cloud-hosted super computers and grids could supply substantial, affordable processing power for complex data analysis. Quantum computing (if and when it takes off) could take business in radically new directions by solving hitherto intractable problems. Quantum systems would be accessed as co-processors from a classical system. Given the difficulty of building quantum systems, hosting by a specialist supplier is likely.

Companies such as aircraft engine and vehicle manufacturers, and utility suppliers, interact with things for data gathering and control purposes. The number of such organisations is likely to increase as the number of intelligent things increases. Action will be needed to manage the security risks.

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7 A start has already been made. See [http://www.nature.com/news/ibm-s-quantum-cloud-computer-goes-commercial-1.21585](http://www.nature.com/news/ibm-s-quantum-cloud-computer-goes-commercial-1.21585)
Assessing IT System Economics

The economic categories chosen represent the business concerns of the CIO and other senior management within an organisation. They are divided into four broad categories, split into two groups: business as normal; and risk factors.

Business as Normal: Delivering IT Services

This category comprises the costs associated with the procurement and continuing operation of the systems. The factors considered are divided into three groups:

*System hardware and software:*  
• Processing power and storage, including disaster back up, and test and development resources  
• All the software apart from the applications, including operating systems, database managers and application environments such as transaction managers for the production systems  
• The software required for disaster back up, test and development systems

*Physical resource consumption:*  
• Electricity for running the systems and providing air conditioning  
• The footprint, that is, the floor space consumed by the systems

*Personnel:*  
• Operations  
• Software support and maintenance

Business as Normal: Developing and Supporting Applications

Any organisation has to provide new IT services for its user constituency to remain competitive in the private sector, and to increase efficiency and manage costs in the public or not-for-profit sectors. While providing new services is never an easy task, it becomes more challenging in a difficult economic climate. The CIO has to do more with less, while not compromising on quality.

The factors considered in this category are:

• The speed of development and deployment of new IT services to maintain organisational agility, for example to exploit a window of opportunity to launch a new product  
• The cost of development and deployment  
• The risks involved in the quality and stability of the new services, and any negative effects on existing services resulting from the changes  
• The costs of continuing maintenance  
• The availability and cost of qualified resources  
• Impact of replicating data versus re-using data services in existing systems
Risk Factors: Reliability, Availability and Security
The factors in this category are associated with the business cost of conditions affecting the ability to deliver IT services. With planned unavailability, there is a potential loss of revenue resulting from an inability to serve customers during the planned downtime. The economic consequences of unplanned absence of services, and compromised services, for example from a security violation, are more serious.

The factors affecting the ability to deliver services include:

**Planned downtime**
- Updating software or application levels
- Reorganising or extending databases
- Hardware upgrades
- Batch versus online availability

**Abnormal conditions**
- Failure up to and including the complete loss of a system
- Unpredictable performance under abnormal and fluctuating loads
- Failure to resist internal and external attacks, and an inability to detect attempted violations
- Unplanned downtime to apply security vulnerability patches

CIOs and other senior management ignore these risks at their peril. Major data violations in the commercial sector, for instance, can result in heavy compensation payments to affected stakeholders, and damaged or even destroyed reputations. And for some public sector organisations such as defence or emergency services, national security and even life may be at stake.

Risk Factors: Application Value
Applications exist to deliver value to the organisation using them, for example generating revenue and profit in the private sector, or serving the citizen more effectively and cheaply in the public domain. Maximum value is obtained by minimising the cost consistent with maintaining the required quality of service. Applications can lose value as result of unreliability or erratic performance, which may incur financial penalties and drive customers away.

They can also lose value if they are not kept up to date by implementing new requirements on time or fixing problems. This may happen as a result of an ill-considered strategic decision to change platform, by moving an application to a different environment. The existing application will have to be kept up-to-date while the new one is being implemented or the business will be adversely affected. Overall costs will therefore increase. The worst possible case is that the existing application is not maintained and so loses value, but the new application is delayed or even fails. This is not an unusual occurrence. It is essential to analyse strategic alternatives carefully to understand the full financial consequences.

The next section explains the evolution of ClearPath systems over the past two years or so. This background is essential before assessing the economics of the systems using the categories described above.

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ClearPath Forward System Direction

Unisys released ClearPath fabric-based systems in mid-2014, roughly coincident with the previous revision of this paper. Since then, there have been a number of developments. All systems are now Intel-based, including those at the top of the performance range. To facilitate the move, Unisys implemented the reliability and security capabilities of the Unisys-designed processor technology in firmware. More recently, Unisys has extended the range with the first releases of the ClearPath Software Series, which may run in Unisys or third party hardware. (A reference architecture is provided to ensure the chosen hardware is able to meet requirements.)

This section provides a general description of the architecture of the ClearPath systems. Details of releases and features of specific systems may be obtained from Unisys through local Unisys contacts or the Unisys website.

ClearPath Forward Libra and Dorado Systems

Figure 2 is a schematic of a ClearPath Forward Libra or Dorado system, running in a platform supplied by Unisys.

![Figure 2: Architecture of a ClearPath Forward Libra and Dorado systems, with a fabric architecture](image-url)
The light blue boxes labelled PMM, ISM and so on represent separate Intel-based components, that is, servers, interconnected through the fabric infrastructure. The upper part of the diagram contains the ClearPath MCP or ClearPath OS 2200 operating systems and associated components. The firmware in the PMM maintains application code compatibility while the ISM firmware maintains data format compatibility.

The lower part of the diagram shows a number of optional EPPs. They may contain Unisys Secure Partitioning (s-Par®) firmware supporting a number of secure partitions. The partitions may run Windows or Linux. Some of the partitions may be Specialty Partitions, such as the ClearPath OS 2200 QProcessor. EPPs may house a single instance of an operating system, for example if the workload is expected to be heavy, as might be the case for an Oracle database. They may also contain VMware or Hyper-V, supporting a number of virtual systems. Workloads may include Java, using a third-party Java Virtual Machine (JVM).

**ClearPath Software Series**

ClearPath Software Series releases comprise Unisys firmware and software, running on Unisys-supplied hardware or a platform of the user’s choice. They may run on bare metal or under a hypervisor – VMware or Hyper-V. Figures 3 and 4 show the bare metal and hypervisor architectures respectively. In the diagrams, NIC = Network Interface Card and HBA = Host Bus Adapter.

![Figure 3: Architecture of a ClearPath Software Series system in bare metal](image)

![Figure 4: Architecture of a ClearPath Software Series system running on a hypervisor](image)
The Economics of ClearPath Forward Systems

This section analyses the economics of ClearPath systems using the economic categories introduced earlier. Any differences between ClearPath Forward Libra and Dorado systems, and the ClearPath Software series systems, are explained.

Delivering IT Services

System Hardware and Software
Providing sufficient processing power to meet demand is a basic requirement; the economics of providing it is therefore a central concern. The following paragraphs describe key ClearPath Forward features.

Deployment options
ClearPath Forward gives clients an extended range of deployment options, well-suited to the implementation of hybrid architectures. ClearPath Forward Libra and Dorado systems may host mission-critical applications, typically with very demanding service-level requirements, within the private data centre. The ClearPath Software Series allows clients to use a platform of their choice, either on bare metal or under the popular hypervisors VMware and Hyper-V.

The first ClearPath Software Series MCP offerings are available to run entry and mid-range systems, and MCP development environments. Allowing ClearPath systems to share the same Intel server as other operating environments such as Windows may be an advantage if clients have a preferred supplier for servers. There is also potential for operating cost reduction as all servers come under a single systems management régime. The ClearPath Software Series has established a foundation for current and future deployment using cloud technology, in house and/or using external cloud service providers. Figure 5 illustrates how the various systems could be deployed.

The lower part of the figure shows Organisation X’s data centre(s). On the left, there are ClearPath Forward Libra and/or Dorado systems in which mission-critical applications execute. The high availability (HA) features of the platforms ensure that peak loads and critical processes such as month-end batch runs can be handled with minimal risk of interruption. The security features protect sensitive data from theft or deliberate corruption. Examples of sectors requiring this level of performance include banking, transportation and emergency service applications. The figure also shows Software Series systems installed in the data centre, in Unisys or other Intel hardware, perhaps in a private cloud environment. They may host development and test services, and other applications.

The upper part of the figure shows the external environment containing consumers of X’s services, service providers and the IoT. X could host some applications within a data centre belonging to a cloud service provider. Applications running under OS 2200 and MCP would require Software Series systems to execute within a cloud environment. External hosting could be used for commodity and less critical applications, and for overflow capacity for services normally hosted internally. An example could be a requirement for additional test services before a major release.

Providing capacity
Developments in micro-electronics have delivered massive improvements in processor cost/performance. They have also helped to change the way processing power can be provided. Lower cost and higher density of chips have allowed systems to be delivered that are capable of handling far more than current loads economically. A platform with a wide range of performance levels can be controlled by software, using a software key to change the performance delivered.

Unisys provides this capability with the Capacity on Demand option. The benefits include rapid upgrades using a performance key; temporary upgrades for planned events such as annual peaks or requirement for extra testing capacity; and redistribution of capacity among systems, for example to speed up a single thread batch process.
An extension of Capacity on Demand is to treat processing power as a utility, the consumption of which can be metered, that is, a pay-for-use business model. The pay-for-use model is the processing power analogue of the charging scheme used for utilities such as electricity or water. The system has the potential to run at full power but the client is only charged for the power consumed. ClearPath Forward Libra and Dorado systems provide the capability by metering MIPS. Consumption and therefore payment is based on ‘MIPS-time’ units. However, should it be needed, the full power of the server is available. See chart 1.

Clients are given control over the peak power available, and hence the expenditure and usage. They can lower the ceiling and hence how fast the work completes. This feature is known as the *Governor*.

The economic benefits of metering are real and substantial. The ability to handle planned as well as sudden, unplanned increases in load, improved response times and the reduction of batch windows all enable more business and therefore more revenue; the organisation is far more agile. As well as handling sudden traffic surges, metering has allowed organisations to provide additional functionality to users without compromising performance.

Extra capacity for Dorado systems can be provided by clustering. Unisys OS 2200 systems eXtended Transaction Capacity (XTC) software, along with the eXtended Processing Complex Locking (XPC-L4) platform, are designed for high traffic volumes, clustering up to six Dorado systems. Members of the cluster can be switched in and out. Systems out of the cluster, for example to perform lower priority work, can quickly be switched back in should there be an unexpected surge in traffic.

*Figure 5: Hybrid architecture illustrating how ClearPath systems may be deployed*
Chart 1 shows a representative daily profile, with two processing peaks, for example morning and afternoon. In an unmetered system, sufficient power must be configured to cope with peak loads. However, as the average is much lower, a lot of power is unused, although it is included in the price of the system. With metering, the cost is based on power used. The cost of the metered system is therefore lower than an unmetered system able to handle the peaks.

Payment for use is also available with the ClearPath Software Series. The pricing metric used is the Cloud Value Unit (CVU), which is measured in processor seconds, not the MIPS Months unit used for other ClearPath systems. There are conversion factors from MIPS Months to CVUs.

**Software characteristics**

The MCP and OS 2200 operating systems allow multiple applications of different characteristics, including mission critical, to run securely and reliably under a single operating system image, with total processor load factors approaching 100%. One consequence of multiple application support is that the logical presentation, application and database tiers can run in the same platform and do not need to be spread across physical tiers.

The overall effect is to reduce considerably the number of ClearPath Forward servers required when compared with Windows, Unix or Linux environments, which can normally only operate safely at lower load factors and may not be able to run multiple applications under a single operating system image. ClearPath systems thus scale up, rather than scaling out and depending on clustering for performance. The more ClearPath systems have to do and the more varied the workload, the better the value.

Reduced architectural complexity is a result of the low number of servers required for ClearPath systems. Although virtualisation has improved physical server utilisation for Windows, Unix and Linux environments, it does not reduce the complexity of managing multiple, separate operating system instances and the intersystem connections required.
Storage is the other major resource requirement. ClearPath systems use commonly available, industry-standard storage subsystems, from Dell EMC for instance, so the unit costs of storage are the same as for use with any other servers. However, ClearPath systems’ storage allocation and database management software tend to be economical with mass storage consumption, so reducing the number of units required.

There are various reasons for the efficient use of mass storage.

- OS 2200 treats storage as a pool, so disk space utilisation can be quite high because of the allocation techniques used; utilisation levels of 80-90% are acceptable. MCP systems treat storage as a family or string of units that can be added to as utilisation approaches 100%.

- Both ClearPath MCP and OS 2200 families use a fixed-block architecture, which is generally more efficient than variable block sizes by file, in part because files do not have to be physically contiguous.

- The disk space requirements for hierarchical databases Enterprise Network Database Server for ClearPath OS 2200 (DMS-2200) and Enterprise Network Database Server for ClearPath MCP (DMS II) are much lower than for relational databases, at perhaps 20% of the space required by the latter.

The case of a US Government agency illustrates the low space requirements for DMS II. The agency runs a website to offer its services to the public. The application was previously run on a SUN system with a commercial RDBMS. A decision was made to move it to an MCP platform, written in COBOL with a DMS II database. The database size is just 20% of that required on the SUN platform.

Many of the benefits discussed above derive from the delivery of ClearPath systems as an integrated stack, an approach Unisys has been following for many years: the firmware and software – operating system, transaction manager, database and environmental software, such as compilers and utilities – are designed, implemented, tested and delivered together. More details about the integrated stack advantages are provided in the appendix.

**Specialty partitions**

A key part of the ClearPath Forward Libra and Dorado architecture is the inclusion of extended operating environments and functions through Specialty Partitions, which run in EPPs (Enterprise Partitionable Platforms) on the fabric using the Secure Partitions provided by s-Par®. They provide cost-effective and efficient implementations.

The Specialty Partitions available support the following:

- IBM® WebSphere® MQ (Unisys ClearPath OS 2200 QProcessor)
- Web enablement, integration of mobile devices and Web Services (ClearPath ePortal), with interfaces into applications and databases in the main processor

The Specialty Partitions do not result in more systems to manage because they are fully integrated within the fabric of ClearPath Forward systems, benefitting from the security features and a common systems management.

**Physical Resource Consumption**

The power consumed in data centres for running and cooling equipment has become a concern in recent years. The electricity consumption of the world’s data centres exceeds that of some developed countries, for example the Netherlands. For many organisations, setting a greener agenda by reducing or offsetting their carbon footprint has become a central item of corporate responsibility policy. Happily, corporate responsibility and economic concerns have coincided: being greener saves money.
As ClearPath Forward systems use Intel servers for all models, power consumption is determined by Intel. The ability to run multiple applications at high load factors may reduce the number of servers required and hence the power consumption. However, a sense of perspective is necessary. Facilities costs, including power, cooling and space, are a small proportion of the total cost of ownership (TCO), *excluding* applications. Analyses of systems of all types by leading industry analysts\(^8\) show facilities costs of around 1% to 2% of TCO. As a proportion of pure *hardware* cost, environmental costs are more significant. However, hardware costs are a small and shrinking part of the TCO; software and personnel are far larger contributors. Server and data centre efficiency improvements are likely to reduce facility costs further.

*Including* applications in the TCO brings in other factors, in particular storage and consumables. Application database storage, for example, becomes significant if large amounts of data are stored. (System storage requirements, i.e. excluding applications, are trivial.) ClearPath MCP and OS 2200 databases require less disk space than other systems – in the case of DMS II, around 20% of a relational database, for instance – so the power consumption is modest. And it is not just power that is saved; floor space consumption is also reduced.

Paper consumption is a concern both from an environmental and cost perspective. Enterprise Output Manager (EOM) can save costs by delivering output in the most effective way, which is frequently not paper: it may be .pdf file, fax, Web page, or email, for instance. EOM works with all systems in the data centre, not just ClearPath systems, so the whole IT environment benefits. The ability to transform the output in various ways by reformatting such as scaling the size and adding company logos is an added benefit.

**Personnel**

Earlier studies and observation of ClearPath system clients suggest that staffing levels required for ClearPath systems have tended to be lower than equivalent environments on other platforms, in particular for systems and applications programmers\(^10\). One factor leading to lower staff costs is that applications continue to run without change when moving to a new system level. A second factor is the Unisys integrated stack. Open systems will have a wide variety of vendors involved. The maintenance and integration requires people, leading to significant costs.

Automating system operations allows staffing levels and hence costs to be minimised while at the same time improving the quality of operation. Three products can be used with any system in the data centre:

1. Operations Sentinel
2. OpCon from SMA, a Unisys partner
3. Enterprise Output Manager

Operations Sentinel and OpCon provide cross-platform automation, which is essential for managing distributed systems, especially for automating recovery processes, up to and including disaster recovery. For MCP systems, Workload Management for ClearPath MCP enables system administrators to specify operations policies in non-technical business terms. The MCP automatically tracks application performance, and adjusts resource allocation so that the operations policies are satisfied. As mentioned above, Enterprise Output Manager automates the handling of print and other output, reducing the need for intervention.

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\(^8\) Gartner, for instance, produces. Key Metrics documents each year, including mainframe, Windows, Unix and Linux systems. The documents provide costs and cost breakdowns for each class of system, excluding applications. See “Sources” at the end of this paper.

\(^10\) See the section “TCO Analysis” for more information.
Developing and Supporting Applications

New IT services may be delivered by implementing new application components, integrating and orchestrating existing applications and databases, or, increasingly often, integrating new and existing elements, typically within a service-oriented architecture framework. This section considers:

- The facilities available for developing new application logic
- The technology for integrating ClearPath systems with others
- Ongoing support and maintenance

There is a rich range of facilities available, more than those unfamiliar with ClearPath Forward tend to assume.

New Application Development

ClearPath MCP and OS 2200 systems have long supported highly productive development and deployment environments, the current versions of which are EAE, AB Suite and BIS. They support easy-to-use graphical interfaces for developers. In the case of AB Suite, the development environment is Visual Studio, including Team Foundation Server. These tools have enabled rapid application development with compact and efficient development teams, requiring minimal specialist IT knowledge. The ability to choose the deployment platform enables the applications to be positioned in an optimal environment.

Both Libra and Dorado systems support Open Group DTP as a native application environment, alongside Transaction Server (MCP COMS), and Transaction Interface Processor (TIP) and High Volume TIP (HVTIP). Java, including the Java Platform, Enterprise Edition (Java EE) is supported using COTS JVM and other software. Facilities are provided for accessing other applications and databases within the ClearPath system.

The Eclipse Integrated Development Environment (IDE) is available for both ClearPath families for COBOL, ALGOL and other languages as well as Java. Unisys provides a number of Eclipse plug-ins to support the ClearPath MCP and OS 2200 environments. The ClearPath Forward ePortal and the ePortal developer with its Visual Studio interface provide a rapid and effective way of extending applications to Web, mobile and Web Services access.

The ClearPath MCP Developer Studio combines the Software Developer’s Kit that is familiar to host-based MCP developers with most of the MCP run-time software to enable testing of new features for production deployment. End-user staging of new application functionality can be easily accomplished. This package also includes the EAE and AB Suite run-time software, the Data Exchange and ClearPath Application Integration Services products and the ClearPath Visual IDE development tool. The Developer Studio is available in a number of options, ranging from the Personal Edition deployed in a PC, to the Premium Edition deployed in a fabric-based Libra system with one EPP.

High levels of automation in application development products from Unisys and integration with Microsoft Team Foundation Server, Eclipse, and other third party tools enable implementation of Agile and DevOps processes to further improve productivity, reliability, and reduced time to implement new features or releases in critical applications.

The use of industry standard development environments and tools helps keep staffing costs low, and enables new programmers to be productive with a minimum of training.
Integration Technology
A wide variety of middleware tools is available for use in integration projects; Figure 6 shows the middleware technologies available.

ClearPath MCP and OS 2200 middleware supports all the recognised technologies for integration. ClearPath MCP and OS 2200 applications may collaborate with others and the databases may be accessed directly.

ClearPath MCP and OS 2200 systems may participate in distributed environments, typically collaborating with other systems in a service-oriented architecture (SOA) framework. A guiding principle underpinning the Unisys strategy for ClearPath systems has been openness. The strategy is therefore to provide the middleware necessary to allow ClearPath to participate in distributed environments using any of the major open and de facto standards.

Middleware products allow existing and new MCP or OS 2200 applications and databases to be incorporated into almost any distributed environment. Before each ClearPath MCP and OS 2200 release, the middleware products are integrated and tested with other middleware, operating systems, native application servers and database managers. Ensuring full working functionality before release minimises any effort required by on-site integration teams when deploying the software.

Figure 6: ClearPath MCP and OS 2200 middleware supports all the recognised technologies for integration. ClearPath MCP and OS 2200 applications may collaborate with others and the databases may be accessed directly.
Ongoing Support and Maintenance

Applications running in ClearPath systems do not need changing to accommodate new hardware or software releases. Upward compatibility of application programming interfaces is a guiding principle; there are many examples of applications running unchanged over extended periods. There may be new features available in new operating environment releases which the applications do not exploit, but the applications continue to work. The economic benefit is that the costly application changes required in some other environments – modification, testing and deployment – are not necessary with ClearPath systems. Developers can concentrate on the changes required for the business without the distraction of changes to accommodate hardware or software upgrades. Furthermore, applications can run faster and serve more users efficiently simply by upgrading the underlying hardware and operating environments, without any application changes.

Reliability, Availability and Security

ClearPath systems are frequently used in mission-critical environments in the private and public sectors, including finance, government, defence, utilities, emergency services and transportation. In addition to performance, high levels of availability and security are expected, together with an ability to recover from any (rare) problems quickly and consistently.

ClearPath systems have always been engineered for reliability. Systems may run for years: for example, a Unisys-hosted freight logistics application, running on a ClearPath OS 2200 system, operated for more than four years without a restart of any kind; and an MCP-based mortgage application exhibited similar stability. With ClearPath Forward Libra and Dorado systems, for example, the high availability (HA) features increase the tolerance to any failure.

The integrated firmware and software stack is a significant reason for this quality of operation: it enables full testing of the whole suite before release, so unplanned downtime to apply emergency patches is very low. And because Unisys provides the whole stack, forward and backward compatibility can be provided, enabling managed upgrades with minimal disruption. Upgrades are typically performed in hours rather than days, and may in some circumstances be done without downtime. For example, MCP applications are available to end users during installation of new versions of transaction processing applications, Enterprise Database Server (DMS II) and Telnet. And UDS databases on OS 2200 automatically balance trees, removing the need to take a database down for periodic reorganisation.

Should problems occur, recovery is rapid. A difference from other database approaches is that recovery is from a point in time. Audit trails are maintained for database changes. If the database is damaged, as a result of a rogue transaction for example, a simple script is executed and the database is recovered from the audit trail. Other databases such as DB2 and Oracle usually have to perform a full recovery and then go forward, which can be a much longer process.

The systems management tools and the automation they bring contribute significantly towards availability by detecting problems and automating corrective action up to and including complete data centre loss. For example, handling problems in distributed systems and recovering from them is very difficult and error-prone without automation. The cross-platform capabilities of Operations Sentinel and OpCon are vital in dealing with these kinds of problem.

Failures may of course occur in the environment in which the systems run, for example a total power loss, or some catastrophic event such as a flood. Infrastructure and procedures need to be in place and regularly tested. The Business Continuity Accelerator (Libra systems) minimises service interruption in the event of a system loss. The extended Transaction Capacity (XTC) for Dorado systems increases resilience as well as supporting high transaction volumes. Both technologies can also minimise interruption for software upgrades.

ClearPath Software Series systems may run under a hypervisor as well as on bare metal. VMware’s vSphere High Availability provides facilities for recovery in the event of a failure. vSphere vMotion enables planned maintenance without any service interruption.
Security is a major requirement for users. ClearPath systems, and their predecessors, have security designed into them, not added on later. Many features provide high levels of security in both system families.

- Applications are protected from each other, so there is no risk of cross-application damage.
- Database access is carefully controlled to manage and record details of access to data. This is of considerable importance in the light of the General Data Protection Regulation (GDPR) in the European Union\(^\text{11}\).
- The system design eliminates common security weaknesses such as buffer overrun, which is a leading cause of virus and worm propagation.
- Auditing technology is an integral part of the operating system environments, not an add-on.

Many features contribute to ClearPath systems’ security. See the section “Sources” for pointers to more information. Further evidence can be found in a NIST database\(^\text{12}\) which records security vulnerabilities. Table 1, below, was constructed using information obtained from this database on 25th October 2017. The two MCP vulnerabilities (the earlier one was in 2002) did not allow access to user data, wherever it was located, so no data were compromised.

<table>
<thead>
<tr>
<th>Operating system</th>
<th>Number of vulnerabilities</th>
<th>Date of last vulnerability</th>
<th>Compromised data</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClearPath OS 2200</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ClearPath MCP</td>
<td>2</td>
<td>09 March 2017</td>
<td>No</td>
</tr>
<tr>
<td>IBM System i (iSeries)</td>
<td>24</td>
<td>31 July 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM System z (zSeries)</td>
<td>24</td>
<td>13 February 2015</td>
<td>Yes</td>
</tr>
<tr>
<td>OpenVMS</td>
<td>36</td>
<td>17 December 2014</td>
<td>Yes</td>
</tr>
<tr>
<td>HP-UX</td>
<td>366</td>
<td>01 February 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>AIX</td>
<td>386</td>
<td>15 February 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>Unix</td>
<td>790</td>
<td>12 September 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>Solaris</td>
<td>1,049</td>
<td>19 October 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>Linux</td>
<td>6,059</td>
<td>22 October 2017</td>
<td>Yes</td>
</tr>
<tr>
<td>Windows</td>
<td>6,659</td>
<td>22 October 2017</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Table 1: Operating system reported vulnerabilities*

Protecting data in motion is essential for secure systems. Both ClearPath families support all the major encryption standards. OS 2200 software includes CryptoLib, a software library, and Cipher API, a subsystem, both of which provide application programming interfaces (API) for encryption, decryption, and related services. Cipher API provides access to a core subset of the CryptoLib algorithms and supports additional data formats. ClearPath MCP also offers a full set of encryption and cryptography algorithms for both system services and user-written applications. The cryptographic library has been offloaded into special environments (either a hardened appliance or the system firmware depending on system type) which are optimised, hardened, and secure.

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\(^{11}\) See [http://www.eugdpr.org/](http://www.eugdpr.org/)

\(^{12}\) Source: [http://nvd.nist.gov](http://nvd.nist.gov)
Applications requiring high levels of security also need to be able to isolate the relevant servers and user equipment. This can be done by creating separate networks or segmenting networks using VLANs and firewalls but can result in high levels of complexity, and additional hardware cost for the added, dedicated networks. The result is a significant risk of incorrect configuration, resulting in connections being left open and thus liable to security breaches.

This complexity can be avoided by using Unisys Stealth®, which provides additional network security by cloaking data from detection as it moves through the network. A Secure Virtual Gateway (SVG) can be positioned inside the secure ClearPath cabinet to encrypt and decrypt data to and from Stealth-enabled end points and to cloak the ClearPath host from visibility outside its Communities Of Interest (COIs). In the ClearPath Forward fabric-based infrastructure, Unisys s-Par® technology and Unisys Stealth provide dedicated, protected resources for critical applications and secure isolation of groups of users (COIs) on the network, complementing the security built in to the ClearPath Forward partitions.

Figure 7 shows how a Stealth COI might be established in the environment shown in figure 1.

Figure 7: Hybrid architecture showing ClearPath Forward systems in a Stealth COI
Application Value

IT plays a critical role in most organisations today. In some cases, such as many financial companies, the applications really are the business. It is therefore important that applications are maintained in an optimal condition – their value to the business is maximised. Failure to keep applications, and the environment in which they run, up-to-date is likely to result in loss of business in the private sector and a decline in client service in the public sector. If allowed to continue, there are likely to be significant costs to repair the damage at a later stage.

There are two sets of activities required to maintain applications at the level required.

- **Infrastructure maintenance**, which includes ensuring current system release levels are used, with sufficient capacity to meet performance requirements; and
- **Application maintenance**, which includes implementing functional changes to meet business and regulatory requirements, and fixing any problems experienced in operation.

How do ClearPath systems help in maintaining application value? Infrastructure maintenance is significantly simplified by the fact that applications running in ClearPath systems do not require changes to allow them to move to a new software release level. The amount of effort required to make the move is therefore small, leaving resources free to concentrate on more productive activity. Risk is also reduced as instability caused by introduced application errors during the update is eliminated. And capacity management in the form of capacity on demand and pay-for-use models simplifies performance upgrades.

The frequency and complexity of application changes and extensions obviously depend on the nature of the business concerned. But all public and private sector organisations need to make changes and extensions to keep up with requirements and to satisfy regulatory changes. The integration tools available with ClearPath systems, as discussed earlier in this paper, facilitate change using a service-oriented approach. For example, many applications serving large numbers of customers have a component managing customer information. Some organisations may have built a customer management component into each of several applications, and have decided to consolidate the information into a single component, shared by a number of applications. The customer management components in each application can be isolated and replaced by calls to the shared new service. Organisations can also share applications such as credit checking, provided by a specialist company and accessed through middleware such as Web Services.

Rather than extend existing applications, some organisations have decided to try other approaches, including developing a new application or moving to a package. While these approaches can be viable, the cost, time and disruption during a change are almost always underestimated. Others have decided to move the existing ClearPath applications to another platform in the expectation that the new hardware will offer an advantage by eliminating a unique hardware platform. Again, the cost, time and disruption are underestimated, often grossly so; many such attempts fail. And the ClearPath Software Series removes the need for unique hardware.

Whichever approach is being considered, it is essential to evaluate the full financial impact of each one. Unisys has developed a model and an associated service for comparing the financial consequences of alternative strategies such as staying with ClearPath systems and enhancing them or moving to another platform. The next section provides a brief description of TCO modelling; a White Paper[^13] provides more details.

[^13]: ‘Understanding IT costs’, July 2014. The paper also explains TCO modelling and services.

http://www.unisys.com/offerings/high-end-servers/clearpath-systems/Whitepaper/understanding-it-cost-id-1845
**TCO Analysis**

Understanding the Total Cost of Ownership (TCO) of an installation is essential for rational decision making for cost management and investment. The TCO models are designed to provide a simple yet robust means of calculating the annual cost of running ClearPath and other systems, including all the cost components. The table below explains the data required in the models.

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Sub-component</th>
<th>Comments and explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Hardware</td>
<td>Systems and dedicated local storage for Live, Test and Development systems. Maintenance and installation cost are included.</td>
</tr>
<tr>
<td></td>
<td>Software</td>
<td>All the software necessary. Maintenance and upgrade costs are included as well.</td>
</tr>
<tr>
<td></td>
<td>Disaster recovery</td>
<td>Costs include the hardware, software, maintenance, power and other facilities.</td>
</tr>
<tr>
<td></td>
<td>Facilities/ occupancy</td>
<td>Power consumption for Live, DR, Test and Development systems. Includes also other facility costs, such as space used.</td>
</tr>
<tr>
<td>Connectivity</td>
<td></td>
<td>Intra- and inter-data centre communication between systems, but not general data centre LAN or WAN.</td>
</tr>
<tr>
<td>Personnel</td>
<td></td>
<td>People providing technical support, operations and their management. Full-time equivalents (FTEs) are used for personnel numbers, with fully-burdened costs. Includes facilities used, e.g. office space and PCs.</td>
</tr>
<tr>
<td>Applications</td>
<td>Products</td>
<td>Licence fees, maintenance and upgrade fees, and database storage e.g. in a SAN.</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
<td>Applications development, support and their management, including facilities used, e.g. office space and PCs.</td>
</tr>
</tbody>
</table>

The models address a number of different combinations of system, including ClearPath systems on their own, and distributed environments containing ClearPath and other system types. Models can also be prepared for environments without ClearPath systems. The latter can be used for comparison with ClearPath systems executing the same or similar workloads.

The models can generate a variety of results, including the following.

- The total cost including or excluding the contribution made by applications can be calculated, with a breakdown of the cost into its various components.
- The costs can be compared with the service level achievement as a contribution to a cost/effectiveness analysis.
- In order to connect the costs directly with the business of the organisation concerned, the models calculate the cost to process or produce specific business items. The nature of these items obviously depends on the business concerned but examples include air waybills created, bank accounts managed, insurance claims processed, vehicles manufactured and incidents handled by an emergency service. If appropriate, more than one item type can be used, for example accounts managed and account movements processed.

The results of a number of TCO analyses from clients in North and South America, Europe and Australasia show that ClearPath systems compare well with global industry averages\(^\text{14}\) for mainframes for cost of processor power and personnel. How do ClearPath systems compare with Unix, Windows and Linux systems? Unisys has performed a detailed analysis of a large, mission critical ClearPath environment and an equivalent environment running the same applications under either Windows or Linux. The TCO of the current environment was easy to calculate. The target configuration was derived using readily available industry data and comparison with similar environments. The ongoing TCO of the new configuration was roughly comparable with the ClearPath system environment. However, the cost of moving would be substantial, and security would become a concern.

For a comprehensive treatment of TCO modelling, and a discussion of the results of modelling, the reader is referred to the White Paper *Understand IT Costs*. A link to obtain the paper is provided in the Sources section of this paper.

\(^{14}\) The data are published by Gartner in ‘IT Key Metrics Data <year>’. They are produced for mainframes (mostly IBM zSeries), Unix, Windows and Linux. Gartner also produces a summary document covering several years, showing the trends in costs. Note that Gartner’s published key metrics include the infrastructure cost components – system, connectivity and personnel – but not applications.
Sources
This paper has made a number of references to sources of additional information. The most important are collected below for easy reference, together with some additional material.

Unisys Sources
The following White Papers and are published on the Unisys Website; the URLs are provided.

ClearPath as an Open System

Service-Oriented Architecture: ClearPath Systems in SOA

ClearPath Middleware Strategy and Products for OS 2200 Systems

ClearPath Middleware Strategy and Products for MCP Systems

Unisys ClearPath Systems: Integrated hardware/software stacks

Understanding IT Costs
http://www.unisys.com/offerings/high-end-servers/clearpath-systems/Whitepaper/understanding-it-cost-id-1845

ClearPath Enterprise Servers OS 2200: Security Overview

‘ClearPath MCP: Unsurpassed Security’

‘ClearPath OS 2200: Unsurpassed Security’
External Sources

The sources of the material below are external to Unisys,

The **Association for Computing Machinery (ACM)** is the source of some of the papers cited, and also of much other material. The Website is [http://www.acm.org](http://www.acm.org). The Queue magazine is free but the Communications of the ACM (CACM) is by membership subscription, or individual articles can be purchased.

**Gartner**, Inc has a great deal of material, including industry benchmark metrics. Gartner also provides custom benchmarking and other consultancy. See [http://www.gartner.com](http://www.gartner.com)


**Microsoft**: Information about Hyper-V can be found at [https://docs.microsoft.com/en-us/windows-server/virtualization/hyper-v/hyper-v-server-2016](https://docs.microsoft.com/en-us/windows-server/virtualization/hyper-v/hyper-v-server-2016)


The **Standish Group** publishes the Chaos Report and has long been concerned with the cost of IT project failure. See [http://www.standishgroup.com/outline](http://www.standishgroup.com/outline) for a summary of the 2016 report.


**VMware**: Details of VMware products can be found at [https://www.vmware.com/](https://www.vmware.com/)

Appendix: The Integrated Stack

What do we mean by an integrated stack? To answer this question, consider first the major components within any computer system, as shown in figure A1.

Figure A1: The components of a computer system. The software has been grouped into a small number of functional categories

The five components at the centre manage the applications and their interactions with data stores, and external systems. They are:

- file and database management
- transport and communications
- middleware
- application environments
- compilers and utilities
The other two components shown at the sides provide services to all the above four components:

- systems management and recovery
- security

All the components run under the operating system.

The software runs in what in figure A1 is called ‘machine architecture’, which provides key functions such as the instruction set and memory management. The machine architecture may be supplied by the hardware platform, as it was in ClearPath systems with Unisys-designed chips, or implemented in firmware, which provides the machine architecture within some other hardware platform. In ClearPath Forward systems, the firmware providing the Dorado or Libra architecture runs in an Intel platform.

Two of the most common approaches for delivering a system are:

- The *Multi-Source model*, where the machine architecture and software are obtained from a number of suppliers, each of which is regarded as the best or most cost/effective option; the term ‘best of breed’ is often used when selecting products.
- The *Integrated Stack model*, where the machine architecture and most or all of the software are designed, developed, integrated and tested before delivery by a single organisation.

The Multi-Source model grew up during the 1980s and 90s, and dominated thinking for a long time because of the assumed benefits of the approach. In particular, a choice of software components such as database managers and application servers led to the view that costs would be lower without any significant sacrifice in performance. However, significant complications became apparent with the Multi-source model, especially in the level of integration effort required initially and on component upgrades, and security weaknesses. The cost advantages have frequently proved illusory.

The Integrated Stack model, typified by the approach taken for ClearPath systems over decades, offers considerable benefits:

- The machine architecture (i.e. the firmware for ClearPath Forward) and software are designed, developed, integrated and tested together before shipment, substantially reducing or even eliminating the client’s integration and test effort.
- The approach optimises performance, availability, reliability and especially security, as all the components come from trusted sources.
- Owning both the software and machine architecture (firmware) enables changes to the firmware as well as software to optimise the complete system. Examples include:
  - Moving functions between software components
  - Implementing special functions in firmware
  - Specialised interfaces between components, based on a firmware/software combination
- ClearPath users do not need to change applications with new firmware and/or software releases, reducing costs and simplifying deployment.
- There is one licensing model and a single support contact for both software and firmware. If Unisys supplies the hardware platform as well as the firmware/software, the single support extends to the hardware as well.
About the Author

Now an independent consultant, Peter Bye was a systems architect in Unisys, based in London. His special area of interest is networked computing, including communications networking, middleware, and architectures. He has many years of experience in information technology, working as a programmer, analyst, team leader, project manager and consultant in large-scale projects in banking, transportation, telecommunications and government. He has also worked in software development centres, during which time he spent two years as a member of an international standards committee working on systems management.

He has worked for extended periods in Sweden, Denmark, Finland, Norway, the USA, France and Spain, as well as the UK. He has presented at a wide variety of conferences and other events, and is the author of a number of papers on networking, systems management and middleware. He is the co-author of a book on middleware and system integration – *IT Architectures and Middleware: Strategies for Building Large, Integrated Systems (2nd Edition)* – which was published by Addison-Wesley.

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