FUJITSU

White Paper
Software-Defined Data Center – infrastructure for enterprise digital transformation

Over the years the trend toward virtualization revolutionized data centers, but it did not change the hardware-centric architecture that still serves as the basis for most data centers today. This could radically change in light of the latest software-defined approaches. Strategy, organization, technology: This white paper serves as a source of orientation for IT managers confronted with software-defined data center concepts.

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Introduction

People, information, processes, things, infrastructures and computers are being connected with each other in networks more than ever before. At the same time, developments like the Internet of Things (IoT), Virtual Reality and Augmented Reality are enabling the merging of virtual and real worlds. Information technology (IT) is thus having a growing impact on our lives – both private and professional. This overall process is also changing IT infrastructures at a rapid pace. The wave of virtualization evident in recent years was probably just the beginning of a development that is now leading to the establishment of the Software-Defined Data Center (SDDC).

This white paper serves as a source of orientation when it comes to software-defined data center concepts.

This paper outlines the differences between today's hardware-centric data center architectures and the architectures found in the SDDC.

It also sheds light on the changes that can be expected with SDDC deployment in terms of human resources, investments and operating costs as compared to the traditional IT infrastructures in use today.

Overview of the architecture model

Traditional model

To date the typical data center infrastructure has been based on servers, a network and storage, plus disaster recovery functions so that daily business operations are protected from outages.

This model has worked quite well and offers a number of benefits – for example, it is flexible and can cope with various workloads and processes. However, in many cases these benefits carry a high price. Administration is a very demanding task which requires specialized personnel with specified certification in many cases. Furthermore, some workloads may require the implementation of specific systems and elaborate security concepts. Quite often customers must learn to live with vendor lock-in, especially when it comes to networks.

A key aspect in the deployment and operation of data centers today is the heavy personnel workload involved – this is evident from the start with installation and the provisioning of technology. The physical systems need to be evaluated, selected, and ordered – once delivered, they must be unpacked, installed, connected with cables and put into operation. Then the software products can be installed, such as the virtualization layer with all the required components and configurations. And this is just one example among many.

These facts are not new and are just as valid as ever: They show that data center operations require a lot of personnel, time and money. In addition, strict management is necessary to kept budgets and planning under control. Otherwise potential project risks can be quite serious – for example, schedule delays, missing or faulty functions, and thus even more work and eventual expense. Such problems will quickly impact business, leading to quality or performance issues, not to mention declining customer satisfaction, image loss and lower revenue.

IT managers are faced with a dilemma: Despite the high levels of complexity and diverse challenges in the data center, the business world (both internal and external) takes the full availability of IT for granted and accepts no compromises. When problems arise, IT managers have the unpleasant task of trying to explain the details in lengthy discussions with business managers.

Can a Software-Defined Data Center change any of this? If so, how?

Software-Defined Data Center

The term Software-Defined Data Center (SDDC) describes the virtualization of data center operations in which a software layer is applied over the physical IT infrastructure. Virtualization itself is not new, but SDDC goes one step further.

Whereas the virtualization of servers, storage systems, network and security has been partially (or in rare cases even completely) implemented in data centers, SDDC now adds a so-called abstraction layer which automates and simplifies the management, control and provisioning of the IT infrastructure. The aim of this concept is to build a completely virtualized and software-controlled IT infrastructure.

When compared with today's data center operations, this concept involves quite a number of changes: For example, the resources required by the business can be made available very quickly – the process is automated and under the control of the IT department.

When appropriate software is installed, the administration workload is reduced dramatically or – in some cases – completely eliminated. Tasks such as

- Installation,
- Operation,
- Monitoring,
- Maintenance and Enhancement

of the IT infrastructure can even be shifted to other areas, such as the operating level.

What's more, automated provisioning enables users (such as specialist departments) to allocate resources themselves in compliance with predefined guidelines – they do not need to contact the IT department in such cases.

The SDDC concept also offers the potential of providing internal and external customers with IT as a Service. This is additionally supported by the fact that servers are used as the basic systems in a SDDC. Whereas the traditional data center model is based on the separate planning, purchasing and operation of servers and storage systems, the SDDC knows only one kind of system – the server.

The SDDC concept changes both the physical infrastructure and the processes of the data center – and thus influences the IT strategy. With this in mind, this white paper will address a number of factors that are vital to strategic decision-making:

- Capacity management
- Software strategy
- Investment and operating costs
- Operational costs

The SDDC also enables applications to autonomously provision IT resources. Since an application can dynamically call for the allocation of resources based on requirements (e.g., faster buffer storage, more computing power, etc.), there is no need to keep specially optimized infrastructures for eventual deployment. This is known as the composable infrastructure concept. This aspect of the SDDC is relatively new and is growing in importance. Application providers will most likely take advantage of any new opportunities stemming from the composable infrastructure.

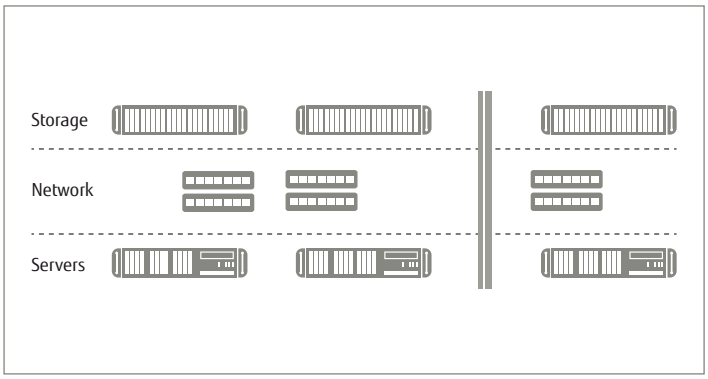


Fig. 1: Infrastructure layers in the traditional data center

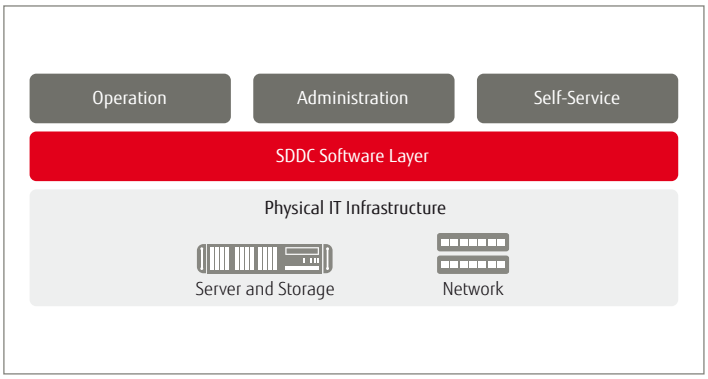


Fig. 2: Schematic structure of the SDDC

Strategic aspects of the transformation to SDDC

Capacity management

As always, the primary purpose of the SDDC is to provide users, specialist departments and customers with the resources they request – including all of the configurations that are required – as quickly as possible. This process must be very simple and automated.

This is a core aspect in the strategic direction that demands appropriate process changes: Whereas traditional models often involve investments in technology and software in line with project or life-cycle factors, the SDDC allows for a dynamic and constant review of resource requirements.

The software that manages the system determines just how many compute, network, storage and security resources will be available before any investments in enhancements or extensions are necessary. This prognosis needs to be included in the budget planning of the actual fiscal year.

At first this may seem like a lot of work. However, this approach opens the door to real performance-based budgeting when it comes to Capex and Opex. When compared with traditional budgeting based on annual figures, this new approach supports dynamic budgeting based on concrete and constantly updated prognosis data.

Integrated systems and software products from various manufacturers are available to support this dynamic planning process. With these products IT departments can easily compare the demands of the business with the infrastructure resources that are available. Threshold values need to be defined in order to optimize peak load resources (e.g., for seasonal fluctuations in retail, which require additional resources).

When first taking this approach, the proportionate costs of an SDDC infrastructure should be broken down in accordance with the IT resources typically available in an enterprise – for example, as costs per virtual machine, costs per bandwidth or costs per GB or TB.

Billing functions can then be used for a relatively easy and effective way of determining costs across all of the cost centers in an enterprise, or to adjust the monthly costs of services provided to the customer. This comes very close to many pay-per-use models.

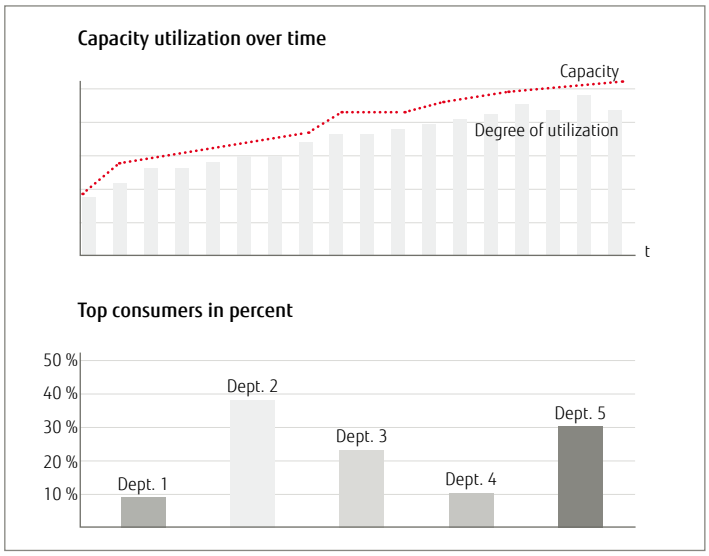


Fig. 3: The SDDC allows for planning with constantly updated figures

Software strategy

Despite advancements in standardization, data centers usually grow and expand in many different ways depending on diverse project requirements – thus all kinds of architectures and solutions can be found in these data centers. Depending on the application scenario, it is not unusual to find hardware and software solutions from various manufacturers deployed in one data center. For example, many data centers use virtualization solutions from both VMware and Microsoft®. In most cases one of the two solutions has a "lead function" role – in other words, it comprises a higher share of the data center. This occurs for reasons of technology, or due to licensing agreements (e.g., Enterprise License Agreement) with a specific provider.

When it comes to the SDDC, enterprises will follow different paths by taking either a multi-vendor or single-vendor approach. Whereas the selection of hardware should be discussed separately, enterprises should definitely evaluate the software solutions required for the SDDC well in advance in order to fully understand the possible advantages and disadvantages.

Multi-vendor approach

This approach is based on an intentional decision favoring the integration of hypervisor technologies and related additional components from several manufacturers.

The objective is to bring together various products such as virtualized servers, storage systems and networks "under one roof". Depending on the range of systems involved, this approach can have the character of a long-term project because, in most cases, complex planning phases are necessary.

It should be remembered that heterogeneous IT landscapes having some virtualization represent a major challenge, especially when it comes to service levels and security – and sometimes issues are never fully resolved. In such IT environments it is also more difficult to control application performance and integrate external cloud services. For the latter an interface specific to the chosen provider is used to automatically provision the resources required.

These IT environments also must have a multi-vendor-enabled management platform.

The advantage of this strategy is having a variety of providers under one roof with centralized management – while also not having to replace most of the technology platform(s) already installed in the data center.

The disadvantage is extreme complexity as well as time-consuming implementation. Generally speaking, additional resources should also be included in planning to ensure that required measures can be carried out while the systems as such are usually in productive mode.

All of this means that in almost every case the services of IT consultants and specialists will be required because any do-it-yourself approaches are far too risky.

Single-vendor approach

Once the virtualization vendor has been chosen, you can expect that the virtualization solutions available from that vendor have already been orchestrated and harmonized as a matter of course.

Whereas the main focus of the multi-vendor strategy is on the integration of heterogeneous systems in the infrastructure, the single-vendor approach intervenes in an existing infrastructure only if absolutely necessary.

By deploying integrated systems like the FUJITSU Integrated System PRIMEFLEX for VMware Cloud Foundation, the single-vendor approach ensures a smooth data center transformation, with minimum impact on the existing landscape, and it does not strain the IT budget.

Each building block contains harmonized and functionally tested components. Servers and storage technologies are now typically merged and offered as server-based storage that includes network components.

Such building blocks are preinstalled, preintegrated and equipped with all required software components before they are shipped from the factory. This speeds up initial start-up and enables IT departments to "go productive" very fast. Extendability, operation and maintenance are made extremely simple, and standardization is sustainably promoted.

The software components necessary for automation and for self-service portals are usually included in the solutions already or can be installed later.

The advantages of a single-vendor SDDC include:

- Fewer human resources
- Little change to existing infrastructures
- Prevention of business outages
- IT infrastructure standardization

Remember that investments can be made according to typical budget cycles by successively replacing obsolete systems with new building blocks. Thus the implementation time intervals for a complete transition to an SDDC-based operations concept are longer than those for the multi-vendor approach.

Dependence on one software vendor can be seen as a lock-in factor – in reality, however, this concept allows for the independent deployment of similar systems from different vendors – all under one SDDC roof.

It should also be noted that many vendors are now offering a number of technology concepts. In the years ahead consolidation can be expected. Of course, all of this adds uncertainty to the decision-making process when trying to determine which technology is best to ensure a future-proof data center. The following factors should be taken into consideration before making a choice:

- **Integration depth of the technology:** Is the solution simply added on top of the virtualization platform (e.g., in the form of a virtual machine), or does the solution offer deep and fundamental integration of the components with each other?

- **Solution offering:** Is only one kind of solution available, or does the vendor have a complete portfolio ranging from hardware to integrated solutions and even cloud offerings?

- **Network virtualization:** Is this supported from end-to-end? Can cost-intensive systems like load balancers, firewalls, routers, etc. be created virtually and operated without hassles in order to reduce costs?

- **Scalability:** What about reference installations, and how extensive is the degree of solution scalability? Feel free to contact reference customers and ask them about their experiences.

- **Test scenarios:** If you have decided in favor of a PoC, then be sure to test it! What is the load behavior of the planned solution like when the individual systems generate high loads? Test the performance with both random and sequential accesses. See if the individual nodes can be configured easily – both in and out. What happens if one or two machines fail? How is performance affected when machines are migrated from left to right and then back again? How easy is the integration of cloud services?

- **Support:** What kind of support/SLAs can you expect? If you operate at international level, which countries are supported, and which SLAs are valid at specific sites? These could vary widely. Does the vendor also have expertise related to the virtualization layer, or does the vendor rely on another separate company to provide service in this area? If a problem arises, how can "vendor ping-pong" be avoided so that a viable remedy can be found as quickly as possible?

- **Investments and Costs:** How high will the entire investment be? How will maintenance costs develop over 3, 5 and 7 years? Remember that many vendors grant enormous discounts – especially for new customers – in order to make a solution attractive. Quite often these parameters change over time once a solution has been in operation. Calculate the TCO. Also look at the vendor's reputation in the market. How long has this manufacturer been in business, and what kind of road map does the company have for the years ahead? How stable is the vendor's business – remember that the business failure of your vendor would mean a loss of support for your solution. This could lead to unexpected investments and costs because you would be forced to find a way to protect your business-critical infrastructure by switching immediately to another vendor.

This list is by no means complete, but it does give you an impression of what can be relevant when making your final decision.

Take the time you need for a complete evaluation BEFORE integrating any solution. Test runs are valuable tools that should be employed before a solution is selected and put into productive operation.

Once you have decided to migrate from a traditional hardware-defined data center to an SDDC, the next essential step involves the adoption of a single-vendor or multi-vendor strategy. This is absolutely critical because changing this decision at some later date will involve considerable investments, costs and resources, not to mention extensive support from internal and external personnel.

You should consider the following aspects:

- Time frame for the planned transition
- Internal human resources needed
- Need for external support
- Expertise available and know-how gaps
- Complexity of the migration relative to later operations
- Ability of the infrastructure to quickly support business requirements
- Capex/Opex calculations
- Future-proof qualities
- Implementation of new technologies

Organization

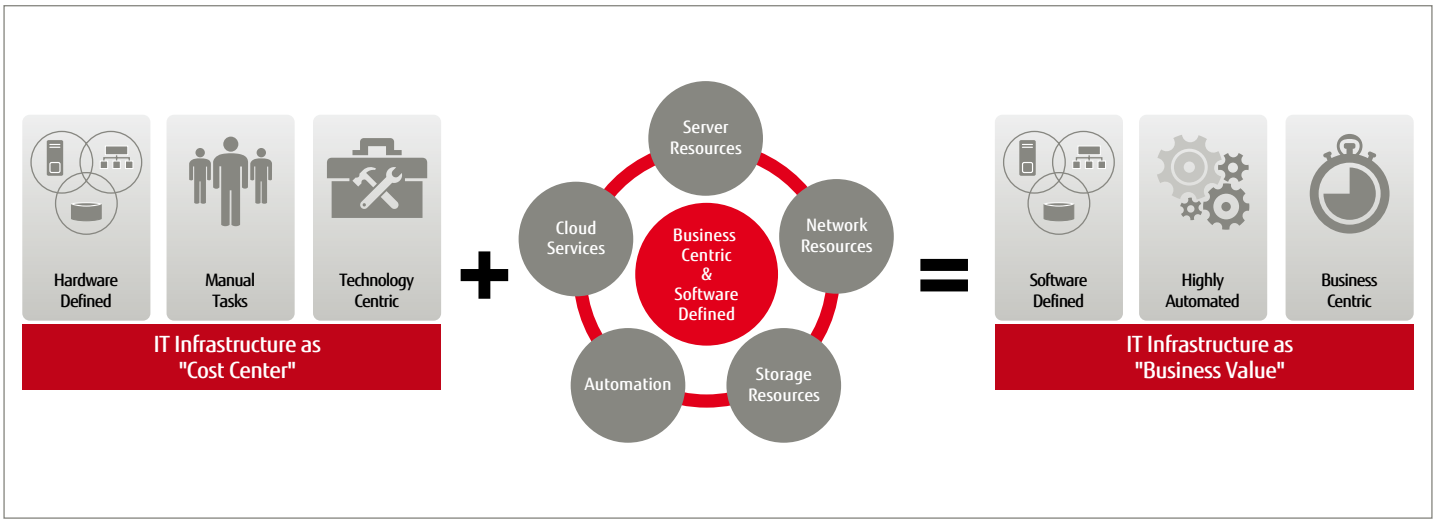
The organization of IT, especially in terms of employees, deserves special attention. Some processes and procedures change perspectively in a software-defined environment. Whereas the operation of traditional infrastructures is often based on distributed tasks when it comes to servers, storage and networks, most software-defined environments are operated by closely-knit teams of employees who work and act together, even across various job functions.

Responsibilities of relevance to software-defined systems are increasingly being defined by virtual roles (administrators for the network, storage, etc.) and can also be distributed. For example, the role of "VDI Administrator" could be created and have automatic rights for the automatic configuration of the areas mentioned above (servers, storage, network). That does not represent a contradiction because system-relevant configurations are conducted in line with software-supported methods – these tasks no longer involve manual intervention. This means that even those employees who do not have network-specific training will be able to carry out software-supported tasks.

That is a positive aspect, but it should be remembered that a process must first be initiated and managed. Another aspect: in recent years most users have discovered that server and storage systems can be replaced without having to rely on one exclusive manufacturer – however, when it comes to networks, vendor lock-in is still the market norm. Administrators have earned certification and know how to manage this sector with high levels of expertise. Thus it is important for IT managers to understand the value that such certifications (e.g., CCNE) have for employees, and that this can have considerable impact on employee acceptance of the massive changes that can result from the transition to an SDDC strategy. At the same time, top experts will be required to manage the transformation and establish the new structures.

Experience has shown how important it is to set the direction early and have the affected employees fully on board. Software-defined structures represent one way of relieving employees from standard routine tasks like system evaluation, installation, operation and maintenance – they can then spend their time on the further development and support of key fields of business (in line with digital transformation). This changes the character of IT operations – rather than a cost center, they are viewed as business value – and this leads to a higher degree of acceptance at management level. Powerful IT is increasingly being perceived as the essential backbone needed for doing business.

In a world where everything is focused on the customer, and in which the speed of innovation processes is driven more by the market and less by business enterprises, an effective and flexible infrastructure and IT organization is absolutely vital.



Investment and operating costs

It goes without saying that investments and operating costs are parameters of strategic relevance. In order to accurately compare traditional hardware-defined data centers with the SDDC concept, the following sections of this white paper are focused on the network/security, storage and server infrastructure levels. This is important because various procedural approaches are usually applied to the individual infrastructure levels.

Traditional IT infrastructure

1. Network and security:

The network is generally the IT infrastructure component that has the longest life – there are several reasons for this:

- Bandwidths continue to expand, but they do not always have to be changed in response to the current business model cycle, because this seldom results in any tangible and positive effects. The network stack only needs to be evaluated when new business requirements arise, such as Big Data, IoT or Software-Defined Anything.
- The network represents one of the most business-critical areas. It often grows over time in symbiosis with network security aspects (e.g. VLAN, firewalling, intrusion detection/prevention or load balancing). Any changes made usually lead to higher risks in terms of defined service levels or – with 24/7 operations – higher planning and project costs (keyword: online migration).
- When it comes to the network stack, enterprises usually rely on one vendor and employees who have special training and experience. Business enterprises expect that various types of systems from one vendor function seamlessly and smoothly with each other and are thus willing to accept vendor lock-in. However, when it comes to security components, enterprises focus much greater attention on functionality and are thus willing to deploy solutions from third-party vendors.
- Network maintenance costs are calculated over a period of several years and are accepted by enterprises because of the extreme importance of the network in the overall infrastructure.

Generally speaking, network investments involve expansion to keep pace with growing requirements, and targeted updates – for example, when increased bandwidths are necessary in specific areas of the infrastructure.

2. Storage

When evaluating investments and operating costs, the most interesting component in traditional data centers is storage. Storage systems are usually purchased in specified cycles, the scope and length of which are defined according to the following factors:

- Maintenance contract agreed with the vendor
- Need for new technology, capacity and/or performance

The purchasing processes for storage systems are far more complex than those for (standard) server systems. The estimation of the storage capacity needed in the future, not to mention performance levels, is a very challenging task. Investments and costs can only be discussed on the basis of this data – it would not make any sense to buy a storage system – even if the price were right – if the system is not precisely suited for the job it needs to do. Purchasing standard servers is much different because various vendors generally offer the same levels of performance and functionality, a fact which thus puts a sharper focus on price.

It must be remembered that storage systems are often the central building block in the overall IT concept, and that they support business continuity at two or more sites simultaneously. That is why they must be designed to deliver ample performance. In any event, investment protection and future-proof technology are matters of great importance to business enterprises.

In traditional IT environments, the willingness to switch to another storage vendor is not very high. Required interventions in existing infrastructures, existing licenses, backup and disaster-recovery concepts, and existing know-how are factors that tend to deter enterprises from switching to new vendors or providers.

In real practice, after procurement has been completed, enterprises often discover that there is a disparity between investment and operating costs on the one hand, and the actual performance delivered on the other. Either they have invested in an over-dimensioned system, or they soon reach capacity and performance limits, a fact which forces them to spend money on upgrades. And that is not all: Changes in capacity and performance requirements will be even more difficult to forecast in the future – and that will boost interest in alternative storage strategies and concepts.

3. Servers

Servers are the workhorses of IT. Enterprises view them as a commodity. Servers must function reliably and must feature easy integration in existing IT landscapes in terms of hardware and software. The following factors are key when choosing servers:

- Purpose of deployment
- Integration and extension capability
- Purchase and maintenance costs

The enhancement or extendability features of a server are often overrated. Due to the high pace of technology development, servers become obsolete rather quickly. That's why upgrading existing systems is not always a good idea – the costs may not be justified.

Reliability is another vital factor, but customers have come to expect that servers are extremely reliable, especially those from brand-name manufacturers. However, there are significant differences among server systems.

The virtualization of infrastructures normally compensates for any failures of individual servers, but you should be aware of the fact that the failure of a server in a virtualized environment will result in some downtime for the virtual systems running on the affected machine. This downtime can also be somewhat lengthy for databases, for example, if the outage requires the subsequent restoration of database consistency before the system goes online again. Thus it is important to choose systems from a vendor known for low failure rates.

The situation is different when it comes to highly specialized tasks such as in-memory computing or dynamic load balancing without interrupting online operations, as offered by the Fujitsu PRIMEQUEST series. The performance range of such systems is so high that the alternative operation of a particular application on a virtualized infrastructure is not economically feasible – and in some cases not even possible from the technology standpoint.

Thus even unexpected investments in standard servers can be forecast with a certain degree of accuracy during budget planning. What's more, approval processes can be accelerated or even avoided altogether as opposed to procurement processes in the traditional storage segment. This is not usually the case for specialized systems or blade centers because these systems have relatively high purchase prices when compared with standard systems.

There are also many older server systems in use that continue to perform specific tasks year for year. Though they may be old and not up to current performance and energy-consumption standards, these systems can be run to fulfill a specific purpose as long as necessary or possible. For operators these systems are key IT budgetary factors because they do not involve any investment or amortization – only the costs of operation are significant.

4. Summary

The situations in traditional data centers differ considerably depending on the infrastructure level. When leveraging the competition among market providers (which involves the serious readiness to switch vendors if need be), the investment intervals and required funding can be summarized as follows:

	Competitive intensity/ Readiness to switch vendors	Investment interval	Funding level
Network	Low	Long-term or as needed	Medium to High
Storage	Moderate	Regularly	Medium to High
Servers (Standard)	High	Medium and as needed	Low

Software-Defined Data Center (SDDC)

1. Network and security

The network stack plays an important role in traditional data center concepts. In the SDDC, by contrast, the network is merely a "means to an end." It is characterized by the following core elements:

- High reliability and availability
- Intelligence that allows an easy enhancement of network capabilities
- Configuration and control processes based on software

The availability and reliability requirements are no different than those in the traditional data center approach because they are of central importance to all kinds of enterprises.

One key difference, however, is the way that network components are managed. In the SDDC this is accomplished through software, which also creates the SDDC abstraction layer. Basically the network virtualization takes place on the level of the so-called top-of-rack switches. For example, an expensive core switch is no long required, and in light of the high bandwidths would make no sense in terms of cost.

Another distinguishing aspect of the SDDC as opposed to traditional approaches is the ability of the SDDC to tie all security-relevant features to the virtual machine itself. This significantly increases security, especially with regard to minimizing or even preventing human error (e.g., from inadequate configuration). In the traditional approach this is hardly possible and, if at all, then only with additional products that can require a high degree of administration.

The SDDC raises the bar for network security to a much higher level: The traditional model relies on a "security onion skin" with which security primarily supports itself on the network during external access control, before transporting the data into the virtualized networks of the individual systems. By contrast, in the SDDC all security aspects are transported to the individual (virtual) machines.

If, for example, virtual machines are shifted among various networks, perhaps to another site, the SDDC automatically makes the required network and security settings. In traditional environments, administrators may have to perform preliminary or follow-up tasks as needed. If these tasks are not carried out, security issues arise in the area of access protection, or the virtual machine does not function at the new site – or it may deliver substandard performance.

This has a significant impact on the technology and the qualified personnel that must be on standby to take appropriate action – and that increases operating costs.

Another lever for reducing Opex-relevant factors involves preintegrated and preinstalled solutions like the FUJITSU Integrated System PRIMEFLEX for VMware Cloud Foundation. These are complete solutions for enterprises and are fully harmonized, wired, preinstalled and tested before delivery, and they already include all of the software components that are required. Among the advantages of such complete solutions is fast setup and initial operation, plus easy extendability. No human resources are required to unpack, install and cable the physical systems, nor is there any need to deploy software. In addition to fast go-live productive operation and operational cost savings, vendors mitigate risks by making sure their systems are tested and validated.

2. Storage

In the pure SDDC model required storage capacity is not provided by one central system, but rather by the installed servers themselves. This is known as Direct Attached Storage (DAS).

As described earlier, a software layer is placed over the physical systems – this layer centrally manages and represents the combined storage resources of the individual servers. When compared with traditional approaches, SDDC-based provisioning of storage capacity has a number of advantages:

- Process for selecting the "right" storage system: The complex and risky process of selecting storage systems has already been analyzed in detail. This kind of storage system is not found in the pure SDDC-based approach.

- Scalability: Whereas scalability and extendability in the traditional model are achieved by selecting larger or smaller storage units, SDDC-based systems are scaled linearly by adding more servers. That is true for storage capacity and for performance as well. This is known as "scale out" – but when small storage systems are replaced by larger ones, we call this process "scale up." Generally speaking, scale-out models offer more advantages than scale-up models.

- Budget: Investments and operating costs in the SDDC are typically lower than those for traditional data center models because server-based systems are deployed. All of these costs are very easy to plan and invoice internally.

  In addition to cost factors, SDDC procurement processes are also easier and faster because standard servers are used rather than complex and expensive storage units. Standard servers also do not entail any long or complex selection processes.

- Functionality: Until recently SDDC-based systems were not favored over traditional environments when it came to moving databases to other sites or the synchronous mirroring of data. However, this weakness was quickly resolved through new software developments and solutions. Now more than two sites can be mirrored synchronously and supported with Oracle® databases or the Windows® Server Failover Cluster. This makes distributed failover data centers in the SDDC sector more attractive to business enterprises.

The SDDC model also has another plus point: Whereas the (further) development of technology was the main focus of the model to date, the software-defined model is able to create faster innovation cycles within software functionalities which can often be applied to existing technology. Thus the pressure on enterprise IT to promote innovation through investments in new hardware is reduced significantly, and it will be successively superseded by faster innovation cycles based on software.

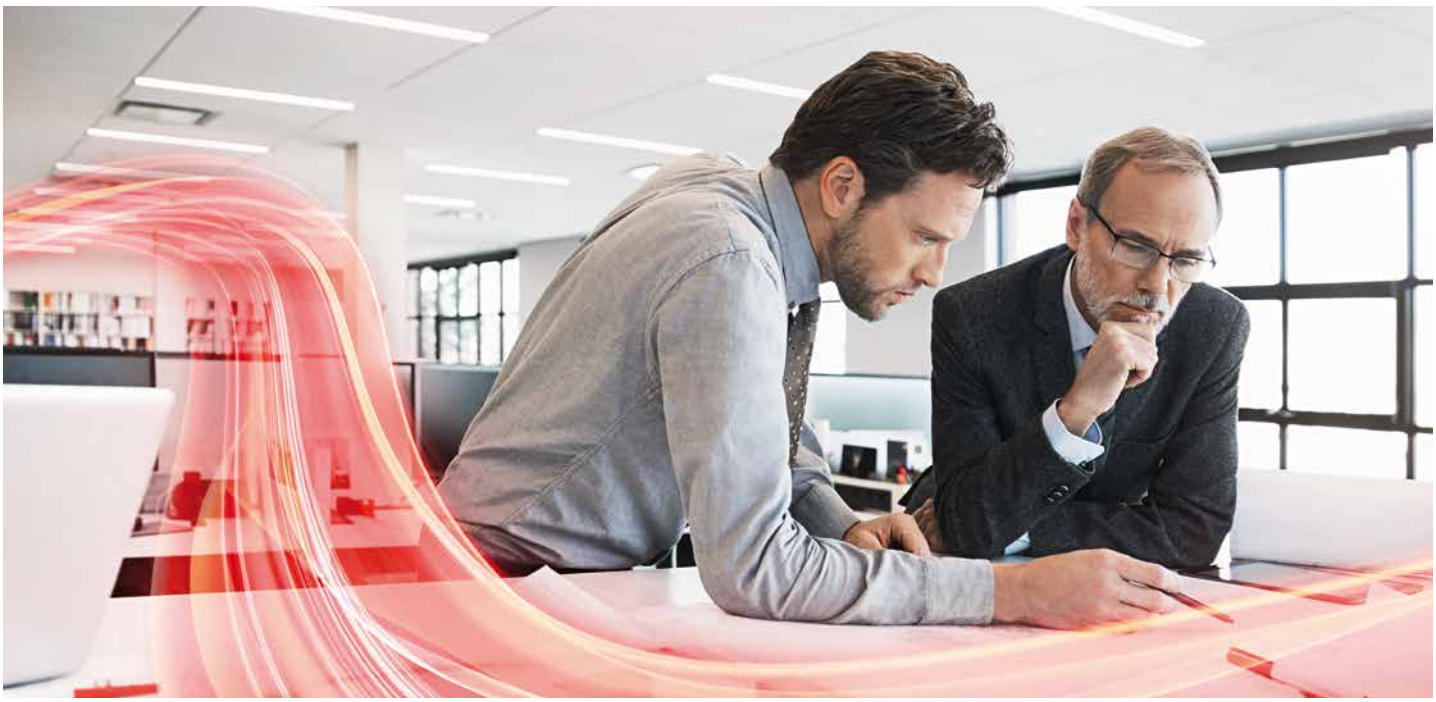
Nevertheless, enterprises will still have to carefully evaluate the road maps of their SDDC providers to determine the feasibility of vendors' plans for further development. This will enable enterprises to enhance their business processes with newly developed functionalities in the future without having to make any new investments.

3. Servers

As described earlier in the storage section of this white paper, servers provide the SDDC infrastructure with computing- and I/O-performance, memory and storage capacity.

For optimal results, it is important that all systems in a defined cluster configuration have the same features and equipment. This is necessary because the overarching software layer must equally distribute productive loads. Of course, various manufacturers offer mechanisms that attempt to balance and "smooth out" the differences in technology. Since vendors usually try to find the least common denominator with this approach, new systems should be designed as a specific cluster and, if possible, not added to an existing cluster of older machines.

This means that planning and budget managers will not have to worry about any issues stemming from systems delivering different levels of performance. The only exception to this rule are systems intended for very specialized tasks (as described earlier in this white paper).



Benefits and limitations of SDDC

Today the SDDC is already a model that must be taken into consideration when strategically planning the future development of the data center. The SDDC is here to stay. Of course, each enterprise must evaluate the advantages and limitations of this concept in relation to specific requirements.

Degree of virtualization

No matter the degree of virtualization already achieved by a business enterprise, the introduction of the SDDC model will quickly and efficiently boost computing, storage, network and security performance by up to nearly 100 percent. This is currently not viable for specialized applications like in-memory databases or applications linked to physical machines. For example, the availability of in-memory solutions like SAP® HANA can be enhanced, but due to the high resource requirements and the virtualized layer, this is usually detrimental to performance. A vendor like Fujitsu, who can address any kind of requirement, is thus the perfect partner for data centers in general and for SDDC concepts in particular.

Time frame

SDDC is a concept that requires a fair amount of time for deployment. It can take several years to set up an SDDC environment, especially if budget conformity is a high priority. SDDC deployment is ideal for environments that have extensive deficits in innovation and which require major investment no matter what steps are taken to optimize operations. For example, a massive in-sourcing project that includes keeping an older IT infrastructure intact would be a good opportunity for considering the adoption of the SDDC model.

Dependencies

The SDDC can reduce or even prevent vendor lock-in when it comes to technology. The reason for this is the major shift toward software. A clear and firm strategy that defines the software to be deployed is the basis for successful migration to the SDDC.

Peripheral aspects

SDDC solutions often have an option for replicating hardware-based systems – like load balancers, routers, switches, etc. – in the software. Since purchasing such physical systems can involve five- or six-figure expenditures, this factor should be included in the ROI/TCO analysis.

Human resources

The know-how and personnel required for the installation of an SDDC depends on whether a single-vendor or multi-vendor strategy is being followed.

Generally speaking, the single-vendor approach requires fewer human resources because a large share of the required know-how is based on software that is designed to harmonize smoothly with the technology. This should be taken into consideration before making the single-vendor/multi-vendor decision, especially in terms of future enhancements.

It should also be noted that an SDDC-based environment also has lower demands when it comes to installation, extension, operation and maintenance.

Capex/Opex in relation to components and complexity

The purpose of the SDDC-based approach is to create a completely virtualized and software-based IT infrastructure. Once installed, this landscape will typically have much fewer components than a traditional model. This will be most evident where storage systems and networks are concerned.

The results are:

- Lower investments
- Lower operating costs
- Lower maintenance costs
- Dramatic reductions in complexity
- Better personnel planning and less required training
- Higher degree of standardization and virtualization
- Better security thanks to network virtualization

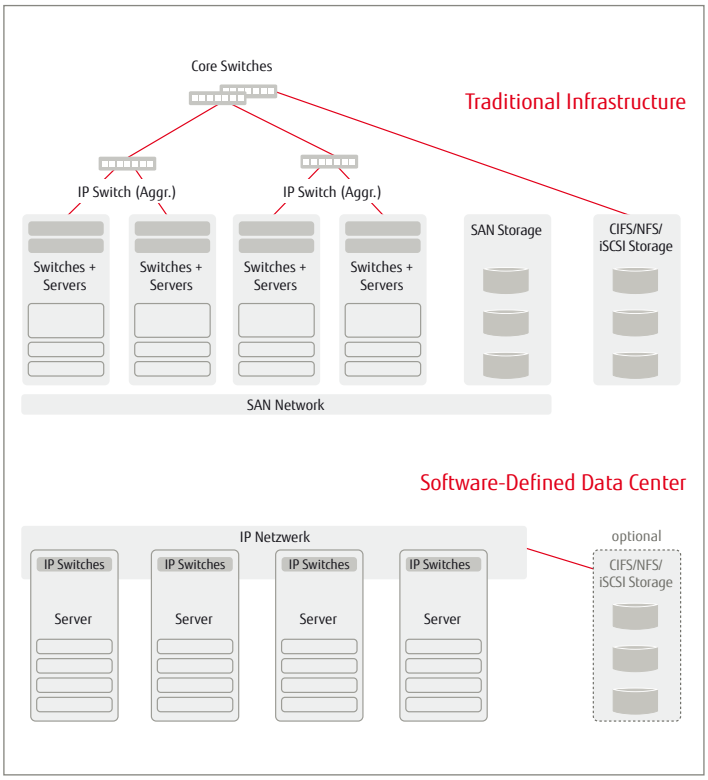


Fig. 4: The SDDC dramatically reduces complexity

Fujitsu – your partner for future-proof data centers

To create value in a world that continues to expand in terms of hyper connectivity, business enterprises must focus on the needs, capabilities and creativity of every single individual. In its role as innovation partner, Fujitsu helps customers by combining industry know-how with technology know-how that is supported by a complete product and solution portfolio.

Especially when it comes to making sure that data centers are ready for the challenges of the digital age, we stand by our customers and support them with our in-depth expertise and leadership in data center optimization and transformation. We have just the right operating model for every IT strategy, and our market-leading solutions serve as the foundation for future-proof data center environments.

Examples are PRIMEFLEX for VMware vSphere, PRIMEFLEX for VMware vSAN, PRIMEFLEX for VMware Cloud Foundation, PRIMEFLEX for Microsoft Azure Stack HCI, PRIMEFLEX for Microsoft Azure Stack Hub and PRIMEFLEX for Nutanix Enterprise Cloud. These complete solutions enable customers to achieve transformation much faster and with more ease – and they benefit from our vast experience in innovation. Here are some examples:

- Fujitsu servers offer the best energy efficiency. The machines regularly achieve top positions, such as first-place rankings in the independent SPECpower_ssj2008 benchmark.
- Fujitsu servers are known for reliability and have the lowest outage rates in the market.
- Energy efficiency and performance go hand in hand. For example, take the VMmark benchmark developed by VMware as an unbiased method of appraising the potential performance of a computer system deployed in virtualization and cloud scenarios. Fujitsu servers have a long track record of continuous outstanding benchmark results. They enjoy the longest leadership positions in most of the VMware VMmark 2.x benchmark categories and continue to lead in VMmark 3.x. This is quite remarkable because critical performance-relevant components such as processors come from other manufacturers (e.g., Intel®) and are thus identical for all server vendors.
- At the end of product life cycles, Fujitsu takes responsibility for system disposal and has achieved a recycling rate of more than 90 percent, well above the legally mandated rate of 75 percent.

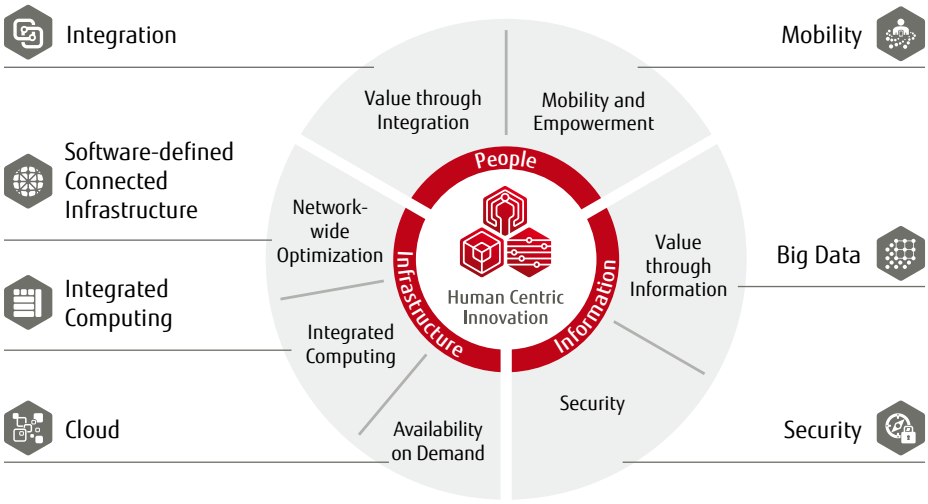
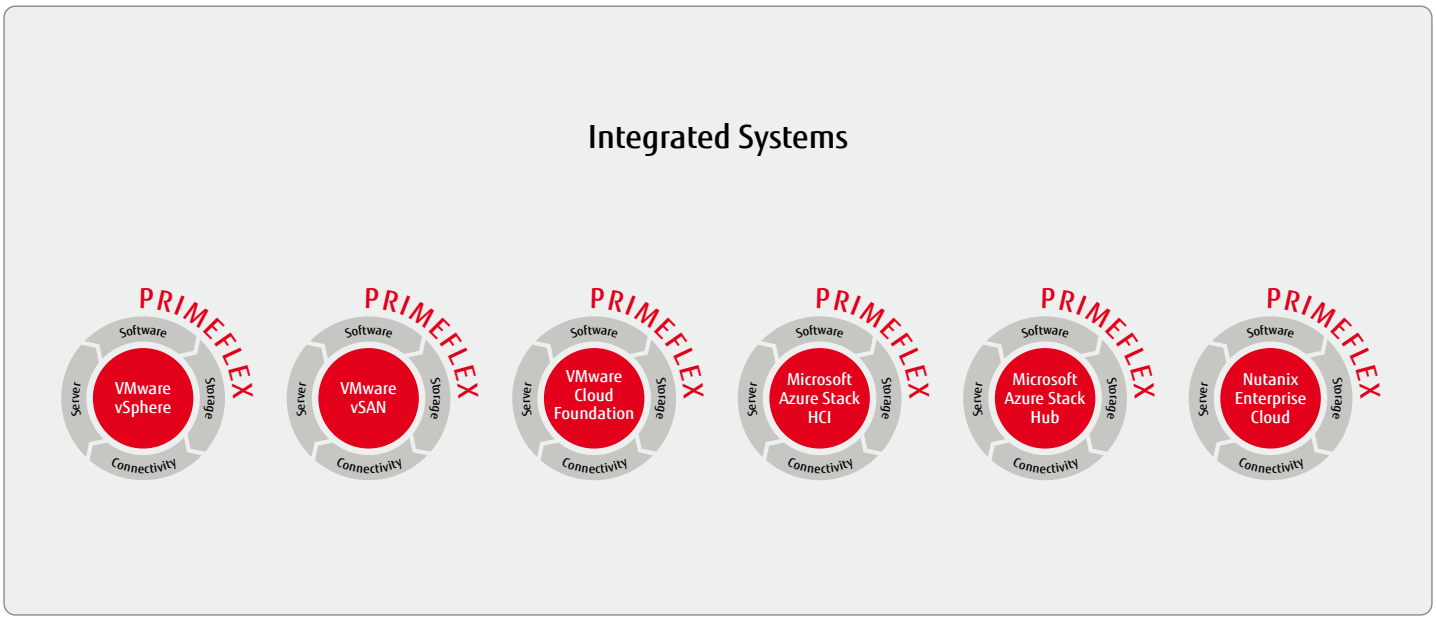


Fig. 5: Fujitsu provides comprehensive support for digital transformation

What's more, by operating 150 of our own data centers around the world, we have gained first-hand insights into the requirements of modern data centers and have applied this knowledge to our products. Customers should also know that the independent Experton Group positioned Fujitsu in its quadrant of leading providers for hyper-converged systems.

Fujitsu PRIMEFLEX integrated systems are known for their top performance. They make IT infrastructure optimization easier for a number of reasons:

- Optimized design with perfectly harmonized components
- Easy procurement and one single point of contact
- Extremely fast installation
- Easy and efficient scalability
- High performance and density
- High energy efficiency
- Additional solutions and services



Conclusion

IT infrastructures must be able to cope with tasks that are becoming more and more complex. At the same time, there is a trend toward more open hybrid architectures that enable specialist departments or business subsidiaries to provision and operate IT independently, thus giving them more freedom and faster processes.

Even though hybrid architectures have yet to be realized in today's enterprises, and with network virtualization still in the early phases of development, all of these technologies will be the standard in just a few years. The current status can be compared with the early days of virtualization. In 2002 most enterprises had no idea how the virtualization of server systems would revolutionize their IT and their business – today virtualization is the basic technology supporting IT operations.

New developments will not be exclusively driven from within or by the business itself. Networks comprised of suppliers and customers will also contribute additional impulses that will impact the further development of IT infrastructures. Over time enterprises will come to understand that more demanding requirements can be addressed by the SDDC concept in ways that are simpler, faster and better than traditional approaches.

In the future, for example, it will be taken for granted that seasonal peak loads should be balanced through cloud-based solutions on demand, rather than having otherwise idle systems on standby to perform this task.

Infrastructures and virtual workplaces will be set up in just a matter of minutes, even across several sites, with just a click – and security will have a higher degree of granularity than ever before.

What's more, the most valuable IT resources in an enterprise – the highly qualified administrators – will be able to focus on the business rather than spending time on the installation and operation of infrastructures.

Partners like Fujitsu, with in-depth overall expertise ranging from hardware and virtualization to software-defined and cloud solutions (private, hybrid or public), will be valuable assets. Not every problem is a nail, and not every solution is a hammer. There is no "silver bullet" that can be applied to resolve all issues in all scenarios.

But the SDDC model can boost competitiveness, keep costs under control and reduce the need for specially trained personnel in an age when highly qualified specialists are few and far between.

SDDC is not a project within a limited time frame, but rather a strategy that governs many years of transformation from hardware-centric IT operations to software-based environments. The ultimate goal is to enable enterprises to effectively and efficiently manage their business processes in a world that relies on tightly knit networks.

We call this environment the Business-Centric Data Center.

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