

# Data Centre Solution Recommendation for Manchester Super University

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**Abstract-** An average day, while somebody waiting for bus and checking the timetable, emails, and a social media in few minutes may accessed three different data centers. For many people data center is a facility, what seems big and very difficult. By reading this report hope everybody has a slightly clearer picture about DC's.

**Keywords:** *Data centre (DC), Information Technology (IT), IP address, Network, Packet, Router, Server, Storage Area Network (SAN), Switch*

## I. INTRODUCTION

My goal in this report to recommend a data centre solution for University of Manchester. The given scenario said two university merge and then they willing to create a data centre to centralise IT operation. In this paper, first I look through the recent literature about data centres, and universities how respond the challenge of growing demand of information. Then I scan the special needs of a university, what makes it different. After I write my research methodology to show how to gain these information and data's. In my main analysis I present what the requirements of a modern data centre are, what standards the university should keep. This part also includes the architecture, the budget, the design, the storage area network, the physical limitations, the energy supply, the server park, the scalability, the sustainability in terms of data centres. In the recommendation part I examine which architecture and design is most suitable to serve more than 30 000 students at the university. I commend some extra features what data centre should possess to make more attractive and interesting this school among prospect students. At the very end of this report, I show my references as well.

## II. LITERATURE REVIEW

Before any recommendations needs to clear what, the data centre meaning is. According to Gartner Glossary: "A data centre is the department in an enterprise that houses and maintains back-end IT systems and data stores — its mainframes, servers and databases. In the days of large, centralized IT operations, this department and all the systems resided in one physical place, hence the name data centre. With today's more distributed computing methods, single data centre sites are still common, but are becoming less so. The term continues to be used to refer to the department that has responsibility for these systems, no matter how dispersed they are. Market and industry trends are changing the way enterprises approach their data centre strategies. Several factors are driving enterprises to look beyond traditional technology infrastructure silos and transform the way they view their data centre environment and business processes. These include aging data centre infrastructures that are at risk for not meeting future business requirements, an ongoing cost-consciousness, and the need to be more energy-efficient." [8].

As Gartner says market trends are forming the approach of data centre, so look how the big market stakeholders see the data centres nowadays. Cisco, as one of the biggest provider and producer of data centre solution write on [www.cisco.com](http://www.cisco.com): "At its simplest, a data centre is a physical facility that organizations use to house their critical applications and data. A data centre's design is based on a network of computing and storage resources that enable the delivery of shared applications and data. The key components of a data centre design include routers, switches, firewalls, storage systems, servers, and application-delivery controllers." [13].

Data centres are facilities designed to house and operate computer systems and related components. These components typically include telecommunication systems and communications, redundant power supply, data storage, air conditioning, fire protection and security systems. Large data centres are industrial-scale plants that consume electricity in a small town and sometimes cause significant air pollution from the exhaust of diesel engines.

A university IT requirement is a bit different than a normal business needs. The institute must run services for existing student, for lecturer and for researcher also. IT department have provided enough resources for all participant even a busier time like enrolment or examination period. As the new “super-university” is a research-based university, the IT department should possess some supercomputer to help researchers and scientist work requiring exceedingly high-speed computations [9].

### III. BACKGROUND

The history of data centres began with the vast computer rooms of the early days of computing. The maintenance and operation of early computer systems was complex and therefore required a special environment. Many cables were required to use the components, and different methods were developed for them: standard rack cabinets, raised floors, and cable organizers. A computer consumed a lot of power and required cooling to keep it from overheating. Security was important because computers were very expensive and often served military purposes. Basic entry rules have therefore been developed to control access to the computer room.

At a time of rapid growth in the personal computer industry, but especially in the 1980s, computers began to appear everywhere, in many cases regardless of operational expectations. As information technology began to become more complex, the companies that operated it realized that they needed to control their information technology assets. Linux began to evolve, and MS-DOS also slowly gave way to multi-threaded Windows operating systems, giving the PC a place in computer rooms. These have been called servers because time-sharing operating systems like Unixes are heavily built on the client-server model. Inexpensive network equipment and structured cabling allowed for hierarchical design, which placed the servers in a dedicated room. The word data centre, by which was meant a room specifically

designed to operate computers, began to spread at this time.

By rising the internet, the number of data centres lifted sharply. Companies needed a fast internet connection and continuous operation to ensure their internet presence. For smaller companies, this was not affordable. Many companies have begun building large facilities that have provided operational services to customers. New technologies and practices have been born to serve these large facilities [12].

### IV. RESEARCH METHODOLOGY

The sensitivity of the topic not allowed to do primary research. Institutes or businesses not giving information about their data centre due security reason. So, my qualitative research methodology has based on secondary research. In general, there are lot of information about data centres architecture, design, issues in libraries and in other sources of internet. These documents are books, articles, journals, E-books, case studies. Document review or content analysis help to gain enough and reliable information to justify the topic of this paper. The reference list proves the validity of my investigation, preferred to use book, white papers, journal. However, some webpages appear in the reference list, they are mostly companies' websites or webpages what only focused on data centre technologies or related services. Searching in electronic library or on the internet is easy and quick if researcher scan with proper words. An interview with a superior of a data centre would very useful, because he/she would mention a subtopic what researcher do not name. Otherwise, this person would give a new viewpoint in a primary contact. Lack of data centre expert's contact is a disadvantage of secondary research.

### V. ANALYSIS AND DISCUSSION

A data centre basically consists of four elements. On the one hand, from the space itself, usually with a false floor, where the servers and storage are located, and on the other hand, from the supporting infrastructure (transformers, generators, sensors, air conditioners, etc.). and storage to everything needed to provide IT services. And fourth, there is a need for operational staff to take care of on-site maintenance of the data centre and ensure its smooth operation. The buildings, also known as server farms, are specifically designed to hold and operate the servers and repositories of multiple companies there safely and efficiently. It is worth distinguishing it from a server room, which is typically a separate room in multi - purpose

buildings (such as office buildings), equipped with the appropriate infrastructure for the central storage of IT equipment (cooling, power supply, etc.) [13].

#### A. Design

Data centres are built to host a huge amount of computing resources, which handled from larger or smaller distance over wide area network. These resources are divided in blocks for many reasons. Blocks or modules are independent from each other, what helps addressing, maintaining and security as well. This partition is serving a further growth possibility and makes easier to identify any breakdown or outage.

So far this is the physical approach of data centre devices. Logically, and sometimes physically devices, are usually organised in three layers: Access Layer, Aggregation Layer, Core Layer, Fig. 1. shows the layers relation to each other.

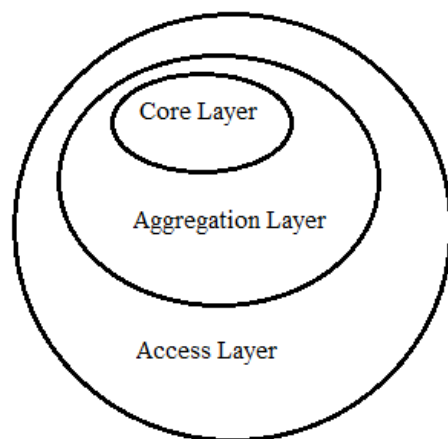


Fig. 1. Multilayer Network Design (source: author)

The access layer provides users access to network devices and connectivity to servers. Usually, built - in Layer 2 devices for better sharing and performance. Switches in access layer are connected to two distribution layer switches for redundancy.

The aggregation or distribution layer grants policy-based connectivity to network base services such as firewall or load balancer. This layer divides work groups towards servers. Using Layer 2 and Layer 3 switches.

The core layer is the backbone of the data centre, which provides high speed packet switching and fast convergence. Using Layer 3 switches.

These three layers is not always so distinct, in a huge data centre the borders are merged. The point of this approach to understand the way of data

flowing. Every single byte, data, packets are going through these 3 layers: access layer identify the user and transfer them to aggregation layer. Aggregation layer segments and forward them towards the core layer. Core layer sort out all packets as fast as possible, without manipulating them [1,2].

#### B. Architecture

To understand the data centre architecture, refer the Fig. 2.

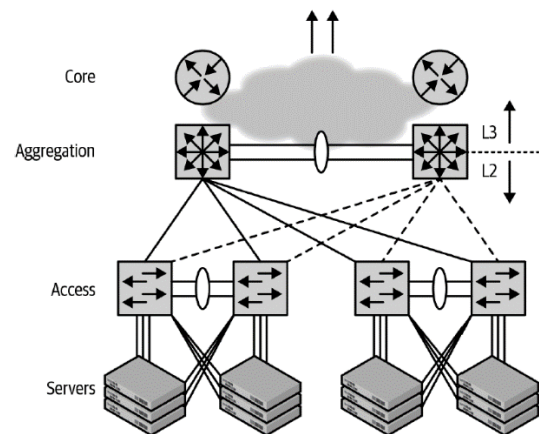


Fig. 2. Access-Aggregation-Core network architecture (source: [www.pensando.io](http://www.pensando.io))

This illustration properly shows, how interconnected the different layers and pointing Layer 2 and Layer 3 zone.

Figure 2. slightly showing another important element of a data centre, this is redundancy. Redundancy helps to avoid possible main failures. For example, an Access layer switch used to connect two Aggregation switch, in case one of these Aggregate Layer switch failed down, still has another to forwards packets [1,2].

#### C. Network topology

In the previous section, Fig. 2. Already showed something about how a data centre could look like. The Fig. 3. display a quite different and more difficult picture about data centres.

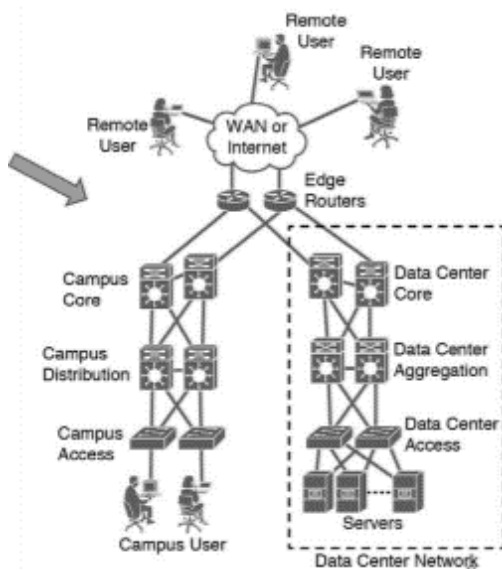


Fig 3. Network topology (source: Raj Jain, 2018.)

Fig. 3. showing the servers what an has an also important role in the data centre. Databases and servers doing the main job, manipulates data's and answers the request. Switches and routers make quicker and more reliable the data flow and responsible forwards packets to appropriate device and return them back [14].

#### D. Management

So far discussed the data centre main devices roles, now look up a bit other requirement, what a data centre faces. The management's tasks are not limited to place and switch the devices on. The large number of devices have needs:

- Upgrade
- Backup
- Data distribution and storage
- Support
- Emergency planning

The task list above is essential to maintain and keep running a data centre. As a data centre running 24/7 crucial to organize well the qualified staff timetable to provide continuous availability. Data centres are categorized by annual availability. To understand how vital the availability is, seeing Fig. 4.

### DATA CENTER TIERS

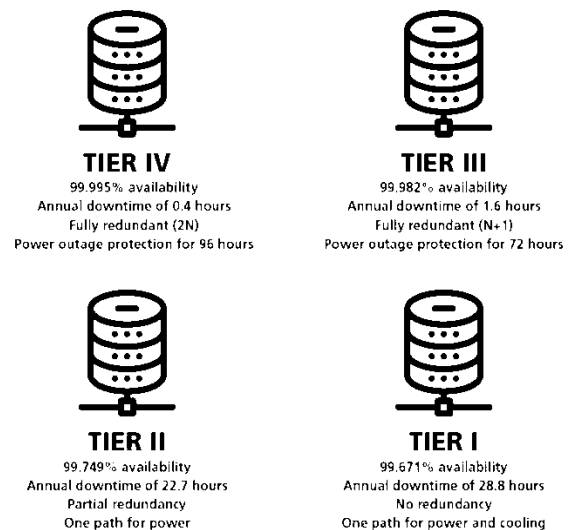


Fig. 4. Data Centre Tiers (source: www.impactmybiz.com)

This numbers are guides only, the Service Level Agreement contains the agreed and expected parameters in term of availability [1, 2, 14].

#### E. Server farm

Earlier mentioned about data centre design, topology, and management and switches task. This chapter will represent other kind of DC devices, the servers. While switches designated for packet forwarding in a data centre and usually contain same devices, server park could give different view in a every single facility. Server farm is a collection of computer servers for client/corporate needs. If the Core Layer the backbone of the data centre, then the Server Farm is the heart.

Three main types of server farm exist.

- Internet Server Farm
- Intranet Server Farm
- Extranet Server Farm

The main reason of the data centre existing is, to serve at least one server farm. The Internet Server Farm goals to support internet-facing applications. Intranet Server Farm is built to deliver the business-critical resources, mostly for internal users. Extranet Server Farm provides both previous functions.

A server farms could have many different server types:

- Application Server
- Client Server
- FTP Server
- List Server
- Mail Server

- Proxy Server
- Web Server [1, 2, 14]

#### F. Load Balance and Fault Tolerance

Now it is clear that the applications are in a server farm. To boost their performance, need some extra device. Server load balancing means that the workload is distributed among servers handling the same application content. This device is the Server Load Balancer. This equipment accepts the client requests, analyse them, and divide requests among same purpose servers, following load balance algorithm. This allows you to optimize the resources of your infrastructure, maximize productivity and reduce response times, thus avoiding potential congestion. The use of a load balancer is recommended whenever the following are required:

- ensuring the continuity of the service provided
- preparation for sudden traffic peaks
- high traffic management.

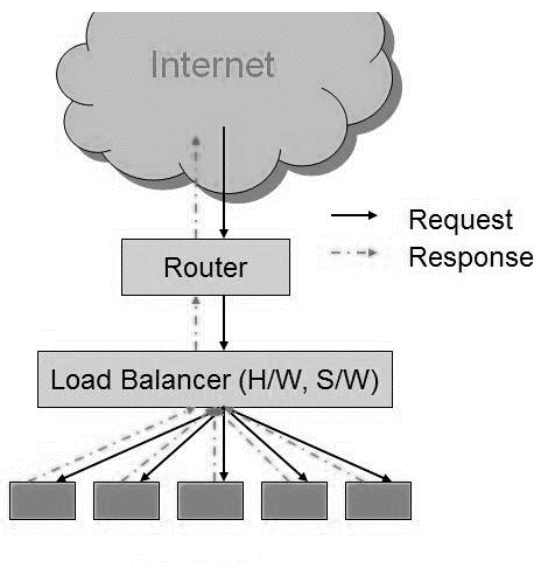


Fig. 5. Workflow of load balancing (www.researchgate.net)

Fig. 5. shows the workflow of load balancing. The benefits of load balancing are numerous: scalability, increased capacity, high availability, quicker disaster recovery, better security, operational efficiency.

Another important feature of servers is fault tolerance. It is mean a process what enable the system to operate in the event of partial or full failure. Every port is in pair: one active, one standby. When the active one`s has broken down, the standby one`s take its role [1, 2, 14, 15].

#### G. Performance

So far discussed DC`s different parts. This chapter extend and deep the knowledge what was scratched in section C. Performance of data centre depend on how quick and reliable the route of the data packets through data centre. There are many ways to boost the performance up:

- Port Channel
- Link Aggregation Control Protocol (LACP)
- Virtual Port Channel
- FabricPath

Port channel is a port trunk technology used by Cisco switches. It allows multiple (2 to 8) Ethernet ports to be combined into a single logical connection, increasing connection speed and fault tolerance. Port channel interface can be configured with its own speed, bandwidth, delay, IP address, flow control. When was realized that the speed of a network was not grows linearly, unlike bandwidth demand. Then has begun to replace two physical interfaces by one logical channel. Link Aggregation Control Protocol (LACP) negotiates communication between different ports with the endpoint if the device on the endpoint is also capable of LACP communication. The vPC permit a port channel extension across two physical switches. This environment combines the benefits of hardware redundancy and port channel. FabricPath blends the benefits of Layer 3 routing with Layer 2 switching. FabricPath is a built-in protocol the most Cisco switches.

Demand of speed and reliability has grown by appeared more high-speed computations methods like Big Data. Storage platform solutions are evolving as applications evolved. Direct-Attached Storage (DAS) was the earliest solution, which was attached to and managed by a single host. Storage consists of disks in a host and/or external disk enclosure that are directly connected to the storage controllers in the host. Next step was the Network-Attached Storage (NAS) is a shared storage option that stores and shares files via standard file system protocols – mainly the Network File System and Server Message Block protocols – over IP networks. The most recent solution is Storage Area Network (SAN). This is a highly scalable, high performance network connecting hosts with a shared pool of block level storage over FC or SCSI based protocol. SAN consists of subsystems and switches. Devices that contain hard disks are organized into a kind of network through fast connection, and this subnet is available to the servers through the switches. Due to the transparent implementation, there is no wasted

capacity, and in the case of record management and transaction management, this solution is unbeatable in speed. An additional benefit of a well-designed network is increased security possible to create a geographically extensive SAN system even. In case of properly mirrored data, SAN can guarantee data security in the event of an unforeseen disaster. [1, 2, 14, 15, 17].

#### H. Scalability

In many data centres, systems only reach their final maximum extent after a few years. Scalability is the capability to grow without performance wreck or service interruption. As mentioned in section A, DC are standing of blocks. These blocks or module are working independently to each other. So, standing a new module in is not affect other module's function. Likewise, fault tolerance; dropout a device does not affect the network operation, adding a new device neither [1, 2, 6].

#### I. Energy usage and sustainability

Data centre's design focused on the past for reliability and performance. Unfortunately, this has led to the energy efficiency of data centres have not been optimized. Energy consumption is an important budget item for IT activities, which in some cases also exceeded the cost of hardware. Recently, software's have shown up in the market, what measure and could optimize the energy use based on gained data's. In general, a system for determining the energy efficiency and carbon footprint of a data centre can serve three different purposes:

- One-time or regular performance testing
- Assigning energy or the carbon footprint to other devices
- Using information to reduce the energy consumption or carbon footprint of infrastructure

A simple measure system can be developed over time by adding additional measurement and modelling capabilities that increase precision and provide deeper insight into energy usage. Newer data centres also pay attention to the carbon footprint, water consumption, and even the utilization of waste heat generated. These factors not only reduce the environmental impact but can also save by increasing the efficiency of the operation and, indirectly, increasing its profit, may attract new partners [1, 2, 5, 14].

#### J. Security

In terms of security data centres have double frontline. First, there is the physical security, to provide the devices physical integrity and prevent unauthorized access to the area of data centre. These concerns rather belong to premise issue, discuss more about these topics in section K.

As in every field of IT, the security is the biggest challenge and issue in data centres also. Increased security measures are justified, because in server parks keeps huge amount of very sensitive data's. The most common technics and methods are following:

- Firewall
- Packet filtering and inspection
- Intrusion detection, and intrusion prevention
- Access control list (ACL), to allow or deny traffic
- Application protocol inspection, to verify the protocol behaviour and identify unwanted or malicious traffic

List above contains methods prevent a cyberattack and avoid data corruption. But security measures should cover any internal malfunction or breakdown not only deflects external threats. Solution is redundancy. The goal of redundant design is to increase reliability, uninterrupted operation and to avoid data loss. Network redundancy ensures that network services are not disrupted by a specific route failure. Due to the redundancy (multiplicity) of network elements, the same network device and its service can be accessed through several routes, so, if necessary, another route can be used instead of a failed one, so that the services can work smoothly despite the error. Refer Fig. 3. again, what shows interconnected devices, now clearer the reason. Other devices or methods used for redundancy uninterruptible power supply, a dual power supply, RAID-organized hard disks, or cloud technology [1, 2, 12,14, 15].

#### K. Premises requirements

As mentioned in previous section, the building of DC itself has many requirements. It is difficult to find a proper location because it must have protection from natural disasters (floods earthquake, etc), must has easy access (avoid residential or industrial zone) and should manage future growth and change.

Requirements of premises room separation within a data centre:

- closed engine room

- visitor corridor, separated by a glass wall
- offline devices room
- storage of magnetic data carriers
- maintenance room (spare parts, measuring instruments)
- air conditioning (close to servers, under the server room)

Requirements of server room:

- double floor in which cables and air conditioning could run
- resistance to moisture
- fire safety
- air condition (cooling)

Air condition is crucial because hundreds or thousands of devices are closed in one building. Routers, servers, switches are producing lot of heat during working. As they are almost always running, the air conditioning must be effective to ensure appropriate temperature all the time. Blowing the fresh air through the floor, extracting by ceiling at high temperature points; recommended ranges: 16-24 ° C, 40-55% humidity.

In previous section mentioned physical security issues. Measurements are strict such as access control with fingerprints or access card, security CCTV, security staff operating 24/7, a quick and effective fire alarm system for the protection of the equipment. [1, 2, 7, 14].

## VI. FINDINGS AND RECOMMENDATIONS AND JUSTIFICATIONS

To considering all above is difficult. Finding a proper solution even more difficult. To start to design a data centre first collect the needs, what is the purpose of data centre, what it will use for? Then explore the requirements of data centre. These two could result a good plan, after a lot of man-hours.

Look what is the new university requirements:

- More than 30 000 students, changing by terms
- 24/7 availability of student application, with peak periods of access such as examination periods, enrolment periods
- Confidential and sensitive data handling and storing such as student personal details, reports, dissertations, marks, and results
- Running e-library

- Updating all the courses related data's
- Additional resources for scientist and researchers
- Possible online education periods

These above highlights only, the real requirement list longer.

My recommendation is a kind of guideline, what function and features the future data centre should have possessed. The criteria list is following in Fig. 6.:

| Criteria     | Solution                                                                  |
|--------------|---------------------------------------------------------------------------|
| Availability | Module approaching, Redundant design, SAN                                 |
| Scalability  | 2 location, Module approaching, Redundant design, Server farm approaching |
| Security     | 2 location, SAN, Firewall, ACL, Packet filtering                          |
| Performance  | SAN, Load balancer, LACP                                                  |
| Location     | Easy access, Growing possibility                                          |

Fig. 6. Criteria and solution list (source: author)

In my view to build a data centre is an opportunity for the university. An opportunity to show, how to do it the proper way. Focusing not only on design, but afterlife also. DC has scalability features, so the occasion is given to use it for business purposes, like hosting or any other IT service provider. This helps university to gain some extra profit and opportunity for IT students to develop as they could spend time in an operating DC. This should be a very attractive among prospect IT students.

As the universities always are pioneers in many fields, reducing energy consumption and carbon footprints could be the second most important goal of building a DC. Coping with other departments of the university could product some new methods, technics to create more sustainable and “greener” the data centre, to be the example to follow in worldwide soon.

## VII. CONCLUSION AND FUTURE DIRECTION

Designing and building a data centre are a huge challenge. Many requirements need to consider from the very first moment of planning. First, lay down the principals, what the institute want to use the DC for, because it is an enormous investment. Different

goals mean different design, what could expand or shrink the budget. Nowadays seems, to build an energy usage efficient and multi-goals data centre is affordable for huge companies only, such as Amazon, Facebook, Google, Microsoft, etc.

Last 10 years trends are approaching to cloud service and/or virtualization. Why companies should spend more money on on-premises IT equipment, when virtualization place all resources in a data centre and in a cloud? These trends concentrate more IT resources in data centres what makes design more carefully and difficult. With more devices the data centre consumption gets higher, so additional measurements needed to reduce energy usage and carbon footprint. Cloud services requires better and secure internet connection at user side, so internet providers have catch up these needs.

The new solution could be the Edge computing. Edge performs the requested calculations on a device close to the client sending the request, which can incredibly speed up communication and the whole process. All of this results in a very strong and fast, on-demand reliable network with a processing and storage methodology tied to randomized, non-centralized servers. Only the market needs to pay more attention to the security vulnerabilities of IoT devices. But since this trend is seemingly unstoppable, there no question that the weakest link is the end user. Services, big companies will have to keep up with this very fast-changing IT world if they want to stay competitive. The most likely solutions for this purpose are the next post-Cloud station, the Edge [16].

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