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Journal of Computational Technologies

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Presentation of the content

In Issue 19 the first article we present, *DUse of virtual classrooms to support teaching in the mixed modality, of the subjects of Ecological Engineering and Air conditioning and refrigeration* by HERNÁNDEZ-GÓMEZ, Víctor Hugo & CHAVARRÍA-ORTIZ, Gilberto, with adscription in the Universidad Nacional Autónoma de México, in the next article we present, *MATLAB GUI application for failure analysis of electrical power system faults* by MORGA-BONILLA, Sergio Iván, TELLEZ-CUEVAS, Pedro and HERNÁNDEZ-SANCHEZ, Juan Fernando, with adscription in the Instituto Tecnológico Superior de Huauchinango, in the next article we present, *Implementation of a development environment within a virtualization environment in data center* by OLVERA-GONZÁLEZ, Edgar Alberto, CERDA-GARCÍA, Jorge Alejandro, VIRAMONTES-REYNA, José Luis and VELAZQUEZ-LEYVA, Erasmo, with adscription in the Universidad Tecnológica de San Luis Potosí, in the last article we present, *Preliminary study of thermography applied to diagnosed faults in Diesel Engine and network rack* by CARDENAS-SANCHEZ, Enrique, DELGADILLO-PARTIDA, Jorge, RAMOS-PONCE, Manuel and RIOS-HERNANDEZ, Juan, with adscription in the Universidad tecnológica de Manzanillo.

Content

Article **Journal of Computational Technologies**
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Use of virtual classrooms to support teaching in the mixed modality, of the subjects of Ecological Engineering and Air conditioning and refrigeration

Empleo de aulas virtuales como apoyo a la enseñanza en la modalidad mixta, de las asignaturas de Ingeniería ecológica y Aire acondicionado y refrigeración

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Resumen

To help reduce the problem of remote knowledge imparting, such as not having access to a computer during class time, not being able to rent an hour of internet or not having Wi-Fi, the authors of the article generated the project PAPIME with PE100222 code, which aims to Generate new didactic resources to improve the teaching-learning process of the aforementioned subjects, so that it can be used in the online and mixed modality. As a first stage, they created virtual classrooms in Classroom and Moodle where they included didactic material such as class videos, notes, support texts, infographics, mind maps, word search, crossword puzzles and practical activities that can be done from home for each subject of the project. . This article presents the actions carried out as the second stage of the project, which includes the adjustments made to each virtual classroom based on the opinions of the students who used them and the generation of virtual classrooms to include support material for the presentation of the extraordinary ones of the subjects involved.

Moodle, Classroom, Mixed teaching

Resumen

Para contribuir a disminuir la problemática de la impartición de conocimientos a distancia, como el no contar con el acceso a una computadora en el horario de la clase, no poder rentar una hora de internet o no tener wifi, los autores del artículo generaron el proyecto PAPIME con clave PE100222, el cual tiene como objetivo generar nuevos recursos didácticos para mejorar el proceso de enseñanza aprendizaje de las asignaturas antes mencionadas, para que sea empleada en la modalidad en línea y mixta. Como primera etapa elaboraron aulas virtuales en Classroom y Moodle en donde incluyeron material didáctico como videos de clase, apuntes, textos de apoyo, infografías, mapas mentales, sopa de letras, crucigramas y actividades prácticas que se pueden realizar desde casa para cada asignatura del proyecto. En el presente artículo se presentan las acciones realizadas como segunda etapa del proyecto, el cual incluye las adecuaciones realizadas a cada aula virtual en función de las opiniones de los estudiantes que las utilizaron y la generación de aulas virtuales para incluir material de apoyo para la presentación de los extraordinarios de las asignaturas involucradas.

Moodle, Classroom, Enseñanza mixta

Citation: HERNÁNDEZ-GÓMEZ, Víctor Hugo & CHAVARRÍA-ORTIZ, Gilberto. Use of virtual classrooms to support teaching in the mixed modality, of the subjects of Ecological Engineering and Air conditioning and refrigeration. Journal of Computational Technologies. 2023. 7-19:1-5

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Introduction

As a result of the worldwide health emergency caused by COVID-19, it was necessary to implement mechanisms for distance learning. Some professors contacted students and conducted videoconferences through platforms such as Zoom or Meet, with the problem that not all students had access to this technology, either because they did not have it, could not rent an hour of internet, did not have wifi or because they could not connect at that time.

To help reduce this situation, the authors of the article generated the PAPIME project "New teaching resources to improve the teaching-learning process of the subjects of Ecological Engineering and Air Conditioning and Refrigeration for online and blended modalities, of the Mechanical and Electrical Engineering Career of FESC with code PE100222, which aims to generate new teaching resources to improve the teaching-learning process of the aforementioned subjects, to be used in the online and blended modality.

As a first stage of the project, Hernández and Chavarria (2022) developed virtual classrooms in Classroom and Moodle where they included didactic material such as class videos, notes, support texts, infographics, mind maps, word search, crossword puzzles, for each subject topic. In addition, they included a section of practical activities that can be done at home, using materials that are easy to find and even recycled.

Since the end of the pandemic, the class was taught entirely online, where students could take the class through the Zoom or Meet platforms, and if for some reason they could not be connected at class time, they could review the videos and notes of each topic directly in the virtual classroom of Classroom, which favored the teaching-learning process for students.

When the opportunity arose to return to face-to-face classes, in semesters 2023-I and 2023-II, the virtual classrooms were used for a teaching process in mixed modality, that is, classes were taught and the corresponding evaluations were carried out face-to-face, but with the support of the didactic material in the Classroom and Moodle virtual classroom.

This favored the students since it was useful for them to review the topic seen in class and reaffirm it with the support videos.

Experience in the use of virtual classrooms

In order to know the opinion of the students who used the virtual classrooms, surveys were conducted for each subject, the questions were as follows:

Full name beginning with last name

Did you pass the course, and if not, why do you think you did not pass?

Regarding the presentation section, syllabus and bibliography, was there any information missing that you needed, why?

Regarding the presentation section, agenda and bibliography, were the videos clear, why?

Regarding each section of the topic, were the videos explaining the topic clear, why?

With respect to each section of the topic, were the notes and subject material clear, why?

With respect to each section of the topic, the notes and subject material, did they help you assimilate the knowledge of the topic, why?

With respect to each section of support material, the videos and texts, were they sufficient, clear, why?

With respect to each section of support material, the videos and texts, did they help you assimilate the knowledge of the topic, why?

Regarding the activities to be developed in each topic, did you like them, were they sufficient, why?

Regarding the activities to be developed in each topic, did you find them boring, did they have to do with the class, why?

Regarding the activities to be developed in each topic, did they help you assimilate the knowledge of the topic, why?

Regarding the practical activities to be developed, were they interesting, why?

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Regarding the practical activities to be developed, did they help you to assimilate the knowledge of the topic, why?

Regarding the practical activities to be developed, were the materials to be used economical and easy to acquire? why?

The final project is an application of the knowledge learned, was the evaluation rubric clear? why?

All the activities to be developed had checklists, were the checklists clear, why?

Did you like having online support material, why?

Did you like that the class was conducted in a blended way, i.e., face-to-face with online support, why?

Do you think you learned more or understood the course topics more easily when you had the support of the virtual classroom, why?

Explain what you would like to change about the information in the virtual classroom and why?

Explain what you would like to see included in the virtual classroom and why?

What percentage of the course syllabus do you think was covered, and why?

Write any comments that will help us to improve the teaching process of this course.

From the opinions expressed by the students, the following can be mentioned:

They consider that the presentation section of the course is adequate, the form of evaluation of the course and the tools that will be available during the course are clearly explained.

Regarding the class videos by topic, they consider that the information was precise, concrete, easy to understand and that it supported them to generate the activities of each topic.

Regarding the didactic support material for each topic, they mentioned that since they were not so long, they were able to locate the information they needed, the information was well structured, they were well illustrated and with many explanations. One considered that in some topics there were too many videos and that they did not have time to watch them all, others considered that they were adequate and that it helped them to better understand the subject.

As for the development of the activities, they thought that they were a good way to learn the subject, but they considered that sometimes there were too many activities, they were repetitive and that made them monotonous. Others mentioned that they liked the activities because they were very easy to do, fun and they could do the practical activities as a team. In general, they felt that the activities helped them to better understand the topics.

Regarding the practical activities, they mentioned that they were a way out of the routine, they helped them to better visualize the subject, they could be easily applied at home, that knowing the theory made the practice fascinating, that it was easier to see how things worked and why, they required materials that were easy to acquire, by doing them as a team the cost of materials was reduced and some requested that the instructions or development of the practice be improved.

Regarding the integrative or final project, they mentioned that the rubric contained all the evaluation elements, sectioned and specific, although there was one who did not understand some of the elements requested, such as the summary.

All the activities to be developed had checklists, and they mentioned that they were useful to know what information should be included in their activities.

The students liked having online didactic material because it reduced the research time, increased the quality of information, because being in classroom mode it is not easy to search and ask the teacher at the time they want or need it, contrary to the material that is always available.

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They liked taking the class in mixed mode because it reduced the workload, they could make consultations at any time, they had enough time to carry out extra activities, they could reinforce the topics and clarify doubts at any time they needed without having to go to look for the professor, and it was comfortable and not very tedious.

They consider that they learned better by not having to take so many notes in class since they could pay more attention to the professor's explanations, they had resources related to each topic, they had the course information at hand at all times, they were reliable sources of information facilitating the search in appropriate and truthful places and that every doubt that arose in class could be consulted in the virtual classroom.

As for changes in the virtual classroom, they mentioned that the rubric for the final project should be clearer, as well as the instructions for the practical activities, including examples of the projects to be carried out and their respective reports, and including the time and place where the professor could answer questions, in case the material was not sufficient for some students.

Some students added comments to improve the teaching-learning process, among them, to do some practical activities in class, not to do so many activities because the students fall behind, to provide more examples and illustrative information during the theory part of the class, to remove a task from each topic would be easier and to make the classes a little more dynamic.

Updating of virtual classrooms

Based on the students' comments, the following actions were taken for each virtual classroom:

The procedure as well as the materials to be used in the practical activities were reviewed.

The number of activities in each topic and their respective checklists were reviewed and adapted.

The instructions as well as the rubric for the final project were revised.

The support material for each subject (videos and texts) was reviewed and updated.

For each subject, the final exams and extraordinary exams were revised and updated.

New didactic resources

A virtual classroom was created in Classroom for the extraordinary exams of each subject, which are shown in Figure 1.

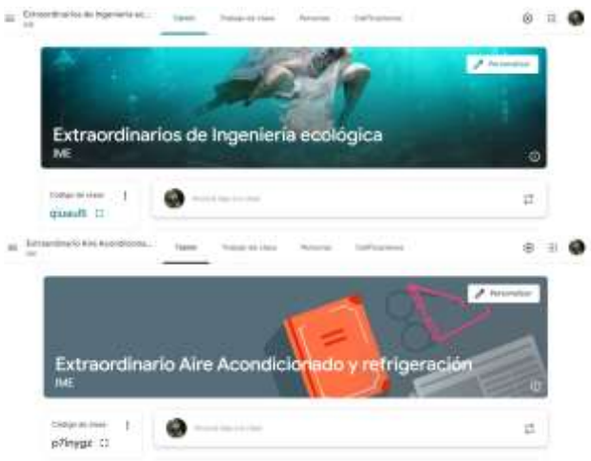

Figure 1 Virtual classroom for extraordinary exams
Source: Self Made

In each virtual classroom, the didactic material section was generated, where several sections were added, such as subject syllabus, forms, videos and reading material. Figure 2 shows the sections for the Ecological Engineering course.

Figure 2 Ecological Engineering support material section
Source: the student's own

Figure 3 for the Air conditioning and refrigeration special course.

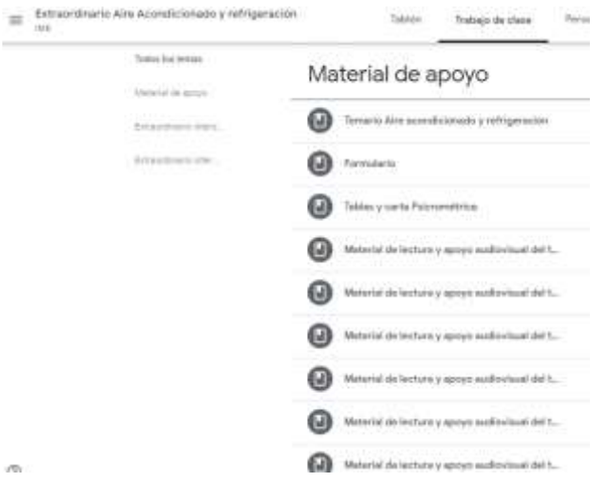

Figure 3 Supporting material section of Air conditioning and refrigeration
Source: Self Made

Within the videos and reading material section, the videos of the support material that were available for the virtual classrooms in each topic were included. Figure 4 shows the videos and reading material for the first topics of the Ecological Engineering course.

Figure 4 Videos and reading material for Ecological Engineering
Source: Self Made

Figure 5 shows the videos and reading material for the final topics of the air conditioning and refrigeration course.

Figure 5 Videos and reading material for air conditioning and refrigeration
Source: Self Made

Even though the special exams are already being held in person, students are invited to join the virtual classroom to learn about the course syllabus and see the didactic material that will support them in accrediting the special exam.

Acknowledgement

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Conclusions

The virtual classrooms were applied during semesters 2023-I and 2023-II, giving good results in terms of student learning. The fact that the course was carried out in a blended manner helped the students to have not only the teacher's explanation of the topics, but also didactic material that complemented their learning and that was available at any time. The revision and updating of the material included in the virtual classrooms, based on the students' opinions, will be used by the students in semester 2024-I, which will begin in August of this year. At the end of the semester, it is expected that the survey will be carried out and all the didactic material will be revised again, leaving the procedure as a process of continuous improvement.

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HERNÁNDEZ-GÓMEZ, Víctor Hugo & CHAVARRÍA-ORTIZ, Gilberto. Teaching of the subjects of Ecological Engineering and Air conditioning and refrigeration of the career of Electrical Mechanical Engineer of the FES Cuautitlán in the distance and mixed modality. Journal of Technology and Education. 2022. 6-15:1-7. DOI: 10.35429/JTAE.2022.15.6.1.7.

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MATLAB GUI application for failure analysis of electrical power system faults

Aplicación con MATLAB GUI para el análisis de fallas en sistemas Eléctricos de Potencia

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Abstract

This paper presents a computational algorithm in MATLAB with the Guide tool to analyse symmetrical and asymmetrical faults in electrical power systems. Fault analysis is important in the design, planning and operation of power systems, and is used to specify interrupting devices and define operating strategies that do not violate short-circuit levels. It also highlights the importance of good fault detection and coordination of protections to consider the type of fault, where it occurs, the phases involved and the evolution of the fault type.

Symmetrical faults, Asymmetrical faults, Fault analysis

Resumen

Este artículo presenta un algoritmo computacional en MATLAB con la herramienta Guide, para analizar las fallas simétricas y asimétricas en los sistemas eléctricos de potencia. El análisis de fallas es importante en el diseño, la planificación y el funcionamiento de los sistemas eléctricos, y se utiliza para especificar dispositivos de interrupción y definir estrategias de funcionamiento que no violen los niveles de cortocircuito. También se destaca la importancia de una buena detección de fallas y coordinación de protecciones para considerar el tipo de falla, dónde ocurre, las fases involucradas y la evolución del tipo de falla.

Fallas simétricas, Fallas asimétricas, Análisis de fallas

Citation: MORGA-BONILLA, Sergio Iván, TELLEZ-CUEVAS, Pedro and HERNÁNDEZ-SANCHEZ, Juan Fernando. MATLAB GUI application for failure analysis of electrical power system faults. Journal of Computational Technologies. 2023. 7-19: 6-11

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Introduction

This paper will analyze the analysis of the current distribution in the network, which allows establishing equations that define the behavior of the system.

A fault in an electrical circuit can be defined as any event that interferes with the normal flow of current.In the design, planning and operation of power systems, fault studies are used for different purposes, such as the specification of interrupting devices or the definition of operation strategies that do not violate short-circuit levels. Faults also occur in distribution systems such as the test systems presented in [9].

The occurrence of faults in a system is inherently random and their study requires a solid basis for problem definition and utilization of the results. When a fault occurs, the type of fault, where it occurs, the phases involved and the evolution of the fault type are some of the characteristics that a good fault detection and protection coordination scheme should consider. Experience has shown that between 70 % and 80 % of line faults are single phase to ground faults that originate in the insulation protection of the line to tower and ground. About 5% of faults involve all three phases and these can be called three-phase faults [1].

A fault is an unplanned connection that disturbs the system balance. The disturbance initiates the dynamic process and the reaction of elements and controls. Faults have different effects over time, with the highest current values in the first cycle [2]. It should be noted here that traditional fault studies consider only a single instant in time, as if the picture of the dynamic response of the system is taken at one point in time.

Most faults occurring in electrical systems are faults consisting of asymmetrical short circuits, asymmetrical faults with resistance or open conductors, and this is where the solution approach considered in electrical systems research is important. Symmetrical components for post-fault analysis, currents and voltages are determined in all parts of the system. A condition for using a symmetrical component sequence network is that the three-phase network is balanced.

A connected three-phase system can be transformed into three disconnected sequence networks by transforming the symmetrical components, which is achieved by diagonalizing the matrix representing the resistance or admittance of the system elements [3].

Fault analysis in electrical distribution systems is a fundamental task to guarantee the reliability and continuity of the electrical energy supply. An electrical distribution system is composed of an interconnected network of transmission and distribution lines, substations, transformers and protection equipment. Over time, these components may fail due to various factors, such as wear, overloads, short circuits, adverse weather conditions or operating errors.

This aims to identify the root cause of a failure, understand its mechanism of occurrence and determine the necessary corrective actions to restore the system to its normal operating state. This involves the early detection of faults, their precise location and the assessment of the damage caused.

Fault analysis in electrical distribution systems is carried out using a combination of techniques and tools, including visual inspections, equipment testing, event logs, data analysis, modeling and simulation. These techniques enable engineers to identify the exact location of the fault and determine whether it is related to generation, transmission or distribution equipment. In addition, fault analysis helps to assess the impact of the fault on the system and to develop mitigation strategies to avoid future outages [4].

A key tool in failure analysis is modeling and simulation of the electrical system. By using specialized simulation software, engineers can create accurate models of the distribution system and simulate different fault scenarios. This allows them to evaluate system behavior under adverse conditions, identify potential weak points and test different mitigation strategies.

In addition, fault analysis benefits from advances in monitoring and diagnostic technology. Real-time monitoring systems, advanced measurement devices and condition sensors can provide valuable information on equipment performance and system integrity.

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Analysis of this data in combination with artificial intelligence and machine learning techniques can facilitate early anomaly detection, fault prediction and more accurate and efficient decision making.

Fault analysis in electrical distribution systems relies on a combination of theoretical knowledge, practical experience and the use of advanced tools and technologies. It is essential to have specialized engineers in this field, who must have a deep knowledge of electrical principles, safety regulations, distribution system components and diagnostic techniques.
Asymmetrical Faults in Electrical Power Systems.

Asymmetrical faults, also known as unbalanced faults or sequence faults, are those in which the voltages and currents in the phases of the electrical system are not equal in magnitude and/or phase difference. These faults can occur due to short circuits between phases, short circuits to ground or a combination of both. Asymmetrical faults can cause unbalanced currents and voltages in the system, which can affect the operation of equipment and cause wear or damage to system components [5]. These include the following asymmetrical faults:

- Single-phase line-to-ground fault.
- Line-to-line fault.
- Double line-to-ground fault.
- Current limiting reactance in synchronous generators.
- Short-circuit current limiting resistor for a ground fault.
- Generator grounded by means of a reactance.

Symmetrical faults in electrical power systems

Symmetrical faults, also known as balanced faults or zero sequence faults, are those in which the magnitudes and phase lags of the voltages and currents in the phases of the electrical system are equal. These faults may occur due to short circuits between phases or between one or more phases and ground. Unlike asymmetrical faults, symmetrical faults do not generate unbalanced currents and voltages in the system, but they can generate high short-circuit currents that can damage equipment and devices connected to the system [6]. Asymmetrical faults are as follows:

- Symmetrical faults in power transformers.
- Symmetrical fault, generator no-load short-circuit.
- Symmetrical fault, transients in RL series circuits.
- Symmetrical fault, sub-transient current calculation.
- Symmetrical fault, motor working as generator.
- Symmetrical fault, fault calculation using Zbarra.

Design of Guide for Failure Analysis in Electrical Power Systems

For the realization of the program in MATLAB [7] we used the GUI (Graphical User Interface) tool to facilitate the user the exchange of data, making it easier to understand the results obtained. The platform automatically generates the Matlab code of each block, which allows faster and easier programming of the different internal functions of the components, so the use of GUIDE facilitates the design and programming process of the GUI interface developed in MATLAB for failure analysis in power systems.

The program has several options to perform the calculation of the different symmetrical and asymmetrical faults, a user interface has been created where you can enter some starting data and observe the different results. The main window of the interface is shown in Figure 1, it is a guide that contains two pushbuttons to choose whether to perform symmetrical faults through the submenu shown in Figure 2 or choose the button with the submenu of asymmetrical faults Figure 3.

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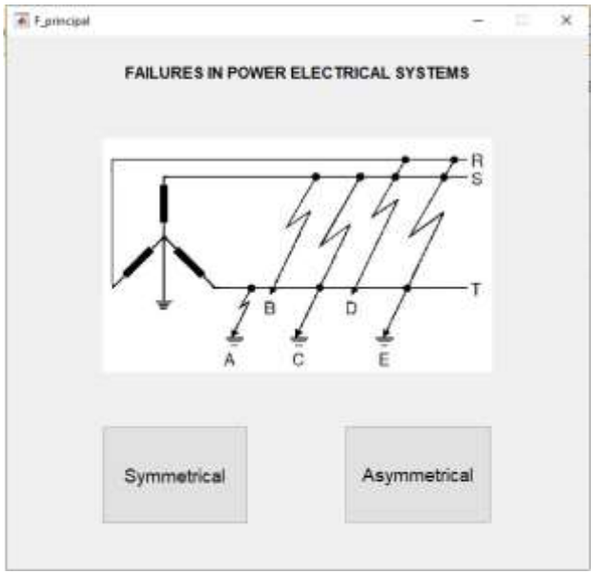

Figure 1 Main menu

Figure 2 Symmetric faults submenu

Figure 3 Asymmetric faults submenu

Depending on the option chosen, it will send us to the corresponding guide. In which by means of different pushbotton we can choose the problem to solve and a pushbotton (Back) to return to F_principal [7].

The programs in which the different problems are solved are composed of three pushbottons, one designated as "Calculate" which performs all the operations and sends the results to a table or tables designated as "T_results". Another pushbotton designated as "reset" which erases all the data of the guide for the realization of another different problem and finally a pushbotton designated as "back" which will serve to return to the previous guide and choose another problem to solve [7].

Program Evaluation

The application is validated by entering all the data in the submenus of the GUI program, in this case the short circuit calculation for a no-load generator is shown, it is considered because the short circuit in a no-load generator occurs when the output terminals of the generator are connected directly, without external load. In this situation, the external impedance is very low or practically zero.

The data to be used to validate the GUI application are as follows [8]:

Cycles: 5
Generator power: 100 MVA
Voltage: 18 VK
Sub-transient reactance: 19%.
Transient Reactance: 26%.
Loss Reactance: 130%.

When the application was run with the data input, the following results were obtained as shown in Figure 4.

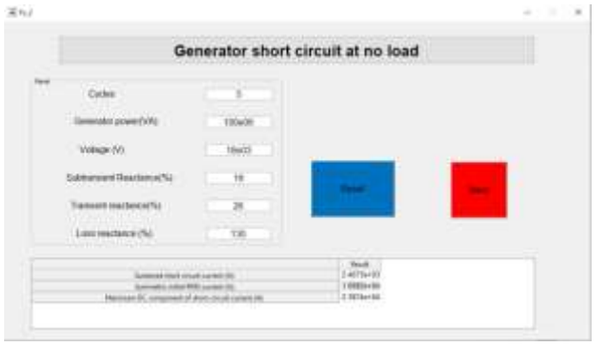

Figure 4 Application data and results for no-load generator short-circuit

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Sustained short-circuit current	2.4673 KA
Initial RMS current Symmetrical	16.882 KA
Maximum DC component of short-circuit current	23.87 KA

Table 1

This data indicates that the sustained short-circuit current of 2.4673 KA would flow in a short circuit after a given period of time, once the short-circuit condition has been established. The initial symmetrical RMS current whose value is 16.882 KA, is the effective current (RMS) that occurs instantaneously in a symmetrical short circuit in the early stages of the short circuit event and finally the maximum DC component of the short circuit current of 23.87 KA is the continuous part of the short circuit current, which is caused by phase unbalance or by some rectifier element present in the system. These results help to evaluate the safety and stability of the electrical system.

The validation of the application was also performed using the asymmetrical faults submenu, using the two-phase ground fault, which occurs when two conductors of one phase are connected directly to ground, generating a short circuit between them and ground. This type of fault can occur due to a variety of reasons, such as damaged cables, faulty insulation or connection errors. The analysis of the two-phase ground fault is important to evaluate the impact it has on the electrical system and to take appropriate mitigation measures. Analyzing the two-phase ground fault current allows evaluating the protection, stability and safety aspects of the power system, and helps to take preventive and corrective measures to maintain the reliability and safe operation of the system.

The data to be used in the GUI application are:

Sequence 1 impedance: 0.20 p.u.
Impedance sequence 2: 0.20 p.u.
Sequence 0 impedance: 0.05 p.u.
Fault impedance: 0.62 ohm
Frequency: 60
Fault voltage: 1 p.u
Power: 100 MVA

Figure 5 Application data and results for two-phase ground fault

Since the fault current is different from zero, a current flow occurs during the fault. This indicates the presence of an unbalance in the system due to the two-phase ground fault. The magnitude and angle of the fault current indicate the amount of current and its phase in relation to the system. In this case, the fault current has a magnitude of 4.3462 p.u. and an angle of -4.9251 rad.

It is important to note that the magnitude of the fault current is determined by the sequence and fault impedances, as well as the fault voltage. The calculations obtained in the application of the fault current calculation in a two-phase to ground fault allow us to evaluate the unbalance and the magnitude of the current during the fault. This is crucial for the design and proper coordination of protective devices and mitigation of the adverse effects of the fault on the electrical system.

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Conclusions

Fault analysis is an essential component in the design, planning and operation of electric power systems. It is used to quantify the impact that faults can have on the system and to specify the protection devices, as well as their settings to avoid equipment damage in the face of high short-circuit current levels.

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It also allows defining adequate operation strategies that guarantee the timely interruption of faults without exceeding the capacities of the equipment involved. This is crucial to maintain the reliability, safety and stability of the electrical system, prevent the propagation of faults and minimize the interruption time of the service in case of eventualities.

By means of the GUIDE tool, it has been possible to program the different internal functions of the graphical user interface in order to obtain an application that allows data entry to calculate and analyze symmetrical and asymmetrical faults in electrical distribution systems. GUIDE facilitated the programming of the interface with buttons, text boxes, menus and other functions that make possible the interaction with the user and the input of data required to perform the calculations and analysis of faults in electrical power systems. This led to the development of a practical application that gives the user the possibility to evaluate different fault scenarios and their impact.

Fault detection and protection coordination are important aspects to consider in fault analysis, since they allow identifying the type of fault, where it occurs, the phases involved and the evolution of the type of fault.

This article emphasizes the importance of having a clear and precise definition of the problem, as well as a plan for the utilization of the results, which are fundamental for a proper failure analysis. It provides valuable information regarding fault analysis in electrical distribution systems, detailing key concepts and steps to follow to carry it out correctly. It also presents a useful tool to facilitate this analysis, which is a necessary process for the evaluation of the impact of faults, the diagnosis of possible problems and the planning of corrective actions to improve the performance and reliability of electrical distribution systems.

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Implementation of a development environment within a virtualization environment in data center

Implementación de un ambiente de desarrollo dentro de un entorno de virtualización en centro de datos

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Resumen

Implementación de entorno de desarrollo para cargas de trabajo empresariales en clústeres de Kubernetes (RedHat Openshift, 2017) utilizando Red Hat Openshift, sobre las máquinas virtuales del hipervisor oVirt, logrando que los contenedores que se ejecutan en esta forma de implementación pueden obtener acceso directo al almacenamiento servido por el hipervisor oVirt. Realizando la configuración del entorno de desarrollo de Red Hat Openshift, así como la ejecución de los contenedores sobre las máquinas virtuales en el software oVirt, para obtener como resultado un mantenimiento sencillo a máquinas virtuales en bare metals teniendo múltiples métodos de instalación (IPI y UPI) y permitiendo el uso en su totalidad el hardware. Proporcionar una manera fácil de implementar los complementos para Openshift y lograr implementar una aplicación web sobre microservicios para demostrar el funcionamiento de los contenedores proporcionados por Openshift, Ofreciendo una plataforma integrada para administrar los contenedores en una diversidad de entornos operativos y como consecuencia, ayuda a reducir significativamente el tiempo que se toma para construirlos, implementarlos y escalarlos. Como herramienta de próxima generación en virtualización de código. Esta publicación es resultado de una tesis desarrollada en el centro de datos.

Virtualización, Contenedores, Servidores

Abstract

Deployment of a development environment for enterprise workloads in Kubernetes (RedHat Openshift, 2017) clusters using Red Hat Openshift, on top of the oVirt hypervisor virtual machines, ensuring that containers running in this form of deployment can directly access the storage served by the oVirt hypervisor. Carrying out the configuration of the Red Hat Openshift development environment, as well as the execution of the containers on the virtual machines in the oVirt software, to obtain as a result an easy maintenance of virtual machines in bare metals having multiple installation methods (IPI and UPI) and allowing the full use of the hardware. Provide an easy way to implement plugins for Openshift and achieve a web application on top of microservices to demonstrate the working of the containers provided by Openshift, Offering an integrated platform to manage containers in a variety of operating environments and as a consequence, helps to reduce significantly the time it takes to build, deploy, and scale them. As a next generation tool in code virtualization. This publication is the result of a thesis developed at the data center.

Virtualization, Containers, Servers

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1. Introduction

Today's global enterprises handle a large amount of information and at the same time need to deploy numerous applications at the same time for their customers, suppliers, employees, etc.; in order to do this, cloud capabilities are needed to efficiently deploy applications.

OpenShift enables users to develop, deploy and manage container-based applications. It is a self-service platform that facilitates the creation, modification and deployment of container-based applications on demand, using faster development methodologies. Coupled with the right tools (installation media and where the software is hosted), Openshift is an amazing innovation for cloud-based applications and robust connectivity worldwide. Companies of different industries and sizes have been able to expand their operations faster.

One of the virtualization tools that is used and is a great option to choose as virtualization software is oVirt. Today, oVirt (Figure 3) is a fast, efficient and stable solution for enterprise workloads; it is easy to administer, fast to deploy and provides integrated storage management (IBM, 2021) (Figure 1). Deploying OpenShift on top of oVirt virtual machines benefits all of the advantages mentioned above. To go one step further, containers (NetApp, 2019) running on this form of deployment can get direct access to the storage served by oVirt.

Presented in the article is the in-depth analysis on the necessary information and process involved in implementing, configuring and putting Openshift into production under the open source software oVirt (virtualization solution) (Figure 4), which will be used to manage and keep track of an enterprise infrastructure. As well as the use of various tools that contribute to make the development environment easy to monitor and control.

The developed project is implemented and carried out in the data center facilities, in the area assigned to the software factory. The main objective to be carried out, is the implementation of said container software previously mentioned in a virtualized environment, this development environment will be left in operation and in conditions for its use, applications assembly, programs, etc.

a)

The steps to follow were:

- Deployment and configuration of the Red Hat Openshift development environment.
- Implementation of openshift on virtual machines in Red Hat oVirt software, as it is easy to maintain, has multiple installation methods (IPI and UPI), allows full use of the hardware and maintenance of virtual machines is easier than in bare metals (García I. J., 2021).
- It provides an easy way to implement openshift plug-ins.
- To implement a web application and mount it in Openshift to demonstrate the operation of the containers provided by Openshift.

2. Methodology

2.1. Software Research and Documentation

The Openshift software (Bluexp, 2021) was selected and the details that comprise it, such as specifications and requirements, functionalities, features, and its configuration, were studied. As also researched about oVirt virtualizer (oVirt, 2018) (Mutai, 2022), offered by Red Hat (RedHat Openshift, 2017).

2.2. RAID and operating system configuration on 8 Nodes

A configuration was performed on each of the RAID nodes (Garcia J. , 2023), the data center consists of 8 nodes, so this procedure will have to be performed 8 times, in the same way, each of the nodes, has the same hardware resources and will be configured in RAID 5. This version helps to protect data against possible losses, either by anomaly in a disk drive or damage caused to a disk. RAID 5 protection protects against a drive failure. If more than one disk fails, data must be restored from the backup media.

2.2.1 Configuración de RAID en 8 servidores

Power up the host, server or reboot it and through the KVM perform all the configuration. When the server starts to boot, press the CTRL + H keys on the keyboard to start the RAID configuration.

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a) Confirm the RAID card to be configured, in this case there is only one, click on the "Start" button.

b) After entering the interface, the main screen will be displayed showing the current status of the disk array and configured through the "Configuration Wizard".

c) You need to clear the previous RAID configuration, make sure that the data on the server is backed up. "Clear Configuration

i) The system warns that the operation of clearing the configuration, will cause the loss of data found there.

d) Create a new matrix and go to the next step

i) Leave the Manual Configuration, once the manual configuration is selected, click on the next button to proceed with the process.

ii) Leave Redundancy as Redundancy when it is possible.

e) Select all the disks row down, verify that all are selected, make sure that the Backplane is not selected, and then "Add to Array".

f) Once all disks have been added to Drive Groups, select "Accept DG" and click Next to proceed to the next step.

g) Add the Drive Group found in the Span Definition window to the other SPAN section by clicking on "Add to Span".

h) In the following Virtual Drive Definition window, you must configure the RAID level that were added to the SPAN, the Strip Size, Access Policy, Raid size, etc. In this case the RAID level to be configured will be number 5. Fill in the RAID size automatically and some other options automatically by pressing the update Size button, and then click "OK". Continue to the next window with Next

i) On the BBU screen, click on the "Yes" button in order to select BBU mode as a WriteBack.

ii) After the configuration is done, a test is performed.

i) Save the configuration that was made by clicking on the Yes button and initialize the new array. The progress will be displayed.

j) Now you can see that the RAID has correctly grouped the disks and created the Virtual Drive. Restart the server and this would be concluding the RAID configuration on the server.

k) This process was performed 8 times, because the RAID configuration was performed on the 8 servers to be used.

2.2.2 Installation and configuration of Rocky Linux on the 8 servers

Once RAID 5 is correctly configured, the Rocky Linux operating system (Memon, 2021) will be installed on each of the nodes that make up the cluster, the process will be exactly the same and will be repeated 8 times. What will tend to vary are the IP addresses that are assigned to the node, as well as the node's domain name.

l) Have a bootable memory with the ISO of the Rocky Linux Operating System, the server must be started from the installation media (Rocky Linux and the installation process begins). The initial screen to configure the installation is as follows.

m) When the installation process starts, select the English language and leave it as the default language of the system.

n) Select the keyboard layout, which is the "Keyboard" option, once inside the keyboard layout, remove the English layout and add the Latin Spanish layout, to save and confirm the changes click on "DONE".

o) Software Selection, select the version and base environment of our Rocky Linux operating system, for the installation of each one of the nodes the minimum version without GUI will be installed, confirm the changes by clicking on "DONE".

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p) Configure the network and host name, for this go to "NETWORK & HOSTNAME" (Wiki, 2022). First, configure the Network. Click on "Configure..."

i) Turn on the Network adapter which by default is turned off, make sure that it is turned on.

ii) Go to the IPv4 window and select the Manual method to assign the IP address manually. To add the IP address click on ADD. Enter the IP address of the node, its subnet mask and gateway.

iii) Add the additional DNS servers (CIRA, 2019), if there are multiple DNS server addresses, separate the addresses with a comma.

iv) Save the configuration in Save.

v) Assign hostname, enter the desired hostname in the "Hostname" section and click on "Apply" to apply the change.

q) Set the date and time of the operating system. Select the time by selecting the time zone on the map, set the time automatically and the date, save the changes by clicking on "Done".

r) Set a password to the root user, go to the Root Password section, enter a secure password and confirm, to save the changes click on Done.

s) Configure the installation destination, click on the Installation Destination option, select the local disk and the Storage configuration in Manual, click on Done.

i) To make the manual partitions easily, click on "Click here to create them automatically".

ii) The serpan mount points will be created intelligently.

iii) The Swap partition will be resized, the file system will remain in SWAP format and the capacity will be extended to 8 GB.

iv) The /boot partition, change the system files to ext4 format.

v) The /var partition is configured in the same way, only the file system will be changed to ext4, the capacity on the disk will be left exactly the same.

vi) The root partition will be deleted, as it will be assigned a different name, to do this select the partition and delete it, then create a new partition with the name /data and assign all the available storage capacity. Assign it the ext4 file system

vii) Modify the group volume name, a name of the volume group is assigned, all the nodes must have the same name of volume group, so that it can be configured in a global way.

t) The installation process will be carried out on the 7 subsequent operating systems nodes, it will be the same installation process for each of the nodes that make up the cluster.

2.3 DNS server installation and configuration - BIND9

Throughout this phase a DNS server is installed in a virtual machine that is hosted in the oVirt virtualized environment that was previously installed and configured. This DNS server will be responsible for resolving and translating IP addresses to domain names that the Openshift container software will occupy.

"Openshift requires two static IP addresses that are outside of the DHCP pool (De Luz, 2023), as well as creating the DNS entries for the OpenShift Container Platform REST API and application domain names."

Once the function of the DNS server has been defined, we will proceed to document the installation and configuration process of the DNS server using the BIND DNS software in Rocky Linux 8 (the virtual machine where the server will be installed has this system).

The Domain Name System is a hierarchical, decentralized naming system for computers, services or other resources connected to the Internet or a private network. It acts like an Internet phone book because it gives each computer an address with an associated FQDN. BIND9 (Berkeley Internet Name Domain) is the package that provides the name conversion to IP functionality.

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– Installing BIND DNS on Rocky Linux.

a) Run the following command in the terminal with root privileges, the Bind9 package installation will be performed.

b) We will wait until all the packages are installed correctly and the output indicates that the installation has been successful.

– Configuration of BIND9 DNS in Rocky Linux.

– Now we will proceed to configure BIND for domain name resolution. In the environment where the server is located, the following configuration is available:

DNS zone – contenedores.domainx.mx
Managed subnet – 10.xxx.xxx.xxx/24
DNS server IP 10.xxx.xxx.xxx

c) Edit the /etc/named.conf file with the "nano" or "vim" editor, make the following changes and create the forward and reverse zones.

i) Modify the following lines, so that it can listen to requests from anyone within the internal network and iterative queries.

Listen-on port 53 { any; }
Allow-query { any; }

ii) Create the forward zone, indicating the name assigned to it and the name of the file where the configuration will be saved.

Forward
zone "contenedores.domainx" IN {
type master;
file "openshiftDNS.forward";
allow-update { none; };

iii) The reverse file is configured in this same configuration file, putting the three octets in reverse, starting with the third last octet.

zone "9.xxx.xxx.in-addr.arpa" IN {
type master;
file "openshiftDNS.reverse";
allow-update { none; };
};

Note: If the DNS server IP for example is 172.29.10.5, the reverse zone will be 10.29.172.in-addr.arpa

iv) This is how /etc/named.conf would look like. Some parameters in the environment configuration file are modified.

– Create the zone files

Create the forward and reverse zone files, in which DNS records such as A, AAAA, MX and PTR records will be updated.

A: This is the host address or forward record and is only in the forward file (above).

PTR: This is the pointer record better known as the "reverse" and is only in the reverse file.

d) The file is created in the /var/named directory and edited with "nano" or "vim", the forward and reverse files are created.

"sudo vim /var/named/openshiftDNS.forward"

In this configuration a serial number must be set to a number that will increment each time you add a DNS record. This is to facilitate the management of large clusters. The name or FQDN of the host name or server is assigned its IP address. As you can also set each IP address of a hostname.

e) Create the corresponding reverse DNS file with the PTR records of the domains added in the forward zone file. Take into consideration that the same serial number in the reverse zone as the one used in the forward zone (Illustration 5).

f) Grant all the correct permissions to the files created above.

sudo chown root:named
/var/named/openshiftDNS.forward
sudo chown root:named
/var/named/openshiftDNS.reverse
sudo chmod 644
/var/named/openshiftDNS.forward
sudo chmod 644
/var/named/openshiftDNS.reverse

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– Allow DNS service through the Firewall (Forcepoint, 2021)

g) Configure the Firewall to allow DNS service with the commands:

sudo firewall-cmd --add-service=dns --permanent
sudo firewall-cmd –reload

– Verify the DNS configuration

h) Execute the commands in order to verify that the configuration is correct and that there are no syntax errors in the zone files.

sudo named-checkconf

i) Verify that the forwarding zone files are well configured, as well as the reverse file, passing as parameter the name of the zone and the file. It should give us an OK status.

named-checkzone contenedores.domainx.mx openshiftDNS.forward
named-checkzone 9.xxx.xxx.in-addr.arpa openshiftDNS.reverse

– Initialize the BIND service

j) Start and enable named.service to start the BIND service.

sudo systemctl enable --now named.service

k) Verify that the service has started correctly. It should be verified that the service is active and has loaded the zone files.

systemctl status named

– Test the DNS Bind service in Rocky Linux.

Now we are going to try to query the DNS server using the dig and nslookup command.

These commands and the above output help to verify that the DNS service is working. So you can start using the DNS server in Rocky Linux 8. You can also add more records to the DNS zone files.

2.4 Configuring GlustesFS Distributed Volume Mirroring

After installing the operating system on the nodes that make up our cluster, the GlusterFS distributed replicated volume (Gluster, 2022) must be configured on the operating system that has been installed which is Rocky Linux. Gluster is a free and open source scalable network file system (Snigdha, 2021) that enables the creation of large-scale distributed storage solutions for media streaming, data analysis and other data - bandwidth intensive tasks.

Prerequisites for installation

a) If you have 8 nodes, you must have at least 6 nodes for the GlusterFS cluster (IONOS, 2021). An even number of bricks must be used in this type of volume.
b) Attach an extraction disk (which is different from the root partition /), so that it can be used to provide the gluster storage unit (brick).
c) Make sure that the time is synchronized between the cluster nodes, they should all have the same time.
d) Open the required Gluster ports/services in the firewall on all nodes in your cluster.

Gluster Volume Types

GlusterFS has support for different volume types offering various features, these include the following:

– Distributed: Files are distributed across the bricks in the volume.
– Replicated: Files are replicated across the bricks in the volume. Ensures high availability and reliability in storage.
– Distributed Replicated: Files are distributed across the replicated bricks in the volume. Ensures high reliability, scalability and improved read performance.
– Arbitrated Replicated: Files are replicated in two blocks in a replica set and only the metadata is replicated to the third block. It makes sure to guarantee data consistency.
– Dispersed: Files are dispersed across the blocks in the volume.

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– Distributed Dispersed: Data is distributed across dispersed sub volumes.
– GlusterFS distributed replicated volume configuration.

In a glusterfs distributed replicated configuration, the number of blocks must be a multiple of the number of replicas. In addition, the order in which the blocks are specified is crucial in the sense that adjacent blocks become replicas of each other.

1. List node details and information, such as hostname and IP address in order to install GlusterFS Check the GlusterFS server status: systemctl status glusterd on each of the nodes that have the Gluster server.

2. Open and Allow GlusterFS services and ports in the Firewall.

a) Configure distributed replicated storage volumen

The gluster volume create command should be used to create a distributed replicated storage volume. The full command syntax to be able to create a new volume in Gluster is:

gluster volume create NEW-VOLNAME [replica COUNT] [transport [tcp | rdma | tcp,rdma]] NEW-BRICK…

Points to consider

– It is necessary to use an even number of bricks when creating a distributed duplicate volume (in this case there are 8 of them). That means that the number of blocks or bricks must be a multiple of the number of replicas.

– The order in which the bricks are specified determines the order in which they replicate each other. For example, if you specify a two-way replica, this means that the first two adjacent bricks specified become a replica (mirror) of each other and the next two bricks in the sequence replicate each other.

b) Creation Two-way distributed replicated volumes

The cluster that has been configured consists of 8 nodes and a replica will be applied to the volume of two. This means that the first 2 adjacent blocks will form a replica, the same with the next two.

In the installation process, the data directory block will be named in three different ways, since the three logical partitions that the oVirt installer needs for its installation were created, the partitions are: data, storage, engine.

So this replication process must be performed in each of the partitions for the eight blocks. The directories will have the names: data-repl, vmstore-repl, engine-repl. In this case the process will be demonstrated using "vmstore-repl" as an example. If the directory does not exist, it will be created.

*gluster volume create vmstore-repl replica 2 transport tcp *
fsnodo1:/vmstore/vmstore01
*fsnodo2:/vmstore/vmstore02 *
fsnodo3:/vmstore/vmstore03
*fsnodo4:/vmstore/vmstore04 *
fsnodo5:/vmstore/vmstore05
*fsnodo6:/vmstore/vmstore06 *

Note: In this case the volume for the vmstore partition is being created, for the other volumes, vmstore is replaced by data or engine.

i) If the creation of the replicated distributed volume is successful. You should get the following confirmation message indicating successful creation

volume create: dist-repl-gfs: success: please start the volume to access data

c) To start the GlusterFS replicated distributed volume.

i) To initialize the Gluster volume with the volume start command. Initialize the volume with the name assigned to it during its creation process.

gluster volume start vmstore-repl

ii) In order to know and list additional information of the blocks and of each of the created volumes, apply the following commands, applying the correct name of the volume you want to obtain the information.

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gluster volume status vmstore-repl detail

d) Mount GlusterFS storage volumes on clients.

Once the mirrored volumes have been installed, they must be mounted on clients so that information and data can be written to them.

Demonstration of how to mount glusterfs volumes, we will be using and mounting on a client with RockyLinux.

Install GlusterFS native client on the operating system.

dnf install glusterfs glusterfs-fuse

e) Create a Gluster Storage mount point. The /gluster_bricks/vmstore directory will be used. There will be three different directories that will be found in the gluster_bricks directory, because the installation of three volumes was performed and the volumes need a mount point (the directories will be data, engine and vmstore). Perform this process in each of the nodes, this process must be done 7 times.

f) Apply the mount command, specifying the system file type as "glusterfs", along with the node name and volume name.

g) For automatic mounting during system boot, enter the following line in the /etc/fstab file, edit with nano or vim, replacing the particular glusterfs storage volume and the mount point that has been determined.

i) Three lines were added to the fstab file corresponding to each of the partitions, the name of the node and the volume. This must be applied to each of the nodes.

fsnodo1:/vmstore-repl /gluster_bricks/ glusterfs defaults,_netdev 0 0
fsnodo1:/data-repl /gluster_bricks/ glusterfs defaults,_netdev 0 0
fsnodo1:/engine-repl /gluster_bricks/ glusterfs defaults,_netdev 0 0

2.5. oVirt installation and configuration

Installation of the required packages on all 8 nodes.

a) On all 8 nodes, perform the ovirt repos installation from https://resources.ovirt.org/pub/yum-repo/. For example, to subscribe to oVirt 4.4 repo.

yum install https://resources.ovirt.org/pub/yum-repo/ovirt-release44.rpm

b) On all 8 nodes, install the following packages

i) cockpit-ovirt-dashboard (provides a graphical environment for the installation)
ii) vdsm-gluster (plugin for managing los servicios de gluster

yum install cockpit-ovirt-dashboard vdsm-gluster ovirt-host

c) On the first host, install the following packages

i) ovirt-engine-appliance (for Engine virtual machine installation)
ii) gdeploy (a container tool around Ansible that helps to configure gluster volumes)

yum install ovirt-engine-appliance

– Gluster configuration and preparation for oVirt

d) In order to configure Gluster Hyperconverged, you need to access the first node, which is where the management panel for the installation of oVirt was installed, enter the root credentials to enter the node through the UI.

e) Go to the virtualization section and select the way in which oVIrt Engine will be installed in multiple nodes, in this case the Hyper Converged version will be chosen, which allows data replication and the Engine not to be centralized in only one node.

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f) Start the Gluster configuration wizard. Provide the hostname of the first three hosts that make up the Cluster, their hostname for the Storage and Public Network. The ansible cockpit to perform the gluster implementation on the hosts. It is necessary to have a key-based authentication setup for the root user between the host running the wizard and the 3 addresses provided for gluster hosts. The deployment process also adds the 3 hosts to the oVirt engine at the end of the deployment process. To ensure that the hosts are added via the management network/interface, provide the FQDN (LINUBE, 2020) to be used for the hosts on the tab.

g) This is an optional step: install additional required packages on all hosts. As this is an oVirt-Node based installation, all necessary packages are already available.

h) In this step of the wizard you define the gluster volumes that need to be created. These gluster volumes are going to be used later in the wizard to create domains (Network, 2021) of storage in oVirt. The first volume is going to be used for the Hosted Engine virtual disk. Two additional gluster volumes will be created. The name of the volume and the directory of the bricks where this volume will be hosted are assigned, for this purpose the directories were previously created in each of our nodes.

i) Vmstore: It is in charge of storing the virtual machine images.

ii) Data: It hosts the data disks of the virtual machines.

i) The Bricks tab configures the devices that will be used for the gluster volumes defined in the previous step. If the devices that are being used for the blocks are configured as RAID devices, the information must be provided in the RAID information section. These parameters are used to create the values for the LVM and file system created on the device. Select the type of RAID that is JBOD and configure. Assign the LV names and size.

j) The last section of the wizard, compiles through a YAML file, the installation configuration, you can modify parameters prior to installation. The installation process starts and once the installation is finished, it will indicate that Gluster has been successfully configured.

– Instalación de oVirt (Hosted Engine)

Through the hosted engine wizard, you can create the engine virtual machine from a pre-installed device to configure it on the fly. This can save a lot of time and ease the configuration. After Gluster has been configured through the cockpit that has been installed on the nodes, you will continue to install oVirt, the hosted engine.

a) Once the Hosted Engine Deployement wizard is initialized. Configuration data must be provided to create the hosted engine, such as VM FQDN, the ip that manages the virtualizer, DNS servers, assign passwords, as well as the resources that the hosted engine machine will occupy.

b) Engine configuration. Assign a password to the administrator portal and the configuration of notifications, server where the virtualizer notifications will be sent.

c) List of the configuration of the virtualizer to be created and the hosted engine, counting all the configuration options. Once you continue, the installation process will be performed.

d) Start the installation of oVirt, you will be able to follow all the installation with the logs that it provides, once the installation is finished, the logs will indicate that the installation is finished.

e) Configure the storage domain that will be used to store the disk of the virtual machine manager and administrator. Assign the Storage Connection and the mounting options.

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f) The disk is created and we wait until the storage domain is successfully configured and the disk with the designated capacity is attached to the hosted engine virtual machine. It will provide us with logs to follow the installation process.

g) Access the domain, FQDN that has been assigned to the virtualizer, when the FQDN is entered, it will redirect to the login screen, the assigned passwords are entered.

h) Now you can see the main screen of the virtualizer that lists the total resources of the virtualizer and the global use of the resources. Now you can manage according to the virtualizer's needs (Figure 2**).**

2.6. Instalación de Openshift en oVirt

– Requirements verification procedure for the oVirt development environment.

Verify that the oVirt environment meets the requirements for installing and running an Openshift Container cluster (Bluexp, 2021). Failure to meet these requirements may cause failures.

Procedure

– Verify that the version of oVirt is compatible with the installation of Openshift Container version 4.

i. In the oVirt administration portal, click on the ? sign (help) and select the "About" option.
ii. In the window that will open, note the oVirt Software Version section, it will give you the version of your oVirt.
iii. Confirm that the oVirt version is 4.4.

– Inspect and verify the Data Center, Cluster and Storage.

iv) In the oVirt administration portal, click on Compute -> Data Centers.
v) Confirm that the Data Center where the Openshift Container installation is planned to be performed is accessible.
vi) Click on the Data Center name
vii) In the Data Center details, in the Storage section, confirm that the storage domain where Openshift Container will be installed is Active.
viii) Take into account the domain name, as it will be used later.
ix) Confirm that the Free Storage has a minimum available storage of 230 GiB.
x) In the Data Center details, go to the clusters section.
xi) Find the oVirt cluster where you plan to install oVirt. Find the cluster name to use later.

– Inspect oVirt host resources.

vii) In the cluster details, click on the Hosts option and tab.
viii) Inspect the hosts and confirm that they all have a combined total of 28 Logical CPU Cores available for the Openshift Container Cluster.
ix) Store the number of Logical CPUs for later use.
x) Confirm that these CPU cores are distributed, so that each of the seven virtual machines that are created during the installation must have at least 4 cores.
xi) Confirm that, collectively, all hosts have 112 GiB of maximum free memory for the newly distributed virtual machines to meet the requirements of each of the following Openshift Container machines:
xii) 16 GiB para la máquina de bootstrap
xiii) 16 GiB required for each of the three virtual machines of the three "control plane machines".
xiv) 16 GiB required for each one of the three compute machines.
xv) To find out the maximum amount of memory to program new virtual machines for later use.

– Verify that the virtual network to install Openshift Container has access to the oVirt Engine REST API. From a virtual machine in this network, use curl to reach the REST API.

$ curl -k -u <username>@<profile>:<password> \ https://<engine-fqdn>/ovirt-engine/api

The <username> part specifies the username of the oVirt account with sufficient privileges to create and manage an Openshift Container Cluster in oVirt. For the <profile> section you must specify the login profile, which can be obtained through the oVirt Administration portal, in the Profile section a dropdown that, on mouseover, will give the full user. While <password> refers to the password for that user.

For <engine-fqdn>, specify the full domain name of the oVirt environment.

– Preparing the network environment in oVirt Configure two static IP addresses for the Openshift Container cluster and create DNS entries using those addresses.

Procedure

1. Reserve two IP addresses

a. On the network where the Openshift Container installation is planned (Bluexp, 2021), identify two IP addresses that are outside the DHCP pool range.

b. Connect to a host that is on this network and verify that each of these IP addresses are not in use. For example, use "Address Resolution Protocol (ARP)" to verify that none of the addresses have entries or are being used.

$ arp 10.35.1.19
10.35.1.1910.35.1.19) -- no entry

c. Remember these IP addresses for later use

2. Create DNS entries for the Openshift Container REST API and application domain names in this format:

api.<cluster-name>.<base-domain> <ip-address>
**.apps.<cluster-name>.<base-domain> <ip-address>*

For the <cluster-name> part specify the cluster name, in this case "containers" will be used, in <base-domain> specify the base domain and in <ip-address> enter the IP address for the Openshift Container API.

Assign the same as above but a different address for the Openshift Container apps.

api.my-cluster.virtlab.example.com 10.35.1.19
**.apps.my-cluster.virtlab.example.com*
10.35.1.20

– Installing Openshift Container Platform on oVirt RHV in insecure mode

By default, the Openshift installer creates a CA certificate, requests a confirmation and stores the certificate that is used during the installation process. It is not necessarily required to create or install one manually.

Although not recommended, it is possible to bypass this automatically generated functionality and proceed with the OpenShift Container Platform installation without verifying a certificate by installing OpenShift Container Platform on RHV in non-secure mode.

– Procedure

a) Create a file named ~/.ovirt/ovirt-config.yaml
b) Add the following content to the created file (ovirt-config.yaml)

ovirt_url: https://www.ovirt.org/download/
ovirt_fqdn: ovirt.example.com - 2
ovirt_pem_url: ""
ovirt_username: ocpadmin@internal
ovirt_password: super-secret-password - 3
ovirt_insecure: true

– In number 1 you must specify the host name or address that corresponds to our oVirt virtualized.

– Number 2 is the full name of the oVirt virtualizer domain name.

– In number 3 you must specify the oVirt virtualizer administrator's password.

c) Installation mode by generating a private SSH key and adding it to the agent.

Generate an SSH key required by the installation program, it is used on Fedora CoreOS (FCOS) nodes through their configuration files, it is also used to authenticate SSH access to the nodes.

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This key can be used to be able to access the boot machine in a public cluster to troubleshoot installation problems.

"In a production environment, it is essential to have this SSH key, as disaster recovery and debugging are required."

– Procedure

i. If you do not have an SSH key that is generated by default in the operating system, you must create one. In the Linux operating system, it is created with the command:

*ssh-keygen -t ed25519 -N '' *
-f <path>/<file_name> - 1

Where in 1 in <path> you must specify the path and filename as ~/.ssh/idOKD, of the new SSH key. If you have existing keys, make sure that the SSH key is located in the ~/.ssh directory, as the Openshift installer takes that path.

iii) Start the ssh-agent process and task as a background task.

$ eval "$(ssh-agent -s)"
Salida de la consola
Agent pid 31874

iv) Adding the private SSH key to the ssh-agent

$ ssh-add <path>/<file_name>

The following console output is obtained:

Identity added: /home/<you>/<path>/<file_name> (<computer_name>)

When installing Openshift Container Platform, the public SSH key must be provided to the installation program. We can see the contents of the key.

– Get the installation program

Before the Openshift Container Platform is installed, install the installation file on the local computer where the Openshift deployment process is being performed.

– Client computer requirements for installing the software

You must have a computer running Linux or Mac OS with 500MB of available storage.

– Procedure

i. Access the infrastructure provider's page on the OpenShift Cluster Manager site. You must have a Red Hat account. Log in with the correct credentials. If not, create an account on the platform.

ii. Select the infrastructure provider.

iii. Go to the page corresponding to the type of installation to be performed, download the installation program for the operating system you have and place the file in the directory where the installation configuration files will be stored. The installation program creates several files on the computer that you use to install your cluster. It is necessary to save the installation program because it has utilities that can be used after the cluster is installed. Both files are required to remove the cluster.

iv. *"The installation program creates multiple files on the computer that it uses to install your cluster. You should keep the installation program and the files that the installation program creates after the cluster installation is complete. Both files are needed to remove the cluster later if desired or required."*

– Extract the installation program

Extract the installation program. For example, on a computer using a Linux-based operating system, the following command should be executed:

$ tar xvf openshift-install-linux.tar.gz

Unzip the installer and from now on you can start the cluster installation process.

– Extract the installation program

Openshift Container Platform can be installed on a supported cloud platform.

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"Execute the create cluster command of the installation program only once, during the initial installation process."

– Prerequisites

Open the ovirt-imageio port to the Administrator from the machine running the installer. By default, the port is 54322.

Obtain the OpenShift Container Platform installer and the pull secret for the cluster.

– Procedure

Change to the directory where the installation program was unzipped and contains the installation program and start the cluster deployment:

*$ ./openshift-install create cluster --dir <installation_directory> *
--log-level=info

– For <installation_directory>, specify the directory where the files generated during the installation will be stored.

– For different information or details of the installation, specify "warn", "debug", or "error" instead of "info".

Respond to the indications of the installation program

a. Optional: For the SSH key, select a public key without a password, such as ~/.ssh/id_rsa.pub. This key authenticates connections to the new Openshift Container Platform cluster.

b. For Platform, select the "oVirt" option.

c. For Engine FQDN[:PORT], the fully qualified domain name (FQDN) for the RHV environment must be entered.

For example:

rhv-env.virtlab.example.com:443

d) The installer automatically generates a CA certificate. For the "Would you like to use the above certificate to connect to the Manager?" answer yes or no, depending on whether you want to install Openshift in insecure mode or with certificate. If the answer is N, you should install Openshift Container Platform in insecure mode.

e) For the oVirt Engine username, enter the oVirt RHV admin panel username and profile, using the following format:

<username>@<profile>

For the <username> option, you must provide the username as an administrator or other type of user who has access to oVirt. For <profile>, specify the login profile. For example: admin@internal.

f) For the Engine Password part, the oVirt RHV admin password or specified user must be entered, with the key that is entered into oVirt.

g) For "Cluster", select the oVirt RHV cluster to install the Openshift Container Platform.

h) For "Storage Domain", select the storage domain to install Openshift Container Platform

i) For the Network option, select a virtual network that has access to the RHV Manager REST API.

j) For "Internal API Virtual IP", enter the static IP address that we select for the REST API of the cluster.

k) For "Ingress Virtual API", enter the IP address that was reserved for the application domain.

l) For the Base Domain, enter the base domain of the Openshift Container Platform cluster. If this cluster is to appear on the public network, it must be a valid domain recognized by the DNS infrastructure.

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m) For Cluster Name, a name must be assigned to the cluster. For example, my-cluster. Use the cluster name of the externally registered DNS entries that were created for the Openshift Container Platform REST API and the domain names of the applications.

n) For "Pull Secret", copy the pull secret found in the pull-secret.txt file or on the Red Hat OpenShift Cluster Manager page.

When the cluster installation is complete, instructions on how to access the cluster, including a link to the web console and credentials for the kubeadmin user, will be displayed via the terminal.

INFO Install complete!
INFO To access the cluster as the system:admin user when using 'oc', run 'export KUBECONFIG=/home/myuser/install_dir/auth/kubeconfig'
INFO Access the OpenShift web-console here: https://console-openshift-console.apps.mycluster.example.com
INFO Login to the console with user: "kubeadmin", and password: "4vYBz-Ee6gm-ymBZj-Wt5AL"
INFO Time elapsed: 36m22s

Neither the installation program nor the files created by the installation program should be deleted. Both are required to remove the cluster.

o) Accessing the Openshift Container Platform web console from RHV

After the Openshift Container Platform cluster is removed, you can log in and access the OpenShift Container Platform web console.

Procedure

1. In the Red Hat Virtualization (RHV) Administration Portal, open Compute → Cluster.

2. Verify that the installation program creates the corresponding virtual machines.

3. Return to the command prompt where the installation program is running. When the installation program finishes, it will display the user name and temporary password to be able to log in to the Openshift Container Platform web console.

4. In a browser, open the Openshift Container Platform web console URL. The URL has the following format:

console-openshift-console.apps.<clustername>.<basedomain>
Para <clustername>.<basedomain>, especificar el nombre del cluster y el nombre de dominio

For example

console-openshift-console.apps.my-cluster.virtlab.example.com

Figure 1 Logical management environment of a Data Center
https://www.ovirt.org/documentation/administration_guide/

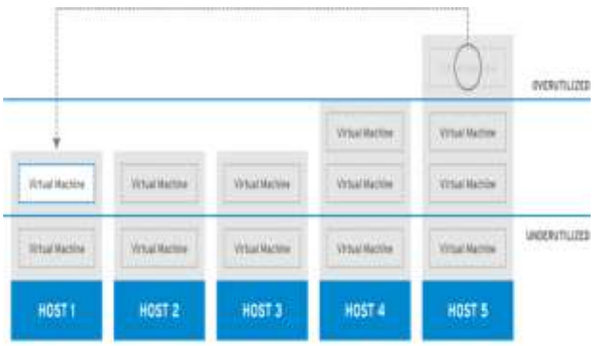

Figure 2 Scheduling policies to virtual machines, *https://www.ovirt.org/documentation/administration_guide/#sect-Scheduling_Policies*

Figura 3 Configuración del motor alojado oVirt *https://www.ovirt.org/dropped/gluster-hyperconverged/chap-Single_node_hyperconverged.html*

Figura 4 Dashboard hipervisor oVirt, *https://www.ovirt.org/download*

Results

The Openshift Container Platform has been left in optimal and functional conditions, as well as the virtualizer where Openshift is mounted, it was achieved that the virtualizer can perform the task of administration and management of KVM. Openshift has been left in its best conditions, to be exploited to the fullest and use its maximum capacity, because it was allocated resources for high performance, allows you to design, deploy and run applications uniformly in the cloud, on premises or at the edge of the network. Thanks to Openshift, applications developed and assembled on Kubernetes (RedHat Openshift, 2017) (Spot by NetApp, 2021), and can be put into production more easily and efficiently.

The free, open source virtualization management platform offered by Red Hat, oVirt, was implemented. The software is capable of migrating virtual machines to different hosts and storage domains, monitoring the status and resources consumed by the virtual machines and the cluster in general, and has high availability on the 8 nodes that make up the cluster.

The implementation of oVirt is of great benefit, since it offers many resources for the development and production of applications that are developed in the software factory area, in addition to the fact that it uses a bare metal environment that offers higher performance and better management in the use of hardware resources. Thanks to the considerable amount of resources available in the cluster (storage, RAM memory and CPU cores), virtual machines of different profiles, desktop machines, servers and high performance machines can be created and configured according to the needs and scope of the project or tool.

On the other hand, a local DNS server was implemented, using a virtual machine hosted in the oVirt virtualizer, the DNS Bind9 server which has the function of managing local network queries, different rules were configured to reach local computers through their private IP addresses, this DNS server was mainly used for Openshift, it used two static IP addresses for the OpenShift Container Platform cluster and DNS entries had to be created using these addresses. The DNS server can be used for internal uses of the cluster (all machines hosted on oVirt).

Finally, the container platform was implemented using the two previously mentioned softwares, the configuration of resources to be used by the container application was performed, as well as the virtual machines (workers and masters) to optimize its operation, according to the number of applications and microservices that will be mounted in this development environment.

As an improvement, it is planned to perform a migration of currently operating services that use this same technology in order to make the operation and deployment of the applications in the data center faster and reduce infrastructure costs.

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Conclusions

For the correct operation of the virtualizer, it is necessary to perform scans and monitoring to each of the nodes, install system updates and activate services that sometimes stop working, this can be done from the cockpit (GUI) of each of the servers, in addition to relying on opensource monitoring tools for the physical interfaces of the cluster such as use of processing, memory, disk space, file system and network.

As for Openshift, after installation. The cluster administrator can configure and customize the following components according to the needs and deployment of applications:

– Configure Storage By default, containers work with ephemeral storage or transient local storage. Ephemeral storage has a lifetime limitation, it is necessary to perform persistent storage configuration to store data for a long time. Storage can be configured in dynamic provisioning and static provisioning.

– Configure network: As a cluster administrator, it is necessary to configure cluster traffic ingress, network policy, enable cluster-wide proxy.

Depending on the needs and requirements, pods can be added to a service or project to improve its performance. These process instances can encapsulate from 1 to many containers that execute shared processes to other instances that require the service regardless of whether or not they are dependent on it, making the service or services always available under a shared environment and in constant communication and also sharing resources, volumes and storage in a single entity.

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Preliminary study of thermography applied to diagnosed faults in Diesel Engine and network rack

Estudio preliminar de termografía aplicada en fallas diagnosticadas en Motor a Diesel y rack de redes

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Abstract

In this study, we applied thermographic analysis to gather data and establish decision criteria for the corrective maintenance of electrical and mechanical systems. Our main objective is to generate a thermographic database for systems such as combustion engines and network racks. To achieve this, we conducted preliminary experiments on electrical and mechanical systems with known faults. We also established calibration criteria for the thermal emissivity of the components. Subsequently, we analyzed a Diesel engine with induced faults, obtaining the maximum temperature threshold in malfunctioning components, as well as emissivity values. Additionally, we carried out an analysis on a network rack, specifically a 48-node Patch, with constant and intermittent connection faults. Our methodology included analyzing the transience of the mentioned systems to identify patterns indicating wear, malfunction, or damage. The collected data allowed us to create a database and perform calibration for effective emissivity.

Thermography, Corrective, Network, Dataset, Analysis

Resumen

En este estudio, aplicamos el análisis termográfico para recopilar datos y establecer criterios de decisión para el mantenimiento correctivo de sistemas eléctricos y mecánicos. Nuestro objetivo principal es generar una base de datos termográficos de sistemas, tales como motores de combustión y rack de redes. Para esto, realizamos experimentos previos en sistemas eléctricos y mecánicos con fallas conocidas. También establecimos criterios de calibración para la emisividad térmica de los componentes. Posteriormente, analizamos un motor a Diesel con fallas inducidas, obteniendo el umbral máximo de temperatura en componentes en mal funcionamiento, así como los valores de emisividad. Además, llevamos a cabo un análisis en un rack de redes, específicamente un Patch de 48 nodos, con fallas constantes e intermitentes de conexión. Nuestra metodología, incluyó el análisis de la transitoriedad de los sistemas mencionados para identificar patrones que indiquen desgaste, mal funcionamiento o daño. Los datos recopilados nos permitieron crear una base de datos, así como realizar una calibración para la emisividad efectiva.

Termografía, Base de datos, Emisividad, Análisis

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Introduction

Due to the increasing demand for thermography devices in the industrial sector for industrial equipment monitoring and preventive maintenance, the production of these devices has been encouraged, with technological improvements in the most recent models. Due to their designs, functions and dimensions, they offer a diversity of applications in industry using thermal imaging, mainly for efficiency measurement, diagnosis, preventive inspections of failures in industry (Rao, 1998; Shepard, 1997; Bagavathiappan *et al*, 2013; Khamisan, *et. al*., 2018; Glowacz, 2021; Javed *et al*., 2022; Nakaguchi, & Ahamed, 2022; De La Cruz, 2023;Usai *et al*., 2023; Vásquez *et al*, 2023; Xu *et al*., 2023).

Heat on a regular basis is often an early symptom of damage or failure in Electrical and Mechanical Systems (EMS), making effective monitoring within preventive maintenance programmes highly relevant (Khamisan, et al., 2018). EMS is defined as the set of all the parts that make up a piece of equipment, including the mechanical part (where motion and friction occurs, such as in a diesel engine, turbine rotor, etc.) and the electrical part. Monitoring the performance of EMS with devices such as a thermal imaging camera reduces the likelihood of downtime due to EMS failures, reducing repair and maintenance costs, and extending the lifetime of assets.

On the other hand, Predictive Maintenance uses the analysis of thermographic data to identify operational anomalies and potential equipment defects, allowing timely repairs to be made before failures occur. For example, the industry can monitor various indicators, such as the decrease in rotational speed of an element caused by wear, as well as the lubrication or temperature reached by the system due to constant friction. On the other hand, using technology-based monitoring and the Internet of Things (IoT).

Corrective maintenance involves identifying, isolating and rectifying a fault so that the broken equipment or system can be restored to an operational condition. Thermography facilitates this process by providing visual evidence of the problem area.

For example, an infrared camera can identify electrical connection or component problems, such as misalignment, steam/water leaks, bent shafts, moisture, among others. This allows immediate corrective action to be taken, which positively impacts the indicators of time and resources spent on troubleshooting.

Microbolometer Sensor Rationale

The microbolometer sensor is an essential component in thermal imaging cameras. It functions as a radiation detector in the infrared spectrum of any radiating object, i.e. when its temperature is above absolute 0 on the Kelvin scale. The emitted radiation is converted into an electrical signal, which is then converted into an output image.

To develop the thermal image, the sensor has a number of microsensors. Each of them detects a corresponding value of the radiation emitted by the object to be studied. This set of information is displayed on a screen as an image composed of the same pixels that make up the sensor. Therefore, the higher the number of pixels in a device, the better the resolution and, therefore, the lower the degree of accumulated error in the measurement.

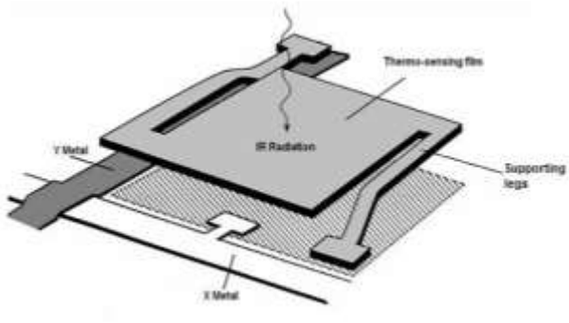

Figure 1 Example of the functioning of a microbolometer sensor and its parts
Image from Blanco-Mora (2013)

Following the principle of the photoelectric effect explained in 1905 and for which Albert Einstein was distinguished as Nobel Prize winner. Einstein explained mathematically how the energy of an electromagnetic wave collides with the electrons of some element; as an example, Vanadium or Silicon-Germanium (Blanco-Mora, 2013); see illustration in figure 1. Then, the radiative source when hitting the sensor emits an electrical signal later transformed into an image, as explained above.

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On the other hand, Wien's law explains the relationship between temperature and the length of the electromagnetic wave (Cardenas-Sanchez, 2013).

This law is expressed as:

$$\lambda_{max} * T = b \quad (1)$$

Where λ_{max} is the value of the maximum length of all total radiation emitted by the object. The value of b is equal to 2897.5 μmK. Wien's law is derived from Planck's radiation equation.

Thermal cameras equipped with microbolometer sensors cover wavelengths from 7 to 14 micrometres. As mentioned above, these chambers do not require special cooling systems, which makes them more affordable and smaller in size. They are therefore practical for field applications (Cárdenas-Sánchez *et al*, 2013).

The importance of emissivity on material diversity

It should be considered that these sensors do not measure the absolute temperature of objects; their operation is based on the measurement of the thermal emissivity (ε) of the incandescent object located at a specific distance (d) and emitting radiation in a range of frequencies with an emitting power E(λ, T), which depends on both frequency and temperature. To calculate the emissive power of any object at a given temperature and wavelength range, the Planck spectral emissive potential function is used, which describes how spectral radiation is emitted from a body at a given temperature, expressed in units of watts per cubic metre (W/m^3).

Emissivity, on the other hand, is a property of all materials and describes their ability to emit thermal radiation. It is expressed as a number between 0 and 1. In general, it represents the efficiency with which a material emits radiant energy in the form of heat at the infrared frequency. The emissivity of a material influences the amount of infrared (IR) radiation it emits when heated.

The emissivity of materials varies according to their petrological components. For example, materials that are good emitters of thermal radiation are close to 1, such as oxidised metals, asphalt, some volcanic rocks, etc. Classically, in physics, a material that emits and receives all radiation with an emissivity of 1 is known as blackbody radiation, see table 1.

Figure 2 shows an example of a thermal image capture to observe the variation of cooling. We can also observe the emissivity of this reflected on the table. The rate is this is polished so the emissivity is very low (less than 0.3), according to table 2 (Cardenas-Sanchez, 2013). On the other hand, note that with this equipment and software we can monitor the maximum temperature (indicated in the coffee rate) and minimum (indicated by the software in the lower left corner) to give sequence to the phenomenon. In this case it is a test example.

Material	Emissivity Range
Polished aluminium	0.05 – 0.10
Oxidised aluminium	0.07 – 0.95
Glass	0.80 – 0.95
Wood	0.90 – 0.95
Plastic	0.85 – 0.95
Cement	0.90 – 0.95
Volcanic rocks	0.95 – 0.98

Table 1 Emissivity range of some common materials *(Bagavathiappan, 2013 Harris, 2013: pp74)*

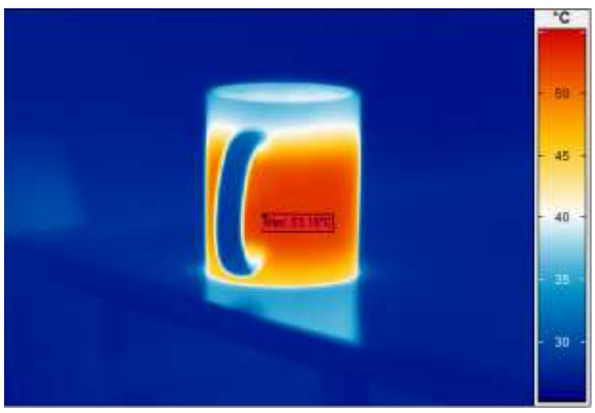

Figure 1 Example of emissivity measured on a coffee cup. Observe how it reflects the thermal radiation on the table on which it is placed. This radiation, if it were excessive, would explain why objects transmit part of the heat to their surroundings until thermal equilibrium is reached. Own image captured in the lab using Irbis 3 software

The emissivity value used for our experiments varies depending on the EMS being analysed.

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Tools, materials and software

Due to cost reductions in the thermographic industry and the incorporation of new technologies, such as the microbolometer sensor, the prices of thermographic equipment have decreased significantly in recent years. An example of this is the microbolometer sensor, which is cheaper compared to the old, expensive sensors that required specialised thermoelectric cooling systems.

Furthermore, in the Latin American context, there are security and licensing restrictions that limit the acquisition of thermographic equipment, especially with regard to data transmission, which is restricted to a maximum speed of 9 Hz. This limitation is not always fully understood by the various importers. However, it should be noted that the technological restriction on the data rate could be related to its exclusive use in the military industry in the North American and EU markets. This should be taken into consideration if you wish to purchase such equipment.

Team	Brand and other features
InfraTech thermal camera model VarioCam.	Microbolometer type sensor with a range of -40 to 1200 oC and a spectral range of 7.5 to 13 µm. Imaging resolution 640×480, viewing angle 1×30mm (30×23o).
Irbis 3 software	The software used for temperature analysis is Irbis version 3.0.
Lenovo Legion Laptop for information processing	Intel i7 9gen, with integrated GPU (not required for processing), and Windows 11 Home.
SD card	For capturing images on the thermal camera with standard 2Gb memory capacity.
Test engine	Diesel engine 6 cylinders in line, turbo charged, Perkins brand model T 6.3544, 150 HP
Panduit 48 Port Patch Panel	Part of the module 1 network rack.

Table 2 Materials used for our experimental tests.

Experimental Method

The methodology to be used in the experiment is divided into four key stages for the evaluation of the thermal condition of a diesel engine and a computer network rack:

The calibration of the thermal emissivity will be performed separately considering the specific material of the engine and the network rack, as they are objects with different materials from each other. This calibration is essential to ensure accurate and reliable measurements of the surface temperatures of the engine and the rack. Standard references shall be used and the emissivity of the equipment shall be adjusted according to the material characteristics.

Data capture:

Data capture shall be performed while the test engine is running. During a continuous period of 30 minutes, thermal data will be collected using a thermal camera at a rate of 20 images per minute. It should be noted that the engine has previously recognised and diagnosed faults, which allows the identification of specific problem areas. This process will be repeated to minimise possible measurement errors and ensure consistency of results, Figure 2.

In the case of the network rack, especially the 48-port Patch panel device, it is located at the Technological University of Manzanillo. The rack, Figure 3, the device, allows the connection of 48 nodes simultaneously, and it is in constant operation 24 hours a day in climate controlled conditions. The air conditioning indicates a temperature of approximately 24 degrees Celsius on average. However, for the measurement, we have captured data during 2 different stages of the day. The first stage was at 9 o'clock in the morning, as this is the peak time for users to connect. Finally, the second stage was set at 2 p.m., as this is the time when users are least likely to be online. For this experiment, sampling was carried out at a capture rate of 20 seconds per image for 30 minutes.

Using the Irbis 3 software of the InfraTech thermal camera, the captured thermal images will be analysed in real time. The software will identify and highlight areas with thermal anomalies that may be related to possible engine damage. For the measurement of the images, in addition to detecting the anomalies directly, test points and sampling areas will be established on the images in time sequences. The test points are fixed points of a pixel of the image where the temporal evolution of the cooling or heating process of the thermal anomalies can be appreciated.

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In the case of sampling areas, they are predefined areas comprising several pixels that completely cover the anomaly. However, unlike point sampling, sampling areas indicate the maximum, minimum and average temperature of the observed area.

Once the thermal anomalies have been identified, it shall be determined whether they correspond to damaged or problematic parts of the diesel engine. The affected areas will be compared with the previous fault diagnosis to establish a correlation between the anomalous temperatures and the specific parts of the engine that require attention.

This comprehensive methodology will effectively assess the thermal condition of the diesel engine and determine if the detected thermal anomalies are related to the damaged areas, thus facilitating the diagnosis and repair process in the maintenance workshop.

Figure 2 Front view of the Network Rack used for our experiment

Figure 3 Diesel engine used for our experiment, Perkins model T 6.3544, 150 HP

Results and discussion

As mentioned in the methodology, the data collection was carried out in a similar way in both experiments. The difference between the two experiments was the thermal emissivity value.

However, the Network Rack has several elements of different materials, from plastic, in the connection cables, to elements combined with painted aluminium, mainly in the 48-port Patch, figure 3. We performed 3 tests with different emissivity values, as shown in table 3. According to the responsible for the maintenance and management of the network system of the Technological University of Manzanillo, the network centre presents a significant deterioration in that element. On the contrary, in the same rack is located a 24-node Patch whose temperatures are below 35 degrees, compared to the more than 50 degrees registered by the 48-node Patch, figure 6. In this sense, we observe that the lower the emissivity, the higher the temperature value observed. Further analysis is still required, this time using another sensor for comparison.

According to our analysis, the 48-node patch has a higher heating than normal mainly during peak hours, that is during the early morning hours, when several users are connected simultaneously, figure 7. In the case of the cooling rate, the sampling areas (C4 and C5) have a lower decay compared to a specific point in the area (P1, P2 and P3), this may be due to the stability of the support used. It is therefore advisable to fix the thermal camera on a solid base, in case a similar analysis is desired.

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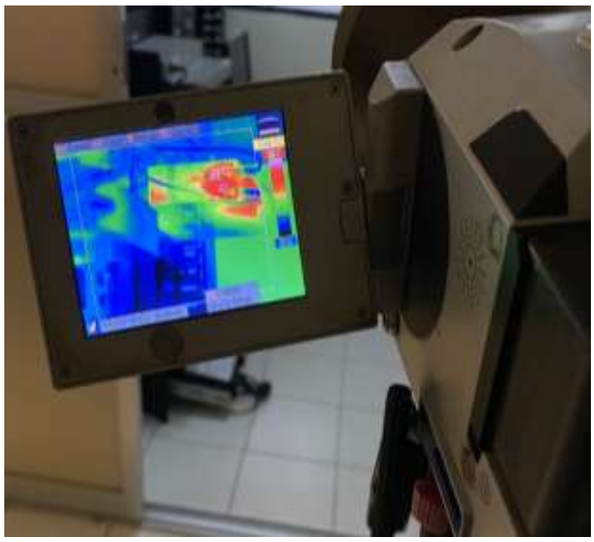

Figure 4 Photograph of the thermography equipment capturing data at a distance of approximately 1.5m from the network centre. This image clearly shows the thermal anomaly mainly in the 48-node Patch module

	Test 1	Test 2	Test 3
Experiment start time	10:19 a.m.	2:50 p.m.	11:17 a.m.
Emissivity	0.95	0.9	0.8
Laboratory temperature	24° C	24° C	24°C
Initial module temperature	40° C	46° C	51° C
Ambient temperature	33° C	32° C	31° C
Relative humidity	69%	68%	71%
Module end temperature	41° C	48° C	49.5° C

Table 3 Table of data for the three tests performed in the Network Rack indicating date, start time, temperature of the cooling system.

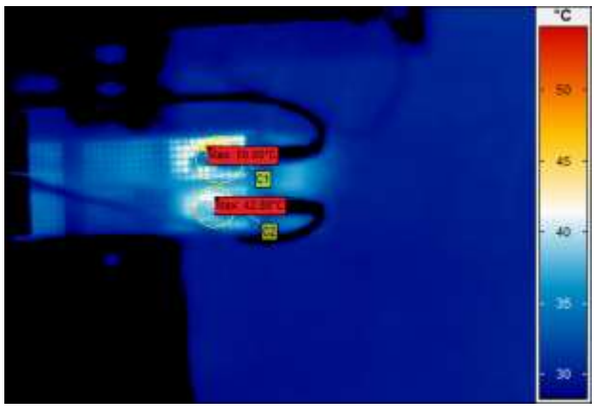

Figure 5 Analysis of the thermal anomalies detailing the high temperatures recorded. The image corresponds to the third experiment, table 3. On the other hand, the average temperature is below 30 degrees Celsius, the highest values can range up to 52 degrees Celsius.

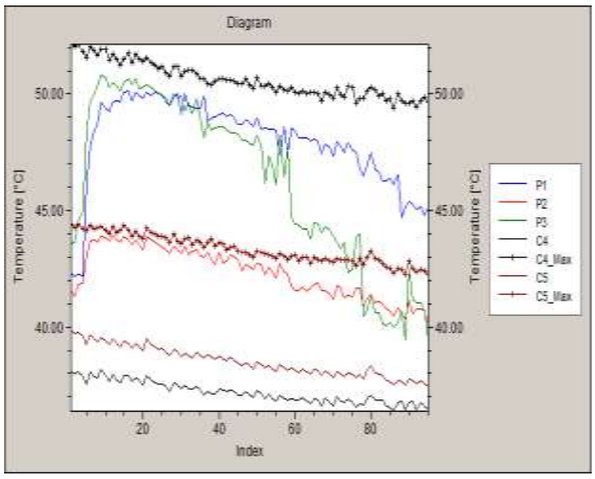

Figure 6 Anomaly analysis for the network rack using 90 images captured every 20 seconds. Note that some sampling points (P1, P2, and P3) decay with higher speed, these are sampling points (the size of the size of 1 pixel). On the other hand, the sampling areas (C4 and C5) show a curve with an almost constant mean value, because it considers the average value of the whole area.

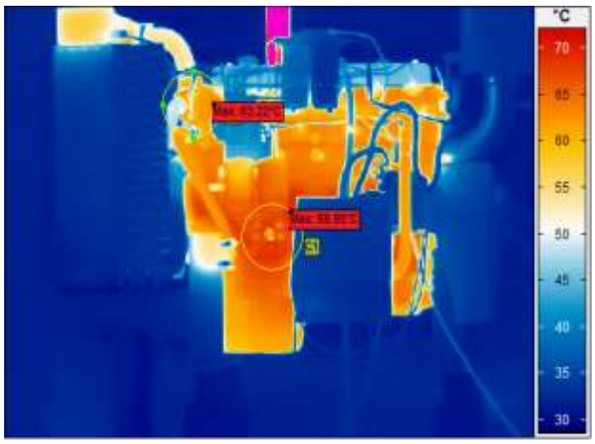

Figure 7 Test T-engine for our analysis with known faults. The image shows sampling areas with circle geometry listed as C1, and C2 respectively

On the emissivity in the engine study, we chose the value of 0.8 fixed for the two tests we did, this choice was due to the rough carbon steel components that make up the main engine casing. Therefore, in general terms the correct analysis performance is in the range of 0.8 to 0.9 in reality. We should continue to perform similar experiments in the future testing emissivity values in this range.

In figure 8, on the combustion engine, it can be seen that there is no coolant circulation from the monoblock to the radiator and temperatures of 35 Celsius. On the other hand, for our experiment we chose that the cooling system has a low coolant level as an induced failure.

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As can be seen in the figure, the equipment has an oil cooler that dissipates the temperature given off by the engine, which can be clearly seen in Circle 1, which is also where the largest temperature range recorded is observed, in addition to the exhaust system. In addition, there is a fault in its thermostats due to the fact that they do not open to the correct temperature (circle 2). Maintaining equipment in this condition could cause catastrophic failures for bearings, connecting rods, crankshaft and monoblock, among others. With the support of thermography we can anticipate possible failure of internal elements that make up an internal combustion engine and avoid corrective maintenance repair costs.

We have also carried out a temporal analysis of the data for our experiment. Although we performed 3 tests under similar conditions; temperature, emissivity and sampling time. However, we observed slight changes over time. Figure 9 shows the time series analysis of the captured images. In total there were 90 images captured at a rate of 3 per minute, or every 20 seconds. Note in figure 9, that the analysis of all the time series data, prior to engine shutdown, shows a higher growth rate over the oil cooler, as opposed to the cooling system, at C2.

On the other hand, the sudden changes in temperature around 30 seconds are due to changes in the thermal chamber, as it was not bolted to the base.

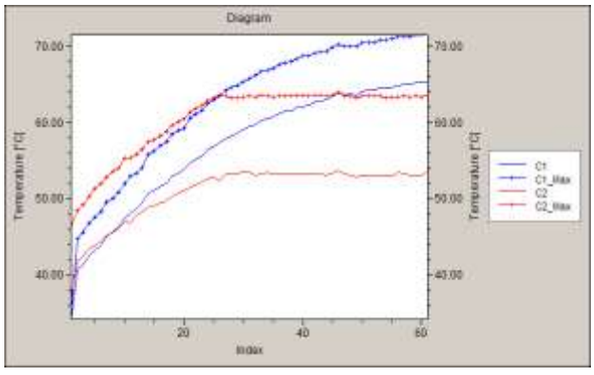

Figure 9 The figure shows the maximum, minimum and average values of circles 1, and 2 respectively in figure 8. Circle 1, above the oil cooler, also shows higher temperature values than the rest of its components

Conclusions

Thermography applied in SEM, such as those described in this article, allowed us to monitor the vulnerable regions in each of the systems analysed, mainly in the emissivity study. However, further studies and comparisons with other sensors are still needed. On the other hand, the preliminary analysis shows interesting results by highlighting high temperatures in areas such as the cooling system of the combustion engine. As an area of opportunity, in subsequent studies, the same engine will be studied again in order to confirm the predictions in order to subsequently carry out repairs, and to observe the difference between the two conditions of the engine under study. The emissivity at 0.8 reflects an adequate score, validated by a sensor device belonging to the same engine, with values around 85 degrees Celsius.

Similarly, in the network rack, the fact of previously knowing the failure on the 48-node patch allows us to have a maximum temperature threshold when it is required during the hours of highest traffic connection service and its comparison during the hours of low demand, as shown in the graph in figure 7. In this sense, this experiment also allowed us to know the effective emissivity ranges for the analysis. In our investigation, the 24-node patch did not show temperature values as high as the 48-node patch. This is logical because the 24-node patch is not faulty and is working normally.

We are aware of the failure of both the patch and the analysed engine. Nevertheless, these experiments have allowed us to build up a database that will grow as we conduct further experiments. With this data, in the future we will be able to define the predominant variables (essential features or characteristics that distinguish the neural network) that will feed the neural network as input data. This is an area of opportunity to generate an automated fault analysis system for similar systems. Below, you can find our database at the following GitHub link exclusively for educational use.

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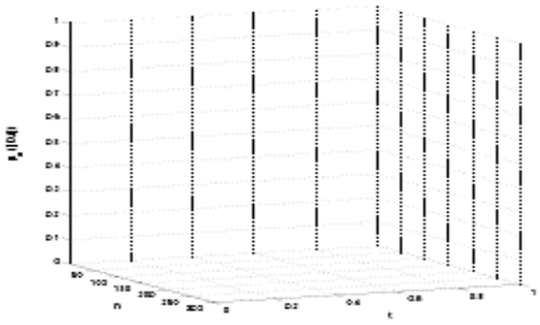

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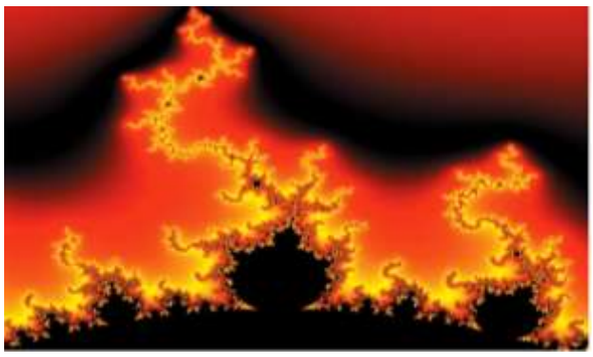

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