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JEAS

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THE MOST GRACIOUS,
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Editorial

Scientific publishing has brought many challenges to authors. With increasing number of scientific journals, varying scopes, reviewing requirements, and cost of publishing to authors, finding the right journal to publish an article is a decision many authors must bitterly confront and resolve. The publication of scientific findings is an integral part of the life of researchers. The process of publishing has evolved to become an efficient system of decimating knowledge and collaboration among scientists. Science journals have institutionalized procedures to manage large volume of article submissions per year. In many cases, journals began to define narrower scopes for a dual purpose: managing submissions and delivering outstanding research.

Based on recent studies, the scientific publishing world consists of more than 25 thousand active journals in various disciplines and fields. Science Direct hosts 3,348 journals (as of February 2014). The Directory of Open Access Journals lists in its search engine more than 9,800 open access online journals.

According to recent estimates, the number of scientific journals grows by 3% per year worldwide. With this large number of journals, journals may find it harder to stay afloat.

In its inauguration, the board of editors is honored to introduce to the scientific community the Journal of Engineering and Applied Sciences - JEAS, another scientific journal from Majmaah University. The board has pledged a commitment to JEAS authors and readers to bring the most dynamic and vibrant journal management with better satisfaction.

Dr. Mohamed Alshehri

Contents

A brief study on Software as a Service in Cloud Computing Paradigm

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Abstract
Software as a Service (SaaS) is a paradigm that provides end users or clients easy and seamless access to various applications, using the Internet without requiring any infrastructure or related software. To virtualize the access to applications and functionalities, SaaS providers use the cloud-computing environment to rent resources, thereby reducing both the capital and operational expenditure. SaaS uses the cloud-computing infrastructure to distribute applications to many users, irrespective of their location or infrastructure capacity. This one-to-many model with centralized control has the potential to transform the behavior of traditional IT architecture, its pricing, partnering, and management. With the emergence of SaaS as a delivery system, the whole software environment is moving toward a producer-consumer system, where both are distributed globally. We point out the motivation for accepting the new technologies, such as to reduce the expense, energy consumption, maintenance, etc. We also point out the challenges and risks associated with the paradigm shift. The present study categorically presents state-of-the-art research on the security issues of collaborative SaaS cloud computing and integrating service-level-agreement and quality-of-service-related issues of SaaS in cloud-computing environments.

Keywords:
Software engineering; software-as-a-service; cloud computing; service-level agreement; quality of service, security

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1.Introduction

In the recent years, the proliferation of bring your own device (BYOD), handheld devices, social networks, and related applications has been posing challenges to the service providers, in terms of on-demand network access, ubiquitous connectivity, resource sharing, resource configuration, down time, speed of provisioning and re-provisioning of networks, and most importantly, the amount of human intervention and effort involved. In the era of automatic computation featuring convenient allocation and withdrawal, seamless connectivity with the support of mobility, and reduced capital expenditure (capex) and operational expenditure (opex), enterprises are keener to use services without hosting them on their physical systems.

This phenomenon introduces the concepts of cloud computing and cloud resource sharing [1]. Service providers are searching for robust and scalable on-demand solutions with minimal management responsibilities, interoperability,vendor-agnostic hardware, flexibility, programmability, and secure control over resources. With the incorporation of the cloud model, all these above-mentioned features can be handled with minimal service-provider interaction and centralized control. The cloud model can be viewed as a bouquet of five important features, namely, on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. These service models can be categorized as software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). The cloud can be deployed using any or a combination of four deployment models: private cloud, community cloud, public cloud, and hybrid cloud [2]. This paper explores the business model of SaaS along with traditional software engineering (SE) and service-oriented architecture techniques. The present paper summarizes the legacy techniques and their usability in designing and developing a SaaS model and obtaining the best out of the designed model. SaaS [3] is a software fabrication and distribution model where applications (plug-and-play) are hosted by a service provider. Customers can access these applications through networks without adding any physical load to their network or experiencing security threats (secure access to private confidential data). The customers need not worry about the physical server where the applications are loaded, the processes involved, or the generation of output. They only pay for the services used and achieve the desired results.

Therefore, the new era of SE can be viewed

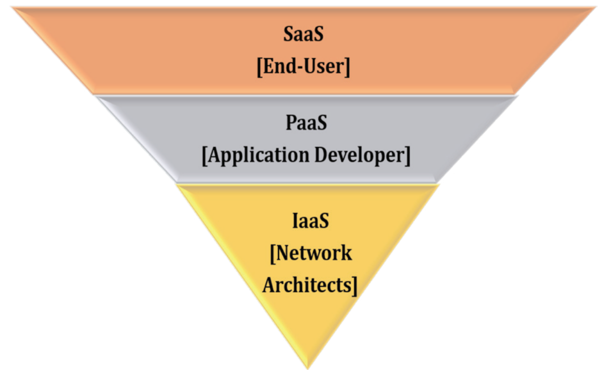

Fig. 1. High-level architecture of Cloud Computing

as service-oriented SE that comprises, integrates, and incorporates the best features of both the service and cloud-computing archetypes to make the development process more advantageous for software development and applications. In light of this, this study discusses an applicable working guideline on the new exemplar in software industries. It also aims to bridge the gap by suggesting substantial best practices, based on analyses of cases of importing SaaS as a running business model [4], [5].

Major Contribution and Organization of the paper:

This paper presents a detailed survey of SaaS, considering the traditional SE and service-oriented SE approaches. It analyses the effects of SE processes in developing quality software. Further, it explores several techniques of SE models and reviews to make SaaS a potential business model. The remainder of this paper is organized as follows: Section 2 discusses the basic architecture, benefits, maturity, risks and challenges, and other issues of SaaS. In Section 3, a detailed exploration of the issues associated with the migration from traditional SE to SaaS is presented. Finally, Section 4 concludes the article by discussing the role of SaaS in changing the whole paradigm of software development.

2. SaaS in Cloud Computing

Cloud computing is a robust and scalable dynamic platform for computing, where configurable resources are made available as services to users over a standard HTTP medium. The underlying advantage is that it is not necessary for the users to have knowledge, expertise, or control over the technology infrastructure in the "cloud" that supports them. A cloud-computing system can be seen as an integration of three subsystems: compute, storage, and management [6].

• Compute refers to the computing power needed to formulate the complex calculations, which can be achieved by installing high-end complex processors in the hardware to provide computing capability.

• Storage is the most important component of any cloud-computing system. It provides the service of storing large amounts of data in the hardware.

• Management takes care of various types of application programming interface (API) functions and other management capabilities that the system must depict and organize for processing.

The high-level architecture of cloud computing is depicted in figure 1. The provider supplies the solution (software, infrastructure, or platform) on the Internet, and one or more users can consume that service "on demand" by paying for the service. Presently, all major companies have their own cloud-computing frameworks, in which different types of services are available [4]. In the following parts, we briefly discuss the categories of services:

• IaaS: When the cloud offers a client with only infrastructure or the actual hardware (servers and disks), the system is essentially an IaaS.

• PaaS: Platform as a service provides all the hardware and computing infrastructure and maintains the platforms that are installed on the hardware. It can be thought of as an additional layer on top of the IaaS.

• SaaS: This is the topmost layer of the cloud framework. SaaS can be defined as "software deployed as a hosted service and accessed over the Internet." [4]. SaaS makes applications available over the Internet, as services. Instead of paying for the in-house installation and maintenance of software, clients can simply access the software via the Internet, without bothering about the internal complexity of software and/or hardware management [4], [7], [8]. These applications are also known as web-based software, on-demand software, or hosted software. They run on the provider's server and the customers need not install, maintain, or update hardware/ software. All these applications can be accessed using the Internet only. Therefore, a single application can serve multiple customers using the multi-tenant architecture. SaaS is developed with a "one-to-many" model, whereby an application is shared across multiple clients. It has the potential to change the way people view of software and therefore, has an impact on buying, trading, and using software [9]. A solution attracts market and investors only when it proves its fidelity to gain. Enterprises and organizations of all sizes can be categorized into two service-oriented dimensions:

• Line-of-business services are aimed at facilitating business processes such as finances, supply-chain management [4], and customer relations, and they handle large-scale configurable and customizable solutions. They are provided on a subscription basis.

• Consumer-oriented services are offered to the public, sometimes, at low costs and may be even at no cost, with the support of advertisement. Moving from on-premise services to on-cloud services is a huge step, which has broad impacts in three interrelated areas: the business model, application architecture, and operational structure [10].

2.1. Benefits of SaaS

By nature, SaaS resides in the Cloud. SaaS sales reached an estimated 10 billion in 2010 and it has been projected to reach 21.3 billion by 2020. If deployed and accessed successfully, SaaS can provide several benefits for both the providers and customers. In the following section, we briefly discuss the benefits of SaaS:

• Risk - Most providers provide a 30-day free trial of the SaaS software's full version. The clients can utilize it for a month before buying and verify whether it fulfils their requirements.

• Commitment - SaaS contracts can be cancelled any time. As a pilot approach, most of the solution providers allow the customers to cancel their contract and pay for only their period of use. Alternatively, it can be hired on a monthly basis.

• Cost - The "pay as you go" approach for SaaS is more attractive than the cost of software licenses, computer hardware, support contracts, and version updates. Thus, SAAS solutions are cost effective [11].

• Deployment - The clients can use the services on demand using SaaS. No prior deployment time, skilled staff, or office setup is required.

• Utilization - SaaS is continuously evolving based on user feedback. Moreover, it is easy to use and less complex, from the end-user point of view. Thus, it is more user-friendly, and is utilized more than the traditional software [12].

• Security - As SaaS is controlled centrally, it is easier to implement security updates, feature enhancement, bug fixing, and reliability solutions in SaaS, compared to the traditional on-premise software environments [13].

• Productivity - With the notion of work from anywhere, anytime, and on any device, SaaS solutions are more productive than the traditional ones.

• Seamless access to the latest and greatest - Ideally, with SaaS, the client does not need to worry about the latest releases and upgrades. The services are always offered with the latest version of software and are being improved continuously.

• Flexibility - The cloud infrastructure can be scaled rapidly to cope with the needs of the customer. In this way, SaaS is a customizable and flexible solution for all types of software requirements. It is a recommended solution for a small firm that wants to expand, or for a firm planning to combine traditional and service-oriented software and reduce capex and opex [14].

2.2. Maturity Model of SaaS

There are several ways service providers can host applications in the SaaS-cloud framework [14–16]. The maturity model SaaS framework is illustrated in figure 2.

• Psudo-SaaS: offers an ad-hoc and customized version of the hosted application, and runs its own instance of the application at the servers.

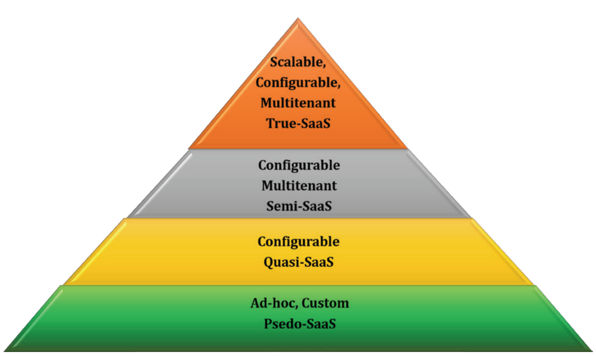

Fig. 2. Maturity model SaaS Framework

• Quasi-SaaS: The provider maintains a separate instance of the application for each customer (or tenant). Each instance of the application is the same at the coding level, but individually customized for each tenant. The customer has the option to specify the appearance and behavior of the application.

• Semi-SaaS: A single instance serves all customers, with the help of configurable metadata that provide a distinct user experience and feature set for each user. Isolation, authorization, and security policies are implemented to guarantee the privacy of data of each client. These sharing architectures are hidden from the end user. This approach allows efficient use of computing resources at low costs. However, the scalability of the application is a crucial issue of this approach.

• True-SaaS: This approach supports multi-tenancy with application scalability, as the provider hosts multiple clients on a load-balanced framework of identical instances, where data isolation is achieved. Furthermore, because of the configurable metadata, each client (tenant) receives a unique user experience and customized feature set.

2.3. Issues

Although SaaS provides many benefits to organizations, as it is in its nascent stage, proper planning, evaluation, and screening is essential to make SaaS acceptable to enterprises. The aim of SaaS is to provide small to medium-sized enterprises with enhanced mobility, office productivity, and improve team collaboration by utilizing the expediency of transferring the responsibility of managing software products to a SaaS provider. It is crucial to understand that SaaS needs robust system architecture capable of supporting peak usage demands and secure and seamless processing of large numbers of transactions in an environment [12]. However, some issues need to be considered carefully:

Regulatory and legal risks- In some countries, Government data-privacy laws and regulations make it difficult for a SaaS user and provider to share critical data when the provider is outside the user's country [17].

Downtime risks-If an organization moves many functions to the cloud with SaaS providers, a critical analysis should be done on the risks of increased downtime. To minimize the risk, before trusting any SaaS provider, the organization must verify the history of the provider from the availability and fault-tolerance points of view, for their real-time mission critical data. Alternatively, enterprises may restrict the processing of sensitive data, in house [18].

Data security- Data security is a big concern for public clouds such as iCloud and Dropbox. With any SaaS solution, there is a risk of sensitive-data breach. To minimize this risk, the security measures of the SaaS providers should be implemented with due diligence [19].

3. Software Engineering and SaaS

Software engineering [1990] (SE) can be defined as an application of a systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software. Software development, on the other hand, is a planned and structured process of developing a software product. Nevertheless, these terms are often used interchangeably, in literature. To make a transition from traditional SE to SaaS cloud computing is a notion of paradigm shift. It is not a small or low-impact technology review. It calls for changing many aspects of software development and operation [20]. In this section, we explore and scrutinize these challenges toward successful SaaS cloud computing.

• Service and service level: The notable benefit of SaaS is the provision of robust, resilient, and flexible services. In order to realize this, a service catalog describing all business terms must be created. This catalog must be able to control and constantly manage the list of services in the cloud environment, from the providers. As it follows a pay-per-go scheme, the service level should be defined and differentiated, and it must be applicable to all processes such as strategy making, supplier management, service portfolio management, and service catalog management [21].

• Problem management: One of the prevalent differences between the traditional SE and SaaS is the change in organization and management structures. There is a need for holistic visualization and seamless problem management, with readiness to solve customer problems fast.

• Risk and impact: SaaS can be more made appealing with traditional feasibility analysis and risk and impact analysis. In the cloud era, it is necessary to have an automatic resource-release-and-occupy setup, capable of dealing with changes in the requirement.

• Capacity: Before provisioning a service, the SE process must predict the total capacity. Therefore, a good prediction model that can make predictions in terms of SaaS properties is necessary [22].

• Finance: Strategic decision making for pricing and operations support system/business support system (OSS/BSS) is another big challenge for SaaS. Flexibility in terms of use can be provided at a higher price.

• Supplier handling: It is highly necessary to integrate different IT services according to the defined SLAs to SaaS [23], [24].

• Policy enforcement and supplier management can help select a supplier from potential vendors with healthy competition.

• Service portfolio management: To explore new business opportunities and manage more clients, SAAS uses the service portfolio management process. This process is supposed to be robust enough to react to every possible situation.

• Common operation support: With the promise of low downtime and faster provisioning, SaaS must feature quick software service development. The development process must be agile, clearly defined, and approved in advance. As SaaS claims to lower opex, tool selection is critical so that it can support high-level dynamic environments [25].

• Service validation and testing: With the traditional SE development cycle, a service validation and testing system is needed for prompt provisioning and flexible scale-up.

From the above discussion, it can be seen that traditional SE approaches must be refurbished in order to make SaaS a reality. Versateeg et al. proposed a provisioning algorithm to ensure several enterprise challenges such as licensing, distribution, and configuration, and similar to achieving the main objective of SAAS, maximizing customer satisfaction and minimizing cost. They claimed that their proposed algorithm could reduce the total cost by 48% and the number of SLA violations by 45%, compared to the best of the previously proposed algorithms [19].

In [26], Park et al. presented a study on the issues, risks, and potential of the SaaS-cloud computing environment, and showed the efficacy of such a system with some case studies. Tariq et al. proposed a new method in [27], for the requirement engineering of the SaaS-cloud model and considered a CMMI modification by adding a new requirement element to the existing process. Several requirement categories were identified to make SaaS more user-friendly and easier to develop, during the software-development cycle.

Wu et al. proposed a secure admission control and resource-scheduling algorithm [28] to improve the overall QoS of the SaaS providers. They demonstrated how their algorithm could help the service providers use their critical resources in real time. Using mathematical models and simulations, they demonstrated that the scheme outperformed the reference ones across all ranges of variation in QoS parameters.

Alsarhan et al. proposed an SLA framework for cloud computing SaaS [29], in which, with the help of reinforced learning and adaptive methods, they showed how the QoS for all SaaS clients could be handled efficiently without violating the SLA. With empirical and numerical analyses, they demonstrated the providers' profit under various cloud-environment conditions.

Peng et al. proposed a systematic framework for monitoring, analyzing, and improving the system performance of SaaS environments [30]. In addition, the authors represented the complex resource-allocation process using an elitist archive and the K-means-based mathematical model. Using some empirical case studies, they claimed that their framework efficiently met the requirements of end users (tenants) in a distributed environment.

SLAs are critical for cloud deployment, the adoption of SaaS, as well as for the replacement of the traditional software model. Considering this, in [31], Mubeen et al. investigated the existing research on the management of SLAs in the IoT applications and categorized them into seven main technical classifications: management, definition, modeling, negotiation, monitoring, violation and trustworthiness, and finally, evolution. They surveyed the existing proposals analytically and discussed their shortcomings.

Boukerche et al. developed a task-centric energy-aware cloudlet-based mobile cloud model [32] to address the offloading performance, scalability, security, and availability problems, aiming at increasing the cloudlet processing throughput, reducing the energy cost on the remote cloud, and improving the offloading execution efficiency and energy efficiency on mobile devices. The authors claimed that the proposed energy-aware offloading model could efficiently improve the offloading performance for mobile devices.

In [33], Nandi et al. proposed an intuitive model for the elastic cloud paradigm of dynamic SLA. They designed the model in such a way that it could capture the anticipated license requirement variations of SaaS users. The model used greedy heuristic-based optimization approaches for the service provider to solve the tenant on-boarding problem with dynamic SLA constraints. They demonstrated the efficiency of their solution by improving the performance in terms of the overall resource utilization and economy for both the service provider and tenants.

Wu et al. proposed a solution [34] to solve the traditional enterprise application distribution and configuration-related challenges. They proposed a resource-allocation algorithm to minimize the infrastructure cost to convert the traditional enterprise to SaaS so that the maximum service level could be guaranteed to the end user using dynamic resource sharing and virtual machines in the cloud environment.

Ghosh et al., proposed software defined networking- based paradigm [35],[36 where multiple controllers have been used to provide service level guarantee for software-as-a-service in smart grid networks.

4. Security and QoS Issues in SaaS and Cloud Computing

In this section, some state-of-the-art studies security concerns of collabirative SaaS and service-level-agreement (SLA)-based quality-of-service (QoS) maximization for SaaS in the cloud-computing environment have been discussed. The principal concerns for security related to collaborative SaaS Cloud have been depicted in Fig 3.

From the end user point of view, the main challenge is selecting an ideal SaaS cloud provider and secure the collaboration service offered by it to prevent unauthorized disclosure of sensitive information.

There is active research being carried out since the conceptualization of Cloud computing. In [37], Khalil et al., extensively discuss the basics of cloud security in the point of vulnerability, risk models, various

Fig 3: Security Concerns in Collaborative SaaS

attacks and similar security flaws. They categorically discussed the shortcomings of existing security modules. Incorporation of Cloud computing SaaS in any industry and real time solution, quality of service (QoS) plays a vital role.

In [38], Zheng et al., proposed a prediction framework for QoS ranking for cloud services. Using the real-world QoS data from past customers the algorithm directly predicts the QoS rankings of several cloud services. The efficacy of integrating of cloud computing in modern service model and empirically discussed several QoS selection problem by providing a comparison framework to evaluate the QoS and performance of cloud models have been discussed in [39]. To make SaaS a reality, cloud service description (CSD) is an important factor to be considered. The lack of standardization in CSD in several techniques spans from language, standards, ontologies, models, etc. creates a huge misconception in technical, operational, business, and semantic aspects of SAAS. Ghazouani et al., in [40] presented a comparative study of CSD issues from different perspectives. They showed the proposed approach USDL (Unified Service Description Language) has the potential to provide appropriate service description by covering three aspects like technical, operational, and business.

In [41], Lovas et al., proposed a novel software container-based cloud orchestration framework to manage both aspects of cyber physical systems server-side framework for sensor-based networks and configurable simulation tool for predicting the behavior of manufacturing systems as well. Software-Defined Networking (SDN) opened up new paradigm for networking by enabling programmability, scalability, dynamic control and fast reconfiguration.

Several works [42-44] studied extensively how these characteristics can be merged to cloud computing to get more benefits in point of traffic engineering, network virtualization, power optimization, reconfiguration, fast failure, performance and security in multi-cloud environment. SDN can take lead role to redesign the service provisioning model of IaaS and SaaS without changing the physical network at all to provide more flexible and efficient cloud computing along with quality and performance of SaaS services [45].

With the proliferation of cloud computing in several business model and solutions, diverse security and privacy issues are coming out which in-cumber the adoption of this new computing paradigm by common users. To guarantee a secure and trustworthy service level cloud environment, addressing security and privacy challenges become very important. In [46–48], critical security challenges and factors have been identified and analysed regarding embedded system, application, storage system, clustering where SaaS can provide efficient solutions. Both Private and Public cloud security recommendations have been listed [49].

Rath et al., investigated issues like system and data security, latency, QoS, communication security, availability of cloud resources [50]. To strengthen the security and resilience of Cloud SaaS application, a general guideline for developing such applications has been formalized. Several useful case studies have been given for security patterns and solutions in AWS and Azure [51], [52].

5. Future Research Directions

In order to make SaaS more popular to Enterprise and IT end users, SDN can play a vital role. SDN controlled wide area network (SD-WAN) can be a powerful choice to get high performance, availability and reliability from their SaaS deployments. Without depending on the data center traffic, using SD-WAN data can be migrated by identifying and offloading internet and cloud traffic in order to achieve consistent, ripple free SaaS reliability, even during link failure. Dynamic and runtime decision can be taken to reroute the information and get higher performance. Network Function Virtualization (NFV) is another important tool for virtualizing important functionalities without changing the physical substrate. NFV can handle the migration of in network computation from dedicated physical hardware substrate to SDN enabled do as needed basis model. Recent trend in wireless communication and Cloud-RAN architecture for radio access networks including future 5G wireless networks can be examined and SDN-NFV can be used for all cloud communication concepts. To provide seamless, fast reliable service to the SaaS end users and increasing deployability of SaaS open issues and future opportunities can be explored.

6. Conclusions

From the above discussion and review of recent literature, it can be easily seen that SaaS has the potential to change the whole paradigm of software development and distribution in the near future. This paper reviewed several aspects of the SaaS in the cloud computing paradigm. Some challenges of service-level-agreement (SLA)-based quality-of-service (QoS) maximization for SaaS in the cloud-computing environment have been pointed out and discussed. Security and virtualization are two main aspects to consider making customers more attracted to the services of SaaS. The present paper also conducts a overview study to move forward with these cutting edge research trends and technologies.

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Hybrid Optimization Techniques for Enhancing Optimal Flow of Power Systems

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Abstract
Hybrid optimization techniques have been extensively utilized for solving optimal power flow problems in distribution systems integrated with or without renewable energy systems, with load uncertainty. Particle swarm optimization (PSO) is integrated with Gray wolf optimizer (GWO) to create a hybrid algorithm, HPSOGWO. HPSOGWO is implemented to augment the optimal power flow solutions of IEEE-30 bus and IEEE-62 bus systems. Five objective functions are considered to investigate the power quality of the hybrid algorithm. The proposed algorithm strength is justified by a comparative study with each individual algorithm. The suggested algorithms provide different accuracy results in small and large scale distributed systems, which indicates their drawbacks in certain systems. The system is solved using MATLAB.

Keywords:
Optimal power flow ; Hybrid optimization techniques ; Exploration and exploitation abilities

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1. Introduction

Recently, several modern optimization techniques have been improved. The joint objective of these techniques is the detection of the most optimal solution and convergence performance. Hence, every algorithm inspired by nature must be contained from exploration and exploitation to guarantee the best global solution.

Exploration involves a search method to obtain a better solution in a large area, which is a global search. When searching for a solution via the method, it is the most suitable to utilize exploitation because it impacts a small area, and it is a local search. Eventually, all modern techniques strive to achieve an equilibrium between the capacity to explore and exploit the situation to search the most appropriate solution and performance in the search space [1].

Particle swarm optimization (PSO) has been implemented for nonlinear optimization issues such as a stochastic method. Kennedy and Eberhart reported that PSO essentially simulates social behavior [2,3]. Due to its convergence speed, reliability, simplicity, and capacity to pinpoint global and optimal solutions, PSO is the best option.

Recently, Mirjalili et al. developed another method known as grey wolf optimizer (GWO), which has been created as per the hunting method and hierarchy exhibited by grey wolves [4]. GWO has been successfully implemented to optimize key metrics from coding algorithms [10]. In addition, GWO can be employed for solving optimizing key values in feature subset selection [11], time forecasting [12], optimum power flow issues [13], economic dispatch issues [14], flow-shop scheduling issues [15], and an optimal double-layer grid design [16]. Several algorithms were created to augment the convergence performance of GWO, e.g., parallelized GWO [17, 18], binary GWO [19], integration of DE with GWO [20], hybrid GWO with genetic algorithm (GA) [21], hybrid DE with GWO[22], and hybrid GWO using the elite opposition-based learning strategy and simplex method[23].

The no-free lunch theorem[24] for optimization permits researchers to search or develop fresh algorithms and augment the quality of the existing ones, indicative of the lack of a single technique that can address all issues.

In addition to PSO, several hybrids exist, such as the particle swarm optimization with gravitational search algorithm (PSO-GASE)[5,6], particle swarm optimization with dragonfly algorithm (PSODA) [7], particle swarm optimization with firefly algorithm (PSOFA)[8], and particle swarm optimization with multi-verse optimizer (PSOMVO)[9].

Port-Hamiltonian algorithm was implemented for optimizing the power flow of multi-terminal DC networks. The technique is utilized for offshore wind integration grid in the North Sea and the interconnection with the network dynamic is examined using numerical simulations[25]. Moth swarm algorithm incorporated with gravitational search algorithm for optimal power flow considering the wind energy system. The technique is tested with IEEE 30-bus, IEEE 57-bus, and IEEE 118-bus integrated with and without wind energy system. The results approved the efficiency and accuracy of the techniques [26].

An interline current flow controller (CFC) is utilized for decreasing the operating cost of hybrid AC/DC, mesh grids using elimination the congestion within the DC lines. The technique is implemented in a case studies of 5-terminal AC/DC meshed grid. This leads to improving the optimal power flow of the studied system, considering the load uncertainty and different configuration of the transmission system [27]

Hybrid modified imperialist competitive algorithm with sequential quadratic programming is employed to solve the constrained of the optimal power flow problem of hybrid power system integrated with renewable energy system. The techniques suggested is evaluated and tested using three benchmark systems which are IEEE 30-bus, IEEE 57-bus and IEEE 118-bus power systems integrated with few PV system and wind energy system[28].

The solution of optimal power flow problem of distribution systems using decentralized saddle-point dynamics [29].

In this study, a new hybrid (HPSOGWO)

that uses both PSO and GWO is examined. The following five functions are included:

1. Minimization of Active Power Transmission Loss
2. Minimization of Fuel Costs related to Generation
3. Maximization of Margin for Reaction Power Reserve
4. Minimization of Reactive Power Transmission Loss
5. Minimization of Emission Index

2. Problem Formulation

2.1. General OPF Problem Formulation

The mathematical formula of the OPF problem is as follows:

$$\text{Minimize } F(x, u)$$

$$\text{Subject to } g_E(x, u) = 0$$

$$go(x, u) \leq 0$$

$$go(x, u) < 0$$

Several control variables for this problem are defined as follows:

$$u = [Q_c^T \ TC^T \ V_G^T \ P_G^T]$$

where

u = control variables

QC = reactive power supplied by all shunt reactors

TC = magnitude of transformer load tap changer

VG = magnitude of voltage at generator buses

PG = active power generated at generator buses

$$x = [V_L^T \ \theta^T \ P_{SG} \ Q_G^T]$$

where

x = state variables

V_L = magnitude of voltage at load buses

θ = voltage angles of all buses excluding the slack bus”

P_{SG} = active power generated at the slack bus

Q_G = reactive power generated at all generator units

N_L = number of load buses

N_G = number of generator buses

The OPF problem, i.e., the optimization problem, is outlined as maximizing or minimizing the objective function, where the problem is put through a series of equality and inequality restrictions.

3.Problem Objectives

3.1.Fuel Cost Minimization

The economic distribution of a load is defined among the different generators of a system, and the variable operating costs must be presented as the active power generated at each generator in a system. Hence, the fuel cost is the essential cost in a thermal or nuclear unit. Then, the fuel cost must be presented as active power generated at each generator in a system. In addition, other costs, such as operation and maintenance costs, can be presented as the power output. Fixed costs such as the capital cost, depreciation, etc. are not included in the fuel cost.

The curve for fuel cost is thought to be estimated by the quadric function of the active power generated by each unit in a system as follows:

$$F_1 = \sum_{i=1}^{NG} (a_i + b_i P_{Gi} + c_i P_{Gi}^2) \qquad (1)$$

where

P_{Gi} = active power generated at an ith generator in a system

N_G= number of generators in a system

a_i, b_i, c_i = fuel cost coefficients of an ith generator in a system.

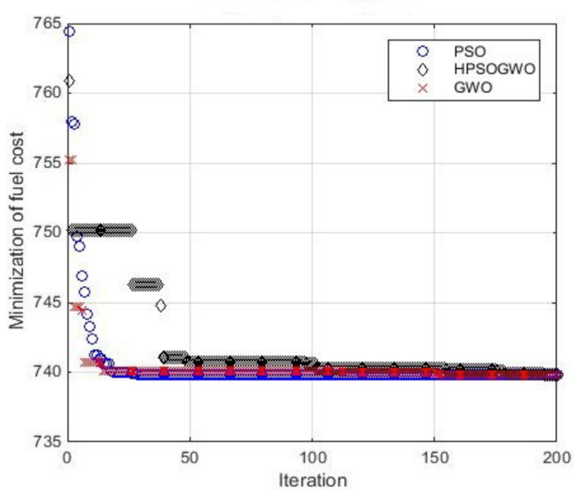

Fig. 1. Generated fuel cost minimization for a 30-bus IEEE system

3.2. Emission Minimization

The function of emissions can be summarized as all types of the considered emissions, such as NOx, SO2, and thermal emissions. As shown in the equation, emissions in terms of their amount are highlighted as the function of the active power, which is generated at each generator in a system, and it is expressed as the sum of quadratic and exponential functions:

$$F_2 = \sum_{i=1}^{NG} [10^{-2} * (\alpha_i + \beta_i P_{Gi} + \gamma_i P_{Gi}^2) + \epsilon_i \exp(\lambda_i P_{Gi})] \qquad (2)$$

where

$\alpha_i, \beta_i, \gamma_i, \lambda_i$ and ϵ_i are the emission characteristic coefficients of the ith generator.

3.3 Total Active Power Loss Minimization

The term PL represents the total I2R loss in the transmission lines and transformers of the system. From equation (3), the total active power loss equals the sum of the generated active power at each generator in a system subtracted by the sum of the active power at each load bus in a system; hence, PLoss must be greater than zero."

$$F_3 = \sum_{i=1}^{N} P_l = \sum_{i=1}^{NG} P_{Gi} - \sum_{i=1}^{Nd} P_{di} \qquad (3)$$

3.4 *Reactive Power Transmission Loss Minimization*

This resulted in the increase in the voltage stability margin and augmentation of the transportation system from real power out of sources to sinks in a network, and QLoss can be either positive or negative.

$$F_4 = \sum_{i=1}^{N} Q_i = \sum_{i=1}^{NG} Q_{Gi} - \sum_{i=1}^{Nd} Q_{di} \qquad (4)$$

1.1. Reactive Power Reserve Margin Maximization

Reactive power reserve margin maximization leads to the minimization of the reactive power losses and improvement of the voltage stability and the generator's capacity to aid the bus voltage under augmented system disturbances or load conditions. The speedy sources (reactive) include FACTs, generators, and synchronous condensers.

$$F_5 = \sum_{i=1}^{NG} \frac{Q_i^2}{Q_{imax}} \quad (5)$$

4. Problem Constraints

4.1. Equality constraints

The equality constraint condition can be expressed as follows:

$$\sum_{i=1}^{NG} P_{Gi} - P_D - P_{Loss} = 0 \quad (6)$$

$$\sum_{i=1}^{NG} Q_{Gi} - Q_D - Q_{Loss} = 0 \quad (7)$$

4.2. Inequality constraints

• Constraints of generation capacity

The generator outputs and bus voltage are restricted by min and max limits as follows:

$$P_{Gi}^{min} \le P_{Gi} \le P_{Gi}^{max}$$

$$Q_{Gi}^{min} \le Q_{Gi} \le Q_{Gi}^{max}$$

$$Q_i^{min} \le Q_i \le Q_i^{max}$$

$$v_i^{min} \le v_i \le v_i^{max}$$

• Constraints of line flow

$$\left|P_{Lf,k}\right| \le P_{Lf,k}^{max} \qquad k = 1,2, \dots \dots, L$$

Where, $P_{Lf,k}$ is the active power flow of line k, $P_{Lf,k}^{max}$ is the active power flow high limit of line k, and L is the number of transmission lines.

5. Optimization Techniques

The mathematical model for each optimization technique is explained in this section.

5.1. Particle Swarm Optimization (PSO)

In 1995, Kennedy and Eberhart proposed PSO [2,3], which is inspired by the social behavior of different animals, birds, and insects. PSO looked at elements such as the schooling of fish or flocking of birds.
The word particle is concerned with a single unit, i.e., a bird in a swarm or a bee from a colony. Each piece comes together with its own intelligence into a collective, building a group or the hive mind.
When one particle or unit locates a path to food, others will swarm and instantly follow even if they are located far from the swarm. This is based on hive intelligence, which is a technique that stems more from behavior than genetics, where algorithms

are known as evolution-based processes. It is where a population of the unit or particles are put into use to solve optimization issues. Each exhibits two essential characteristics: velocity and position.

The particles are present in the search space, and they can be in the best possible spot when examined in terms of the objective function. The particles can be updated to a better position, and their velocities are estimated by equations 9 and 10. This perspective is gained from hive or swarm behavior to augment global optimization function solutions [30].

These mathematical equations are as follows:

$$\omega = \omega_{\max} - k * \frac{\omega_{\max} - \omega_{\min}}{\text{Maxite}} \tag{8}$$

$$V_{i,j}^{k+1} = \omega * V_{i,j}^{k} + c_1 * r_1 * \left(Pbest_{i,j}^{k} - X_{i,j}^{k}\right) + c_2 * r_2 * \left(Gbest_{i,j}^{k} - X_{i,j}^{k}\right) \tag{9}$$

$$X_{i,j}^{k+1} = X_{i,j}^{k} + V_{i,j}^{k+1} \tag{10}$$

where N represents the population size, and dimension D is presented as $X=[X_1,X_2,\ldots,X_N]^T$, where T is a transpose operator. Each particle is presented as $Xi = (I = 1,2,\ldots,N)$ is presented as $X=[I,I_{i,2},\ldots,I]$]. In addition, the initial velocity of the population is indicated as $V=[V_1,V_2,\ldots,V_N]^T$.Thus, the velocity of each particle in a population $Xi(i = 1,2,\ldots, N)$ is presented as $V = [V_{i,1},V_{i,2},\ldots,V_{i,D}]$. The index i mutates from 1 to N, whereas the index j mutates from 1 to D."

5.2 Grey Wolf Optimizer (GWO)

Mirjalili et al. were the first to develop the GWO algorithm, which is essentially inspired by the leadership hierarchy and hunting methods of grey wolves [4]. The wolves in question are thought to be at the top of the food chain and live as a collective.

The study examined four species, including (α), beta (β), delta (δ), and omega (ω), respectively, in terms of the simulation patterns of the leadership hierarchy and basic GWO parameters.

In terms of the GWO design, as per the hierarchy of the wolves, alpha (a) is designated as the best solution. The second and third best solutions are designated as beta (β) and delta (δ), respectively. The remaining candidate solutions are designated as (ω). The WHO algorithm simulates the behavior of the wolves during hunting in three stages: chasing, hunting, and tracking the prey, in addition to attacking the target. This behavior is considered during the design of GWO, which can be expressed as follows:

$$\vec{D} = \left|\vec{C}.\overrightarrow{X_P}(t) - \vec{X}(t)\right| \tag{11}$$

$$\vec{X}(t+1) = \overrightarrow{X_P}(t) - \vec{A}.\vec{D} \tag{12}$$

where (t) is the present iteration, Xp is the prey position vector, D, A, and C are coefficient vectors, and X is the GWO vector. A and C are calculated as follows:

$$\vec{A} = 2\vec{a}.\vec{r_1} - \vec{a} \tag{13}$$

$$\vec{C} = 2.\vec{r_2} \tag{14}$$

The hunting behavior of the grey wolves is simulated assuming that alpha (α), beta (β), and delta (δ) have enhanced knowledge of the prey site that is likely to be targeted, which can be explained as follows:

$$\vec{D_\alpha} = |\vec{C_1}.\vec{X_\alpha} - \vec{X}|, \vec{D_\beta} = |\vec{C_2}.\vec{X_\beta} - \vec{X}|, \vec{D_\delta} = |\vec{C_3}.\vec{X_\delta} - \vec{X}| \tag{15}$$

$$\vec{X_1} = \vec{X_\alpha} - \vec{A_1}.(\vec{D_\alpha}) \tag{16}$$

$$\vec{X_2} = \vec{X_\beta} - \vec{A_2}.(\vec{D_\beta}) \tag{17}$$

$$\vec{X_3} = \vec{X_\delta} - \vec{A_3}.(\vec{D_\delta}) \tag{18}$$

$$\vec{X}(t+1) = \frac{\vec{X_1} + \vec{X_2} + \vec{X_3}}{3} \tag{19}$$

At $|A| < 1$, the wolves are forced to attack the prey, where A is a random value. Searching for the prey is the exploration ability, while attacking the prey is the exploitation ability. At $|A| > 1$, the wolves are forced to diverge from the prey.

6. A New Hybrid Algorithm

Several hybridization techniques for heuristic techniques. Talbi [31-32] reported the hybridization of two or more techniques. HPSOGWO is the combination of GWO and PSO, where the strengths of both techniques are put into place during exploration when the Pbest value of PSO is switched with that of GWO. In terms of HPSOGWO, the position of the first three agents is updated in the equation for the search space (15), with an additional inertia constant (ω) to control the exploration and exploration within the search space. The equation that results from this modification is expressed as follows:

$$\vec{D_\alpha} = |\vec{C_1}.\vec{X_\alpha} - \omega * \vec{X}|, \vec{D_\beta} = |\vec{C_2}.\vec{X_\beta} - \omega * \vec{X}|, \vec{D_\delta} = |\vec{C_3}.\vec{X_\delta} - \omega * \vec{X}| \tag{20}$$

where ω denotes the inertia weight. For combining PSO and GWO, the updated equation and velocity can be expressed as follows:

$$V_{i,j}^{k+1} = I * V_{i,j}^{k} + c_1 * r_1 * (X_I - X_{i,j}^{k}) + c_2 * r_2 * (I - X_{i,j}^{k}) + c_3 * r_3 * (I_3 - X_{i,j}^{k}) \tag{21}$$

$$X_{i,I}^{k+1} = I + V_{i,j}^{k+1} \tag{22}$$

Basic steps of HPSOGWO

STEP 1: Create an initial population (agents) or (grey wolves).

STEP 2: Initialize a, A, C, and ω equations (8, 13, 14).

STEP 3: Perform fitness evaluation of each agent.

STEP 4: Calculate the position of the grey wolf. Xα, Xβ, and Xδ equations (20) and (16–18).

STEP 5: Update the velocity and position equations (21, 22).

STEP 6: Repeat STEPS 2–5 until the stop criteria is reached.

STEP 7: Stop.

7. Results and Discussion

Figure 3 and Figure 4 show the results for the 30-bus 6-generator and 62-bus 19-generator IEEE systems, respectively. The total active power demands for the 30-bus and 62-bus systems are 283.4 MW and 2,912 MW, respectively, and their corresponding total reactive power demands are 126.2 MVar and 1,269 MVar. Five OPFs are individually implemented as one objective function during the process optimization by using PSO, GWO, and HPSOGWO and compared (Table I and Table II):
F1 Fuel Cost Minimization
F2 Emission Minimization
F3 Total Active Power Loss Minimization
F4 Reactive Power Transmission Loss Minimization
F5 Reactive Power Reserve Margin Maximization

NO.	PSO	GWO	HPSOGWO
F1	739.8271	739.8284	739.8568
F2	2.0637E–04	2.0485E–04	2.0491E–04
F3	8.8753	16.7702	5.1
F4	–15.8380	–11.2374	–16.7756
F5	1.2414E-41	6.0820E–58	7.6379E–18
Percentage	66.67%	63.33%	70%

Table 1. Values of the Five Functions (OPFs) by PSO, GWO, and HPSOGWO for a 30-bus IEEE System

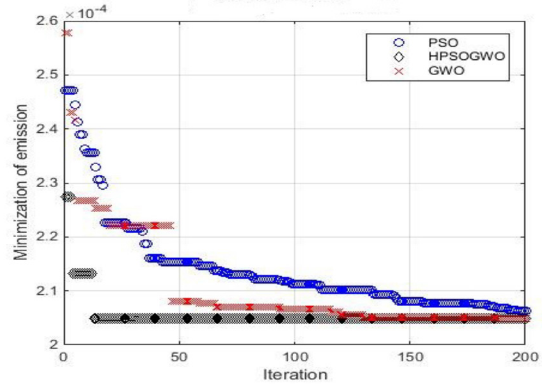

Fig. 2. Emission index minimization for a 30-bus IEEE system

NO.	PSO	GWO	HPSOGWO
F1	2342.3	2343.7	2361.6
F2	0.397	0.395	0.393
F3	547.8	572.6	566.6
F4	437.9	457.5	450.9
F5	5.28E–18	5.68E–24	7.77E–09
Percentage	80%	60%	60%

Table 2. Values of the Five Functions (OPFs) by PSO, GWO, and HPSOGWO for a 62-bus IEEE System

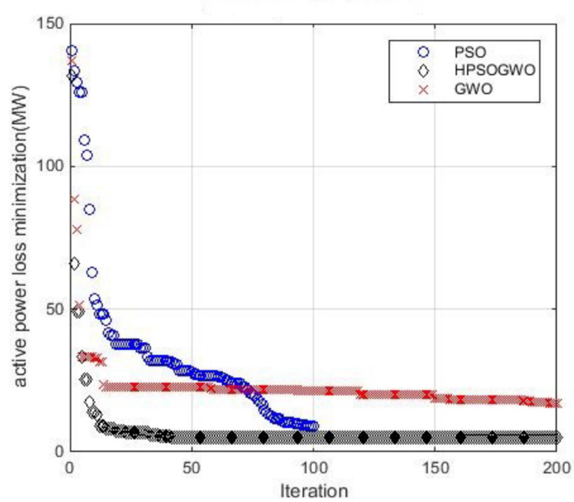

Fig. 3. Active power loss minimization for 30-bus IEEE system

Table 1 summarizes the best optimal solutions, convergence performance, and best statistical values achieved by HPSOGWO for five function values. The performances of GWO and PSO are satisfactory, but neither can match up to that of HPSOGWO: “HPSOGWO is more reliable in providing superior quality results with reasonable iterations and prevents the premature convergence of the search process to a local optimal point and provides superior exploration of the search course."

Table II summarizes the best optimal solutions, convergence performance, and best statistical values achieved by PSO for five function values. The performances of HPSOGWO and GWO are the same, GWO only exhibits the best optimal solution for the maximization of reactive power reserve margin, and HPSOGWO only exhibits the best optimal solution for the minimization of emissions.

Parameters	Quantity
Population size	100
Number of iterations	200

Table 3. Standard Values of All the Used Algorithms

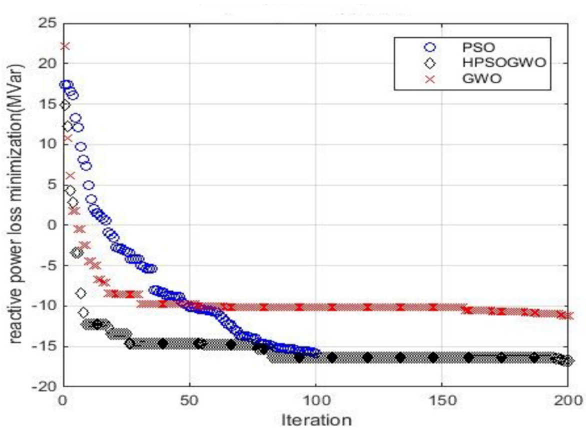

Fig. 4. Reactive power loss minimization for a 30-bus IEEE system

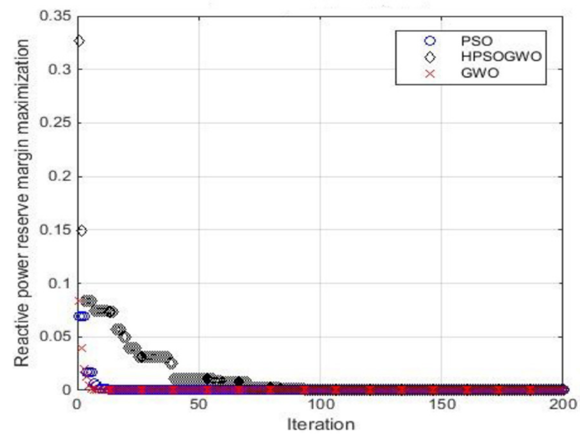

Fig. 5. Reactive power reserve margin maximization "for 30-bus IEEE system

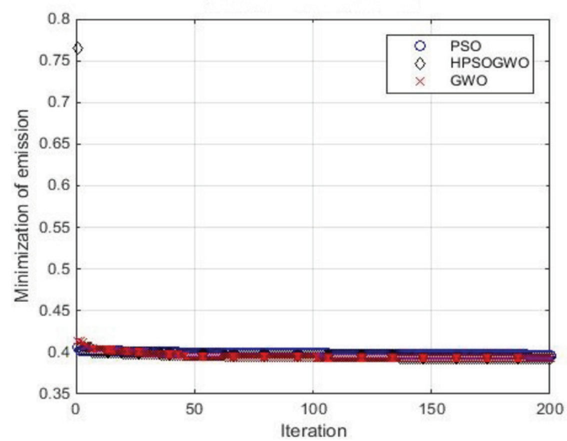

Fig. 6. Generation fuel cost minimization for a 62-bus IEEE system

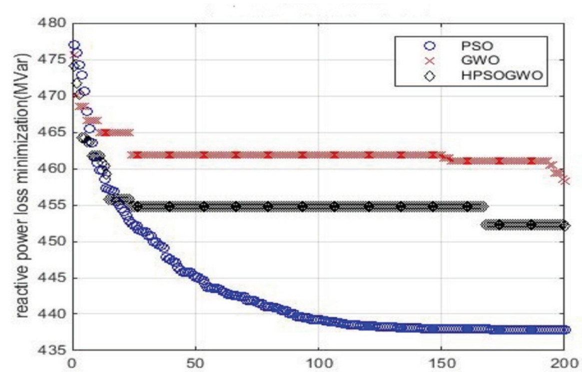

Fig. 7. Emission index minimization for a a62-bus IEEE system

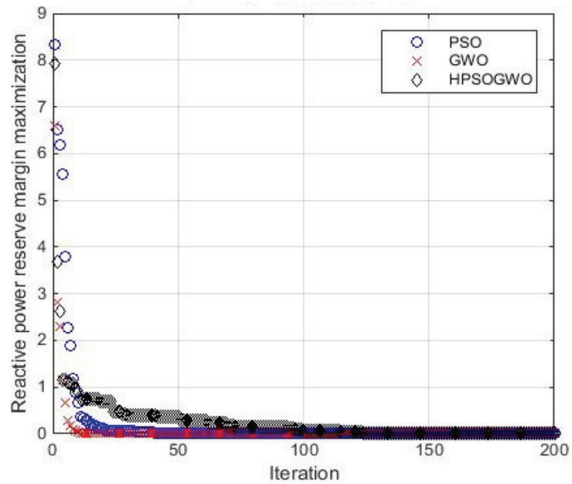

Fig. 8. Active power loss minimization for a 62-bus IEEE system

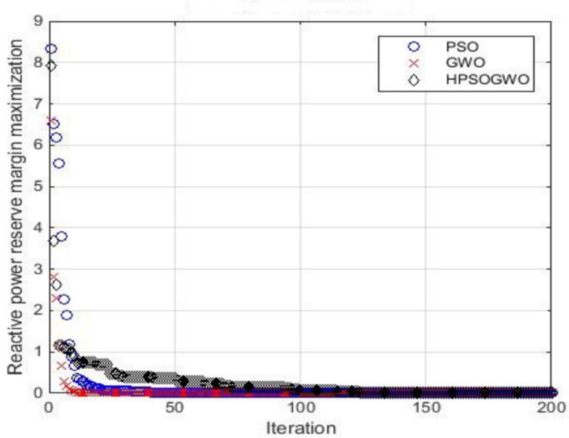

Fig. 10. Reactive power reserve margin maximization for a 62-bus IEEE system

8. Conclusions

The hybrid optimization technique comprising two algorithms, i.e., PSO and GWO, respectively, was outlined in this study for different scenarios. The quality of this technique was examined using two 30-bus [33] and 62-bus IEEE systems [34] with different cases. Five objective functions were considered to investigate whether the proposed algorithm was of a desired quality. Furthermore, the hybrid algorithm was compared with PSO and GWO. Results revealed that compared to

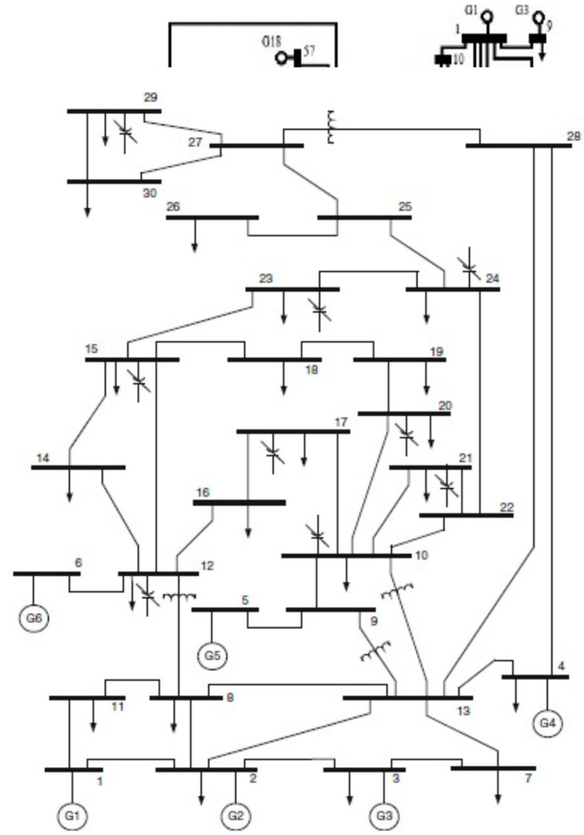

Fig. 11. Single-line diagram of a 30-bus IEEE test system

GWO, PSO and HPSOGWO afford better results by a low number of iterations and high-quality solutions. The suggested hybrid algorithms mostly provide very good results and high accuracy but not in all cases, due to nature of each optimization algorithm

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Multiagent Systems Applied to Smart City (NEOM AS A MODEL)

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Abstract
In this paper, we proposed the multi-agent technologies in various fields for smart city projects particularly New Future (NEOM). Indeed, Multi-agent technologies are very effective in solving complex multidisciplinary problems. For conceiving the Multi-agent technologies Model for a smart-city, the proposed paper brings out the wants of the city and the goals to be met. In particular, the conventional six characteristics of a smart city dictate the needs. Based on the proposed multi-agent technological model, we can claim that it can provide the best outcomes in various applications of the smart cities' projects

Keywords:
Multi-agent technologies; smart cities; NEOM;

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1. Introduction

With the recent developments in Artificial Intelligence (AI), Agent and multi-agent-based systems are regaining prominence. Rationality, the most important attribute of an agent, makes it capable to increase rapidly its performance with minimal requirements and energies as well as time and cost [1]. Comparing to simple reflex agent, a model-based agent or goal-based agent [2], [3] [4], the utility-based agent is most proactive and efficient in harsh environments. By providing a measure of performance and success at a given state, it provides an extra component of utility measurement, which makes it special. However, currently, with the extraordinary development of a machine learning techniques, learning an agent is very promising as it is the sort of agent that can learn from previous experiences, or because it has the learning potential [5]. It begins behaving with the fundamental knowledge and then being able to automatically act and adjust through learning. Based on the effective performance, the learning agents are famous and focused by scientific researchers for further improvement and applying to various fields. Its main characteristics consist of flexibility, reactivity, proactiveness and social capability [6]. Multi-agent systems, focused on the interactions of multiple learning agents, have been used in an extensive range of uses, ranging from relatively small personal assistant systems to open complex industrial software systems. Building smart cities with unique opportunities and abilities [7]-[9], require multidisciplinary systems coping with the increasing demand for flexibility, productivity, security, etc. Indeed, the current socio-economic challenges place an increasing pressure on traditional cities to have more effective services and infrastructures, often for a reasonable cost with enough security [10]. Multi-agent systems may offer interesting solutions to the challenges and problems posed by the Smart cities. Indeed, they can offer a high level of success with a high ratio of productivity at a minimum cost and time.

A smart city can be defined as a city that does well in these six characteristics in a forward-looking way: smart governance, a smart economy, smart mobility, smart environment, smart living, and smart human level. In general, the clear vision and mission of the current leadership always introduced these goals and strategies, which revolve around these characteristics [8].

A great and high degree of Information and Communication Technology–ICT has made these smart cities-structures capable of transmitting energy, information flows multidirectional and connecting to various industrials and residential sectors like mobility, water, social, energy, and economy. Consequently, facilities and infrastructure needed for building such smart-cities with the required six characteristics [4], [13], [15], [16], can be further advanced through the emerging rational and learning Artificial Intelligence multi-agents.

Moving in the direction of efficient cities, the leadership of KSA has initiated some new projects for achieving the goals and objectives for their citizens. Neom Business City (Figure 1(a)), New Taif City (see Figure (b)), King Abdullah Economic City (KAEC), King Abdullah City of Atomic and Renewable Energy, and Sudair Industrial City [17]-[20].

(a)

(b)

Fig. 1. The Future model of Neom (a) Taif City (b) Projects

On Wednesday, Saudi Arabia announced that the development of the first NEOM urban area and the $500 billion mega-city planned will begin. Crown Prince Mohammed bin Salman chaired the founding board and has approved the design of the NEOM Bay master plan that will include residence, lifestyles, facilitation for tourism, and “innovation centers” [21]. It is expected that the plan will concentrate on luxury living that will consist of high-end villas and hotels. The growth of the NEOM Bay area would have a new paradigm of an urban model, allowing it so that it can be a platform for world best mind attraction, to build advanced economic sectors [22].

Fig. 2. The geographical location of Neom -The City of Future Saudi Arabia

Furthermore, on Wednesday 10/01/2020, NEOM revealed that it would implement the groundbreaking solar technologies to generate environmentally sustainable, low-cost energy, enhancing NEOM's reputation as an emerging center for innovation and environmental protection. NEOM strikes out in the development of a solar dome for a sustainable desalination project, as proposed in Figure 3.

Although wishing to turn cities into smart cities, however, they haven't established infrastructure models that make the relation and interaction of different sub-sets to make the smart city real.

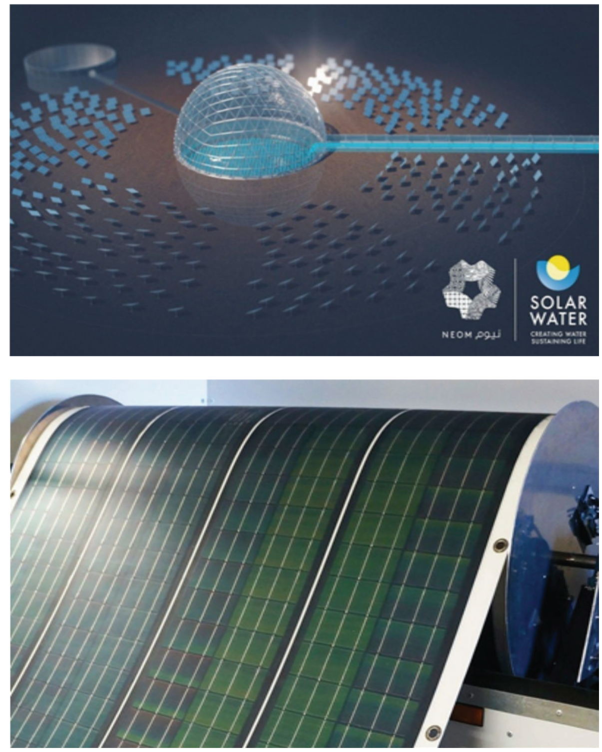

Fig. 3. Neom solar dome technology for water desalination project

The goal of this paper is to explore a smart city model with a multipurpose agent network and the network of things which offers a city with data as a key set-up for defining a concept that can be replicated and exported, as advocated by the European Union [13], [23].

2. Needs and objectives in different sectors of smart cities

It includes developing new high-performance services in different cities so that to become smart. Cities today will need to build innovative and effective services in all sectors.

1.1. Transport and intelligent mobility

Some of the confrontations are to incorporate multiple types of transport like train, cars, walking, and cycling into a well-organized, sustainable, secure, and with zero carbon footprints integrated networks. Such incorporation allows a reduction in carbon footprints, optimizes the usage of public land and provides a wide variety of accessibility options for city residents to meet all their needs. Moreover, tomorrow's city will have to incorporate new developments in the area of mass transit and electrical activity.

1.2. Environmental management

There are two main zones in which cities need to work: electricity and waste. The challenge that cities will face regarding waste is that of minimizing or eliminating waste manufacture and setting up effective waste recovery and recycling systems (the mechanism by which a waste material or worthless product is updated to a new content or invention of good standard or usefulness). In the field of the electric market, cities will need to reinforce the intervention related to energy effectiveness (low-consumption public lighting innovations) and to create local electric generating systems (waste power generation, solar panels building roofs, etc.).

1.3. Effective urbanizing and smart housing:

Combined with the limited land supply, the high valuation of real estate in city centers make present development multifaceted. In reality, the urban sprawl; costly in terms of land, public services and electricity that has prevailed until now, is not feasible anymore. We must reproduce urban models that simultaneously value required privacy, guarantee enough sunlight, promote "living together" and tolerate any change. Aiming to bring advancement, promote energy efficiency, and also decrease usage, the building would also need to be more intelligent.

1.4. Data and communications technology: the way to efficiently make decisions.

Innovative ICTs (smart meters and sensors, domestic automation, digital media, communication apps, etc.) is going to be in the center of tomorrow's smart city.
The evolution of New ICTs is going to enable effective control of urban areas through the collection and reviewing the main information (renewable electricity generation facilities service, state of public service networks in real-time, road traffic checking, measuring the level of pollution, etc.) via city operating system and modern framework for information management. Such structures promote decision making by local authorities through maintaining the effective use of the knowledge multiplicity. Hence, they make it possible to improve existing services and to bring new infrastructure to the city (organization of charging stations for electrical vehicles, intelligent public lighting, video monitoring, civil warnings, intelligent parking, smart

way of managing waste, etc.) and for the residents (the reduction of water and energy use, waste control, facilitation of urban voyages, protection, etc.).

3. Conceptual Models-based Multi-Agent for applications in Neom smart city

The recent smart city projects requires a high connectivity, automation, flexibility and management between vendors, customers and the network to optimize the data transmission and delivery function [20]. Multi-agent systems technologies are favorite candidates to efficiently implement and manage all these issues. We propose in Figure 4, a conventional conceptual model for the application of Multi-agent systems technologies to Neom smart city.

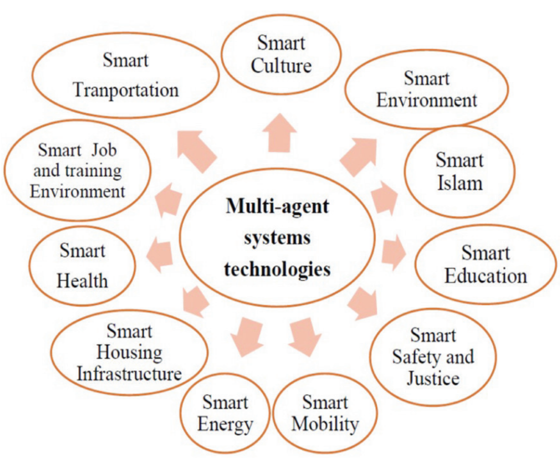

Fig. 4. Conceptual model based multi-agent systems technologies for Neom smart city

Figure 4, shows various applications related to different fields that must be implemented and managed by a common concept. This without forgetting that these applications require systems characterized by specific interaction, collaboration and in some cases, competition and negotiation. multi-agent systems that are known for their high capacity for collaboration, interaction and negotiation, fulfill all these needs.

Figures 5 and 6 propose conceptual models based on multi-agent systems for respectively smart education and smart Islamic applications. In particular, the agents must be of learning types. Indeed, learning agents have a high capacity of adaptation to highly variable environments as the case of smart education and smart Islam.

The Smart City's proposed conceptual models (Figues 4, 5 and 6) are a compilation of views and definitions, which form the basis for discussion of the Smart City's features, uses, attitudes, interfaces, specifications, and standards. The model offers the framework for interoperation and standard analysis, for Neom smart city growth.

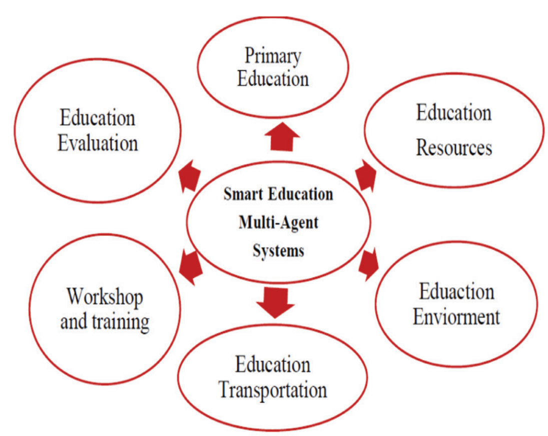

Fig. 5. Conceptual model based multi-agent systems for smart

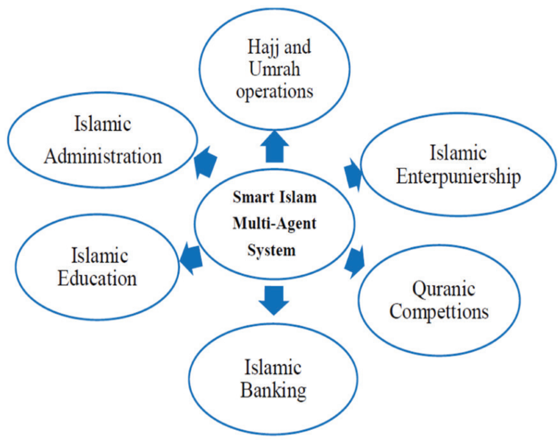

Fig. 6. Conceptual model based multi-agent systems for smart Islam.

4. NEOM smart city model based multi-agent systems

The NEOM is a new future city having many opportunities in the areas of AI-based technologies. The deployment of multi-agent systems technologies in the different smart NEO city applications aims to increase their effectiveness so that this city of the future, which is part of the KSA's vision 2030, will live up to expectations. In the literature, different architectures are proposed for various applications based multi-agent systems [24] [25]. For Neom smart city', the multi-agent system architecture must ensure dynamic and flexible deployment of intelligent agents. Thus, they can handle efficiently the interactions of smart applications related to various fields. To cope with real time complex environment of smart applications, we propose a layered architecture of multi-agent systems. In this architecture, the intelligent agents are deployed on two hierarchical types: coordinator-agent and technical-agents. The technical-agents are concerned by solving the application-specific problems and the coordinator-agents observe the technical-agents and assign scenario to them (see Figure 7.).

A physical layer that contains a network of nodes preinstalled with coordinator-agents supports the layer of coordinator-agents. These nodes are connected by physical links as Wifi, Ethernet and Bluetooth. The coordinator-agents search for other coordinator-agents through physical network and arrange virtual overlay network of coordinator-agents. In addition, the coordinator-agents built a virtual overlay network for technical-agents, so they can communicate and cooperate for the execution of an application scenario. The independence of the overlay network of technical-agents from the physical network' configuration is important for the efficiency of the multi-agent systems.

To maintain the efficiency of the smart city, the networks should not have a considerable relationship with one another; they need to communicate with one another using minimal quantities of shared knowledge with the latest technical instruments.

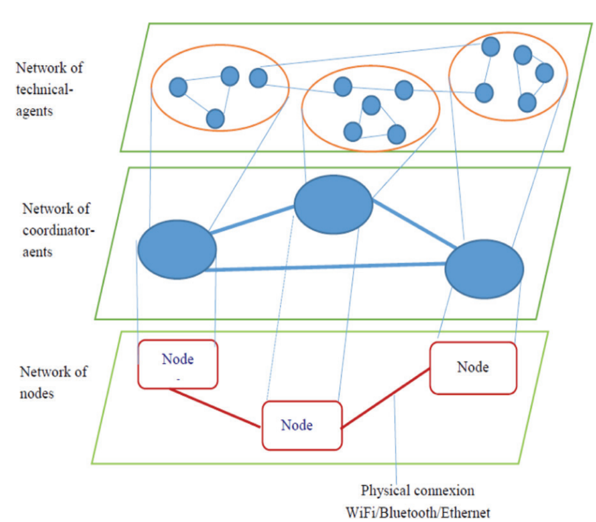

Fig. 7. Proposed multi-agent systems architecture

5. Conclusion

In this paper, we have highlighted the issues and opportunities of using multi-agent in smart cities, particularly in Saudi Arabian smart city projects such as NEOM, Taif City and many other smart projects. Indeed, Multi-Agent Systems are very appropriate for the multidisciplinary smart applications required to build a Smart City with conventionally required characteristics. A conceptual Multi-Agent based model for the future Neom Smart City was proposed. The proposed conceptual models and the multi-agent systems architecture constitute a beginning for future works on the design of a more elaborated model based on Multi-agent systems technologies

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Evaluation of Thermal Performance of Modern Building Wall Constructions: Real Scale Experiment Under Arid Weather Condition

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Abstract
Thermal resistance of wall constructions plays a key role in determining the cooling load of buildings especially in regions with extreme ambient temperatures. With the construction industry having several options for wall material, selection of the best alternative is mainly based upon their thermal resistance. Experimental data presently available on wall resistances are based on steady state measurements which are not real indicators of their performance. Onsite real time thermal performance data under summer conditions of four commonly used wall constructions in Saudi Arabia have been collected using experimental study in a test room maintained under similar conditions for all the wall. The time lag, decrement factor and their relative thermal resistance values indicate that Insulated brick walls and Adobe walls are the most suited candidates in terms of thermal performance for decreasing the cooling load. This study will help construction engineers to select the appropriate building wall material and also to estimate the air conditioning system capacity.

Keywords:
Building walls, insulating bricks, wall thermal resistance, Energy efficient walls, decrement factor, Building envelope;

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1. Introduction

Sizable part of building energy bill goes for air-conditioning interior spaces especially with the increasing average global temperatures due to global warming. Maintaining uniform and comfortable internal conditions in a building against the existing outside conditions depends on the ability of the building to regulate the heat transmission using its wall components. Hot deserts are among the most challenging regions in terms of energy consumption in buildings due to the intensive demand for cooling, as they experience extremely high air temperatures. One-third of the energy loss from a building occurs from the walls and another one-third is lost from the roof in the case of an un-insulated brick building, [1]. Hence performance study through experimental and simulation studies on walls were conducted by different researches. However, different types of building blocks having come into use with large variations in material properties which has made it difficult to maintain consistent parameters during performance simulation. Several experimental techniques have been developed to determine the thermal performance of the walls to help in proper choice of building wall components. Presently, building blocks with plain concrete as per ASTM C55 and C90 standards as well as blocks with insulation as per ASTM E2634 standards are in use. Also adobe blocks as per ASTM C62 standards are widely in use for single story buildings. Building walls under these categories are only tested in this study. This study does not include effect of plastering, wall paneling etc. Humidity pays an important role in thermal conditions of a building but it is not considered in this study.

Studies on wall thermal performance are classified under three categories, namely, numerical studies under steady state conditions, numerical studies under dynamic conditions and experimental studies on actual dynamic performance.

Theoretical studies on effect of building material on the energy balance of a building in an arid region is studied by [2] and the importance of construction according the local climatic conditions is stressed upon. [3] conducted a review of the experimental and numerical studies in energy conservation in buildings with the help of porous material. Computational fluid dynamics is used to study the steady state thermal performance of five different types of concrete blocks to study the effect of different configurations on the thermal transmittance by [4]. The effect of cavity filling and use of low emissivity coating on the thermal transmittance is studied with positive results. Similar studies are reported in several works by incorporating changes in the physical conditions of the wall. However, results of this method of wall performance analysis was grossly different when compared to real field performance. Conjugate heat transfer analysis using simulation of the heat transfer taking place between the solid concrete and fluid interfaces inside the air pockets within concrete blocks is done by [5]. Finite volume analysis with blocks of different configurations are done to study the effect of the air enclosure configurations and different void fractions by [6]. [7] made a steady state numerical model of clay bricks with cavities of different sizes and material and reported an increase in thermal resistance by about 20%. Similar numerical studies using finite element method is reported by [8].

[9] made a numerical simulation of a building wall to study the effect of thermal inertia on the wall temperature distribution. It is clear that thermal inertia of the wall played an important role in delaying the temperature changes occurring within the wall thereby increasing the comfort.

[10] conducted experimental studies on a specially built room with different material and measured the effect of moisture

content and insulation thermal mass on the thermal performance of the building. Specific measurement of indoor and outdoor temperature, relative humidity, barometric pressure, wind speed, wind direction, sky radiation and solar radiation are done. Effective thermal conductivity of hollow bricks with the different cavity fillings is experimented with a setup involving a thermal insulation box and a set of temperature and heat flux probes at the different points is done by [11]. Experimental results helped to compare the thermal conductivities of different arrangements.

U-Value meters are used by [12] and a method for measuring the heat loss is presented. U-value meter measures the heat transfer in the unit W/m2K and is used in several projects to upgrade the energy performance in temperate regions. U-value meters are used to check whether heat transmission coefficients (U-values) meet the requirements as stipulated in the Building Regulations. Building wall heat conduction problems are multi-dimensional and transient that need numerical calculation or computer simulations. Experimental conditions also vary due to different external and internal factors making testing difficult under identical conditions. Hence a common construction incorporating the different wall structures becomes important. Thermal hot box method is one method of determining the heat transfer performance of building wall with different components. However, inconsistencies in the R-values of the different sub components of the wall structure leads to inaccuracies according to [13].

Experimental methods that are used to evaluate the building block thermal performance includes thermal hot box method, heat flow meter method and the Infra-red method according to [14]. Comparison of the results with that of numerical results indicate higher accuracy for experimental ones. This is because factors like wind speed and humidity were not considered in numerical studies. It can be inferred from the above studies than on site measurements will be the most accurate method of determining or comparing the thermal behavior of building blocks. This study will help construction engineers to select the appropriate building wall material and to estimate the air conditioning system capacity.

For the purpose of onsite experimental investigations of thermal performance of four exterior building system modules, the four types of walls constituting the north facing wall of an air- conditioned test room with dimensions 600x730 cm2 and 220 cm height was tested as part of thermal insulation test room by [15]. The room is constructed on the roof of the Mechanical Engineering Department, King Saud University, in Riyadh city which has latitude of 248°N and longitude of 46.460°E. Two 1.5 TR air conditioning systems were installed in the rooms to provide uniform indoor air temperature. The results of the experimental study which is conducted on a representative hot day were used to compare the thermal performance of the building walls.

2. Heat transfer across building walls

Although different methods have been adopted by researchers to determine the thermal resistance of building walls experimentally, numerically or analytically, on site comparison of the actually constructed wall structure gives the most accurate results. Heat transfer across building walls is determined by the thermal resistance of the wall structure and the heat transfer coefficients (Fig.1). This includes the convection and radiation heat transfer coefficients. The heat flux through the wall is determined by the inside wall heat transfer coefficients, the outside wall heat transfer coefficients and the thermal conductivity of the wall itself. Housing codes have standards for the minimum allowable R-Value, or the resistance to heat transfer, which is how well the insulation works. The general arrangement of the experimental stand is shown in Fig. 1. The experimental set up consists of the necessary instrumentation for measuring the surface temperatures. A set of thermocouples are placed on internal and external surfaces at specific points of each wall. The four types of wall modules are tested under the ambient conditions prevailing in the month of September. The specifications of the thermocouple shown in Fig.1 made by Omega Inc., USA are:

Type K (CHROME-ALUMEL),

Maximum Temperature 175°C (350°F) continuous

Minimum Temperature is -60°C (-75°F) continuous Dimensions is 25 L x 19 W x 0.3 mm

The calculated uncertainty of the thermocouple from bias and precision uncertainty tests with a level of confidence of 95% is ±0.0153 °C.

Two thermocouples are used for each measurement and their average values are taken. Outdoor air, indoor air, inside wall and outside wall temperatures were measured. Thermocouples were used to measure outdoor air, indoor air, inside and outside wall surface temperatures by using two thermocouples each at two different levels and the average of their temperatures were taken. Two heat flux sensors were used on each wall to obtain the heat flux through the walls. data acquisition system OMB-DAQ-PDQ is capable of receiving 30 differential inputs or thermocouples. The data acquisition system is connected to a USB hub by data cable which in turn is connected to the computer for recording the measurements. Measurements were taken in September which represents hot climatic conditions. The average of the temperatures measured by the top and bottom thermocouples was taken.

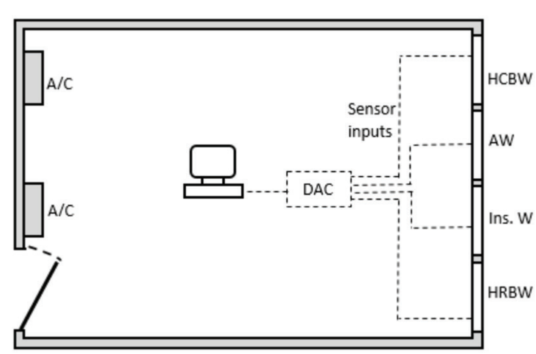

Fig.1 Scheme of the experiment

3. Structure and physical properties of the experimental walls

Four types of wall systems or modules are constructed as part of the north wall of the test room. The four modules are maintained under same indoor and outdoor conditions. Each building wall module has a surface area of 120x120 cm2. The structure of each module was different in material and design. Each module is isolated from effects of lateral heat flow using siporex blocks with a thickness of 20 cm on all sides. Thus heat flow is allowed only normal to the wall surface area. The four building system modules are shown in Fig. 2. The thermal performance of the four walls is analyzed under real indoor and outdoor climatic conditions. The time lag and decrement factor of the four wall types are determined and compared.

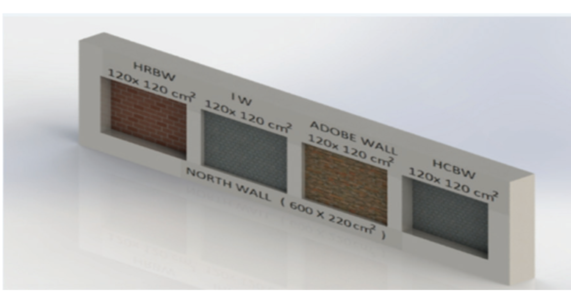

Fig.2 The four building wall systems separated by siporex layer

The structural, physical and thermal properties of the four walls; namely, Hollow Concrete Block Wall (HCBW), Adobe wall (AW), Insulated Wall (Ins.Wall), and Hollow Red Block Wall (HRBW) which are the subject of the present work are described in Fig.3 and Table 1.

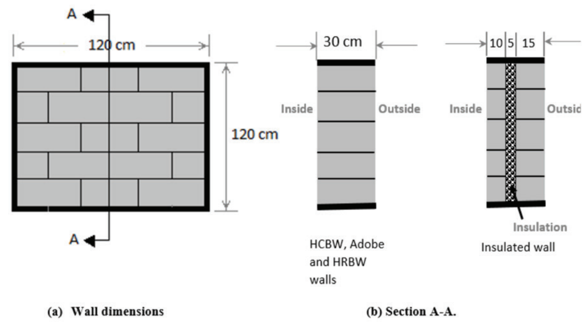

Fig.3: Schematic of the wall type constructions

The section of the Hollow Concrete Block Wall (HCBW) consists of single layer made from heavy weight concrete blocks with 30 cm thickness. The section of the Adobe wall consists of one layer made from solid adobe (clay) bricks with 30 cm thickness. The section of the Insulated Wall (Ins.Wall) is shown in Fig.3b, which consists of three layers. The inside layer is a 10 cm thickness hollow concrete blocks and the outside layer is 15 cm thick hollow concrete block with an insulation layer in between.

The section of the Hollow Red Block Wall (HCBW) consists of one layer made from Hollow Red Block with thickness 20 cm.

Type of wall		Width, Cm	Density, kg/m^3	Specific heat, $J/kg.k$	Thermal conductivity, $W/m.K$
HCBW [9]		30	1105	840	1.05
AW [10]		30	1400	1000	0.58
IW [11][12]	Inner Concrete layer	10	1618	480	0.81
	Insulation	5	26	1215	0.032
	Outer Concrete layer	15	1618	480	0.81
HRBW [13]		30	1450	837	0.55

Table 1. Thermal properties of the wall components

4. Time lag and decrement factor

Time lag and decrement factors are very important thermal performance indicators that reflect the heat conducting and storage capacities of building wall material.

Higher storage capacities will increase the time lag as per the studies by [16]. The thicker and more resistive the material, the longer it will take for heat waves to pass through. Time lag (Φ) is the difference in time corresponding to maximum temperature points at the outside ($t_{To\ max}$) and inside ($t_{Ti\ max}$) when subjected to periodic conditions of heat flow (IS 3792-1978) as given in Eq.1. Decrement factor (f) is defined as the ratio of the maximum inside and outside surface temperature amplitudes as given in Eq.2. Lower decrement factor means the heat transfer across the material is lesser. For example, a material with a decrement value of 0.5 which experiences a 200 diurnal variation in external surface temperature would experience only a 100 variation in internal surface temperature.

$$\Phi = t_{T_o^{\max}} - t_{T_i^{\max}} \quad (1)$$

The first term in the above equation represents the time of maximum value of the outside temperature and the second term represents the time of maximum value of the inside temperature.

$$f = \frac{T_i^{\max} - T_i^{\min}}{T_o^{\max} - T_o^{\min}} \quad (2)$$

The numerator in the above expression represents the difference between the maximum (T_i^{max}) and minimum temperatures (T_i^{min}) of the inside wall and the denominator represents the difference between the maximum (T_o^{max}) and minimum (T_o^{min}) temperatures of the outside wall.

Results and discussion

The plotted data is from measurement of the following items:
- Inside surface temperatures of the four types of walls (2 set of readings)
- Outside surface temperatures of four types of walls (2 set of readings)
- Ambient temperature (1 set of reading)
- Room temperature (1 set of reading)

The difference in readings in the first and second case was less than 1%. The plot is made by fitting the data to a 6th degree polynomial with a regression coefficient R2>0.992 for all the cases.
The curve showing the instantaneous indoor and outdoor air temperatures and surface temperatures are given in Fig.4a to Fig.4d for the four types of walls. The indoor air temperature ranges between 23 and 26°C. The outdoor air temperature ranges between 19 and 48°C. The indoor air temperature must ideally be maintained at 24 degrees but the delay in response of the air conditioner thermocouple produced a temperature range of 3 degrees. The outdoor air temperature followed the typical pattern and disturbances were minimal in this measurement.

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Table 2 gives the results for the four types of walls considered in this study. It can be seen that as the thermal transmittance is reduced the decrement factor is also reduced. Maximum heat flux ix obtained from the data recorded by the heat flux sensors. Since time lag is calculated based on the room temperature and ambient temperature, it has a value of 2 hours and 12 minutes. The decrement factor values also agree with the difference in temperature between the wall outside and inside temperatures. Lower decrement factor means that the rise in the inside surface temperature is less while the simultaneous outside surface temperature rise is higher. These mainly depend on the specific heat capacity and thermal diffusivity of the building materials and not on the surface heat transfer coefficient.

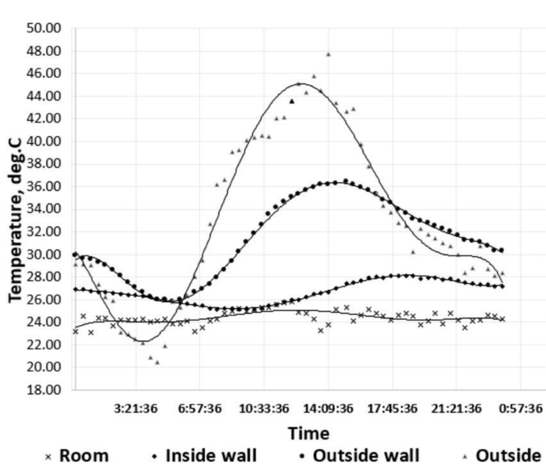

Fig.4a Temperatures distribution for HCBW for 24 hours

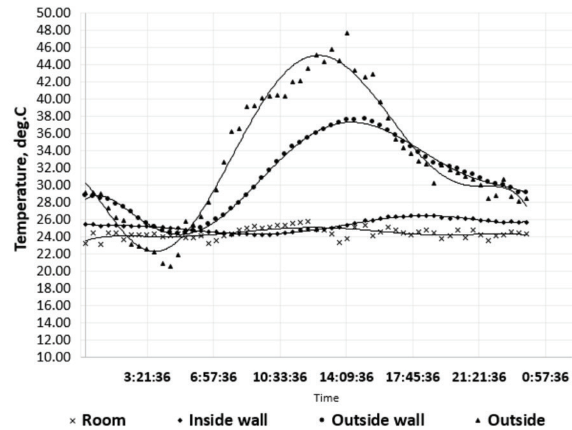

Fig.4b Temperatures distribution for ADOBE wall for 24 hours

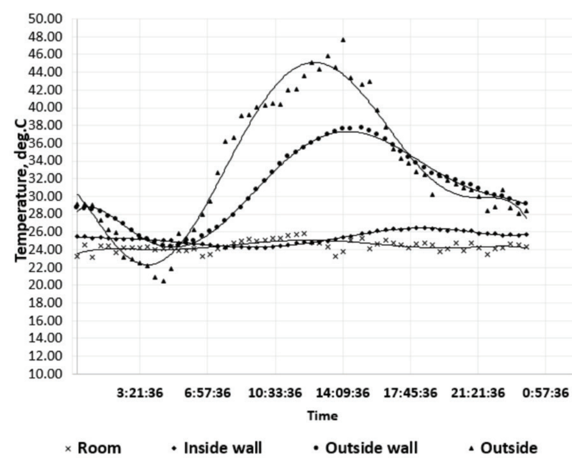

Fig.4cTemperatures distribution for HRBW wall for 24 hours

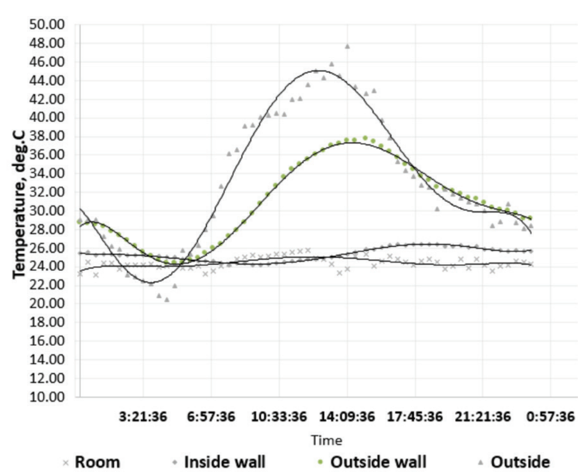

Fig.4d Temperatures distribution for INSULATED wall for 24 hours

Mean inside air temperature was about 24 o C whereas the mean outside surface temperature was about 38 o C in the hot day. Fig.5 shows the temperature difference between the outside and inside surface of each type of wall.

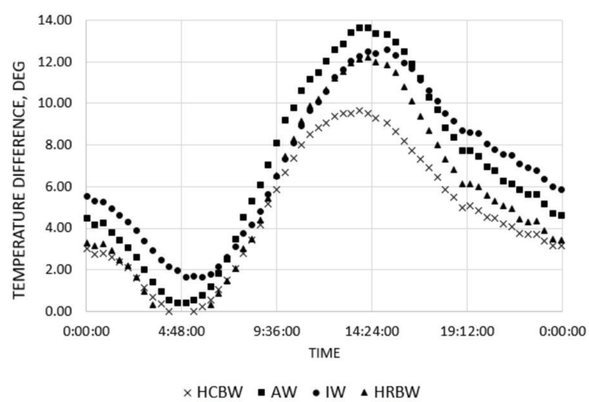

Fig.5 Difference between the outside and inside surface temperatures

Wall Type	$\bar{T}_{si}$, °C	A_{is}, °C	Max $(T_{so}-T_{si})$, °C	Max q $_{max}$ W/m ^{2}	Max $(T_{si}-T_i)$ °C	Decrement factor
HCBW	26.6	1.8	9.5	49.9	4.1	0.0847
HRBW	24.37	1.15	12	34.3	2.5	0.0309
Adobe Wall	25.5	0.45	13.5	26.1	2	0.0257
Insulated Wall	24.5	0.4	12.5	6.6	1	0.0631

Table 2. Results of the temperature measurements

The most important indicators of the thermal performance of exterior building walls are:Wall inside surface temperature; this has to be very close to the inside air temperature for better thermal comfort.

• Amplitude of inside surface temperature; the lower its value is an indication of lower fluctuation of inside surface temperature.

• The heat flux through the wall; of course the lower its value the better is the thermal performance of the wall. This means lower electric bill.

Results presented in Fig. 4a to Fig.4d and Fig.5 and Table 2 reveals interesting points. Table 2 summarizes the following parameters: Average inside surface temperature,T_{si} . This is calculated by taking the average of all the temperature readings over the complete working cycle. Amplitude of inside surface temperature, A_{is}, Maximum heat transfer flux, q_{max}, and maximum (T_{so}-T_{si}). The most important two parameters of the thermal performance of exterior walls are the inside surface temperature and the heat flux through the wall. Results presented in Table 2 shows clearly the superior performance of the insulated wall as compared to the rest of the walls. It's inside surface temperature is very close to that of indoor temperature and its amplitude is only about 0.4 o C. Most interesting is its maximum heat flux which is only about 13% of that for the concrete wall, 19% of that for red block, and 25% of that for the adobe wall. Comparing the other three walls, the Adobe wall has a better performance with regard to time lag and decrement factor.

6. Conclusions

The experimental comparative study of thermal performance of four types of wall construction material used locally in Saudi Arabia was evaluated experimentally by building a test room of real size under real working conditions. Temperature measurements were recorded for a representative hot weather day. Interpretation of the results indicated that the insulated wall shows superior thermal performance, with regard to thermal comfort and heat flux through the wall. Insulated walls demonstrated better performance in terms of wall inside surface temperature, Amplitude of inside surface temperature and heat flux. Comparing the other three walls, the Adobe wall has a better performance with regard to time lag and decrement factor. The adobe wall gives a maximum value of time lag followed by the insulated wall. The remaining two walls showed poor performance, where both have higher inside surface temperature and amplitude together with high heat flux. The results obtained are useful for designing appropriate building envelope configurations for buildings under similar conditions. It is also useful for air condition engineers to determine the het lod in buildings with above types of walls.

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Nomenclature

IW	Insulated wall
AW	Adobe wall
Φ	Time lag
$t_{T_o^{max}}$	Time taken to reach maximum temperature of outside air, hrs
$t_{T_i^{max}}$	Time taken to reach maximum temperature of inside air, hrs
f	Decrement factor
T_i^{min}	Minimum inside temperature, ^oC
T_i^{max}	Maximum inside temperature, ^oC
T_o^{max}	Maximum outside temperature, ^oC
T_o^{min}	Minimum outside temperature, ^oC
$\bar{T}_{si}$	Average inside surface temperature, ^oC
A_{is}	Amplitude of inside surface temperature, ^oC
T_{so}	Outside surface temperature, ^oC
T_{si}	Inside surface temperature, ^oC
q_{max}	Maximum heat flux, W/m^2
T_i	Inside temperature, ^oC

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