

Future Dynamic Computing and User Profile Execution Considering User Migration in Social Media Contexts

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Abstract - Asymmetry in user subscription aboard social media platforms leads to a case where emerging social media platforms have more users than existing and established social media platforms. This leads to a scenario where the computing capacity aboard the data centers of established social media platforms is unutilized or underutilized. In addition, emerging social media platforms are often capital constrained and require access to computing resources to host and execute user profiles. The presented research proposes a network architecture that enables emerging social media platforms to make use of the idle computing resources of established social media platforms. The power usage effectiveness and computing resource utilization are enhanced by 31.2% and (32.8-50.5)% on average, respectively.

Keywords - cloud computing; social media networks; computing utilization; power usage effectiveness

I. INTRODUCTION

The use of computing platforms plays an important role in enabling service delivery by social media-related firms and providers. Data centers in cloud computing platforms host data that describe the status and profile of multiple subscribers. In addition, servers host computing resources enabling the execution of functionalities embodied in algorithms that deliver services to the user(s).

Therefore, the subscribers and users of social media providers (SMPs) execute functions that lead to resource usage and power consumption in servers that constitute data centers and cloud computing platforms. Currently, there are many SMPs that operate their own data center facilities. Examples of SMPs in this regard are LinkedIn, Meta (Facebook, Instagram, WhatsApp), and TikTok (which utilizes Oracle, Google, and Amazon Web Services). These SMPs host different and distinct interfaces and front-end platforms to interact with their users.

The independent operation of data centers by SMPs results in the use of power resources by each SMP to maintain user profiles and store user data. This manner of resource usage does not consider that SMPs may have profiles for the same individual in their cloud computing platform. Hence, SMPs consume a significant amount of resources in making data center services available. These

resources are expended even when a profile is not being accessed by the associated user.

The current usage of resources i.e., power and computing by SMPs does not consider the active and inactive state of the user profile for a given SMP. However, existing research shows that there is an asymmetry in the user subscription to different SMPs [5–7]. This implies that the data center of some SMPs host user profiles with high activity ratios while the data centers of other SMPs have low activity ratios (LAR). The occurrence of high activity ratio (HAR) and LAR.

The occurrence of HAR and LAR influences the power used in operating and cooling servers aboard data centers. This also results in an influence on power usage effectiveness (PUE) and computing resource utilization (CRU). In addition, it is important to limit inefficient resource usage. This occurs when an SMP with a reduced activity ratio profile hosts a user profile on a high PUE cloud computing platform. The research being proposed addresses this challenge.

The main contribution of the presented research is the design of a network architecture that enables emerging SMPs to utilize the computing resources aboard the data centers and cloud computing platforms of established SMPs.

The discussion in the paper addresses the design and presentation of a system focused on the emerging SMP. In this case, the emerging SMP has significant capital constraints and is unable to operate its own data center. In the proposed solution, emerging SMPs (EMSPs) do not have sufficient capital resources to engage in the ownership of cloud computing platforms comprising networked data centers. Nevertheless, EMSPs have an increasing number of onboarding users and subscribers. Established SMPs (ETSPs) have data centers and cloud computing platform but have a reducing subscriber profile. This reduction is being experienced due to the migration to EMSPs by a significant number of users. The PUE, and CRU of ETSPs with EMSP migration is also formulated and investigated.

The discussion here is organized in this manner: Related background work receives focus in Section II. The proposed network architecture is in Section III. The performance formulation and modelling are addressed in

Section IV, and Section V, respectively. The discussion is concluded in Section VI.

II. BACKGROUND WORK

Appel et al. [8] identify the high level of subscription to social media platforms by users. It recognizes social media as a communication channel. The disposition in [8] identifies that social media has a pervasive role in computing with focus on its influence in marketing. The discussion has not considered the variation in the number of users on different social media platforms.

Sawicki et al. [9] recognize the increasing usage and subscription to TikTok by users. The discussion recognizes the ubiquity of social media platforms. However, the supporting and underlying architecture and its operational details have not been considered. An analysis of the algorithm underlying TikTok has been presented in [10]. The analysis is conducted from the perspective of self-making and self-representation. The concept of networking receives consideration from the linking of self-representation and identity management. This link provides the capacity for social connection. The focus of the discussion in [10] is the analysis of user experience due to interaction with the TikTok platform.

Zulkifil [11] addresses the challenges associated with data privacy in TikTok. The concern in [11] recognizes the challenges associated with conforming to regulations on data sovereignty and retention. The realization of data sovereignty requires the design of data center network architecture to realize a distributed cloud with controlled data access [12–14]. The discussion in [14] examines the approach of managing data centers by Facebook, an SMP. The analysis of the efficient operation of Facebook data centers is done from the perspective of providing low latency services to Facebook users. The efficiency has not been considered with a view to examine the role of user immigration of emigration in relation to Facebook. This transition is implicitly and not explicitly considered. Hence, the context of resource over-provisioning with the aim of supporting a significant number of onboard users can be implied. However, the event of user immigration or emigration can be implied from the discussion in [15–17].

The transition from one SMP to another SMP as seen in [15–20] does not reduce or eliminate the need for social media providers to have operational data centers as a computing and communication base. However, new social media platforms may have an increasing subscriber profile without a corresponding data center/computing platform operational base. However, a declining number of users can be observed to be associated with an SMP having an established data center network. In addition, an emerging SMP with increasing subscriber profile may not necessarily have the required data center platform support base. For example, ByteDance and Mastodon are emerging social media platforms with a smaller data center operational base in comparison to social media platforms like LinkedIn (Microsoft), Twitter and Meta (Facebook). However, ByteDance and Mastodon have an increasing subscriber base. Hence, a scenario wherein EMSPs such as Mastodon and ByteDance (TikTok) can make use of the computing

resources and assets of ETSPs like Facebook require additional research consideration.

The presented research alongside the proposed mechanism is deemed to be beneficial to the case of capital constrained social media platforms. Such platforms are unable to acquire large scale and distributed data centers and cloud computing platforms. This is due to significant capital constraints. It is recognized that such media platforms can make use of existing cloud computing service providers. However, such a scenario limits the choice of these emerging social media platforms in the absence of the proposed mechanism and associated network architecture. Furthermore, the presented research decouples the computing platform and the social media platform which has been closely coupled in the existing case as seen in the case of LinkedIn (Microsoft owned and uses Microsoft Azure), Meta (having own data centers), Twitter (having own data centers) and Telegram (having own data centers). The case of the Fediverse describes the context of the proposed computing paradigm. However, Fediverse based social media platforms such as Mastodon make use of the non-social media cloud computing platforms only [21]. The proposed research advances the case of the Fediverse by incorporating more client cloud computing platforms for the emerging social media platform.

III. PROBLEM DESCRIPTION

The context being considered is one in which there are multiple existing and established social media platforms. Each of these platforms has own data centers and users. The set of ETMPs is denoted α such that:

$$\alpha = \{\alpha_1, \alpha_2, \dots, \alpha_A\} \quad (1)$$

The number of subscribers associated with the a^{th} social media platform $\alpha_a, \alpha_a \in \alpha$ at the epoch $t_y, t_y \in t, t = \{t_1, \dots, t_y\}$ is denoted as $N_1(\alpha_a, t_y)$. The maximum and minimum number of subscribers associated with α_a are also dynamic and denoted as $N_{max}(\alpha_a, t_y)$ and $N_{min}(\alpha_a, t_y)$, respectively. The a^{th} social media platform α_a requires more servers (data centers) when:

$$A_1 > B_1 > C_1 \quad (2)$$

$$A_1 = \sum_{y=1}^p (N_{max}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (3)$$

$$B_1 = \sum_{y=p+1}^q (N_{max}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (4)$$

$$C_1 = \sum_{y=q+1}^y (N_{max}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (5)$$

The scenario in (2) is described as the case of high activity ratio. This arises because of a significant increase in the number of users. Server (data centers) experience a low activity ratio when:

$$A_2 > B_2 > C_2 \quad (6)$$

$$A_2 = \sum_{y=1}^p (N_{min}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (7)$$

$$B_2 = \sum_{y=p+1}^q (N_{min}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (8)$$

$$C_2 = \sum_{y=q+1}^y (N_{min}(\alpha_a, t_y) - N_1(\alpha_a, t_y)) \quad (9)$$

The set of ESMPs is denoted β and given as:

$$\beta = \{\beta_1, \beta_2, \dots, \beta_B\} \quad (10)$$

The ESMP $\beta_b, \beta_b \in \beta$ is deemed to have an increasing number of users and does not have sufficient resources to acquire a server based and capacity. The ESMP β_b can utilize the server capacity of α_a when (6) holds true (low activity ratio of the ETMP). However, an architecture and solution to enable this has not received sufficient research consideration. This is the focus of the proposed mechanism and network architecture.

IV. PROPOSED SOLUTION

The proposed solution is presented in this section that has two aspects. The conceptual background for the proposed solution is considered in the first aspect. The second aspect discusses the proposed network architecture.

A. Conceptual Background

The proposed network architecture essentially increases the amount of potential computing resources that can be utilized by ESMPs. In the existing case, ETMPs such as Facebook, Twitter and Telegram have own data centers that enable the provisioning of service to users and subscribers. In this case, the ETMP and the computational resource base have a close coupling and are not separated. Instead, they co-exist as a single entity. The scenario of this close-coupling context is in Figure 1. In Figure 1, the social media platform and the computing platform are indistinguishable and are enclosed in the context of providing the social media service.

A second scenario is one in which the ETMP such as Twitter is perceived to be a server capacity organization. Such a perspective can be derived from the view of Elon Musk on Twitter being a server capacity provisioning company at its core as found in [22]. This implies that ETMPs can potentially provide server capacity and associated software to other companies. However, this aspect is yet to receive further research consideration. In this case, the social media platform-computing platform has a less close-coupling than the case of the close-coupling context and is presented in Figure 2.

Social Media Functionality and Service

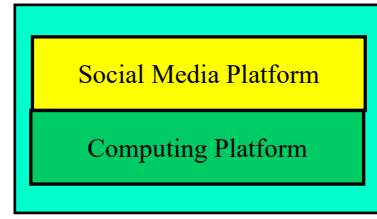


Figure 1. Relations between the social media platform and the computing platform in the closely coupled context of an ETMP.

Social Media Functionality and Service

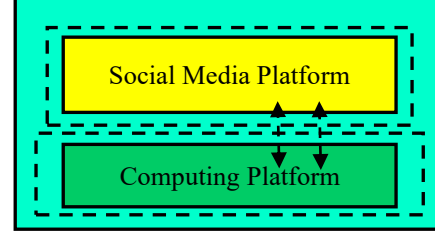


Figure 2. Relations between social media platform and the computing platform in a less closely coupled context of an ETMP.

The proposed case is one in which the computing platform provides services to other applications besides those related to social media platforms. In this case, the additional applications being considered is the ESMP. This is the context in Figure 3.

Figure 3 shows the case where the established social media provider (ETMP) and the emerging social media provider (ESMP) share the use of the computing platform as proposed. In this case, the computing platform is a data center owned and operated by the ETMP. However, a sharing of the computing platform has been presented in Figure 3 to indicate the operational context of the proposed solution. In this case, the ETMP can be an established social media platform such as Twitter. The ESMP is a social media platform which is newly established and in which the operators have significant capital constraints with limited capability of owning and operating computing platform.

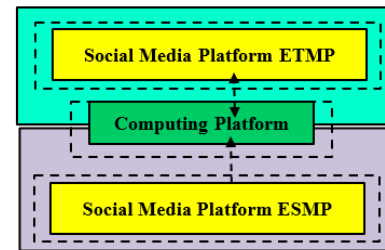


Figure 3: Relations between the social media platform and the computing platform in the considered context.

B. Proposed Network Architecture

The proposed network architecture considers that ESMPs have significant capital constraints thereby limiting their acquisition of data centers (significant number of networked servers). The ETMPs are not subject to these constraints in our consideration. The ESMP hosts entities enabling the monitoring and determining the occurrence of large user subscription. In addition, the ESMP hosts

computing entities that interact with the network. These computing entities send the server and computing resource requirement of ESMPs to a cloud-based database entity (CBDE).

The CRDE also hosts repositories that receives information on the availability of computing resources when ESMP have a low activity ratio. The CBDE has two main repositories i.e., the ESMP repository (ESMT) and the ETSP repository (ETMT). The ETST holds data on the computational resources (memory and networking capabilities) available from the ETSPs having a low activity ratio.

In realizing its functionality, the CRDE is hosted aboard multiple data centers in the cloud computing platform. The concerned entities i.e., the EMST and ETST interact with the ESMP and ETMP, respectively. In this case, the interaction is essentially between the gateway entities of ESMP and ETMP. The relations between the interacting entities enabling the sharing of computing platform between the ESMP (EMST) and the ETMP (ETST) are presented in Figure 4.

The aim and novelty of the architecture presented in Figure 4 is to describe how emerging social media providers and established social media providers determine the usage (request for and utilization of computing resources) alongside the execution of the required and associated communication.

In Figure 4, EMST and ETST access the cloud computing platform via own gateway entities. The gateway entity for the ETST and EMST are ETGW, and EMGW, respectively. Each of the EMGW and the ETGW engages in communication with the computing platform via the network entity (NE).

Figure 4 shows the relations between the ESMP, ETMP and the CBDE. The ESMP comprises the EMSP gateway (EMGW) and the computing resource determining entity (CRDE). In a similar manner, the ETMP comprises the ETMT gateway (ETGW) and the CRDE. The CRDE determines the required and idle computing resources by the ESMP and ETMP, respectively.

In Figure 4, the EMGW and ETGW communicate with each other via the cloud gateway (C-GW). This communication enables the ESMP to use available computational resources of the ETMP. The concerned computational resources are used to host data related to the ESMP user profile and execute algorithms associated with the delivery of different functionalities associated with the ESMP.

The C-GW incorporates a high-speed network with a low latency backbone enabling the rapid transfer of data in a bi-directional fashion. The exchange from the EMGW to the ETGW enables the ESMP to make use of accessible (idle) computing resources at the ETMP's cloud computing platform. In addition, an increase in the number of subscribers (users) of the ETMP necessitating an increased demand for computing resources that was previously suitable for use by ESMPs.

In addition, the C-GW engages in communications with external cloud computing platforms (data centers) via

the external cloud gateway (ECGW). The ECGW is connected to other data centers whose use is deemed necessary when there is need to access additional computing resources.

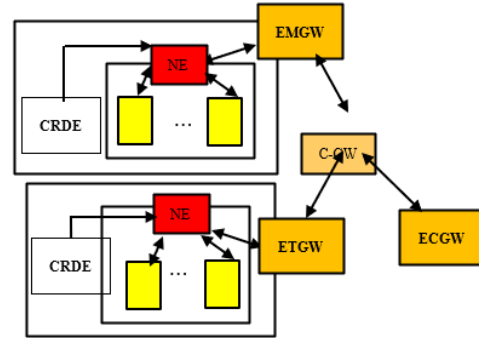


Figure 4: Relations between the ETMP and ESMP.

The CRDE determines the amount of computing resources and sends this to the concerned repository. Information in either repository i.e., ESMT and ETMT is sent to the network entity (NE). The NE interacts with the ESGW or the ETGW as deemed necessary. The flowchart for the architecture is presented in Figure 5.

In Figure 5, the occurrence of a low activity ratio (LAR) in the ETMP implies the low usage of computing resources aboard the concerned computing platform. This arises when (1) there is an overprovisioning of computing resources in the cloud platform, and (2) massive emigration of users due to the adoption of unfriendly policies. Emigration is deemed to have occurred when a user profile does not experience significant activity for a pre-determined duration. A high activity ratio (HAR) is deemed to have occurred when there is increasing usage of computing resources aboard a concerned computing platform. Such a case arises when an EMSP experiences increased subscription from many subscribers. In this case, there is a consistent increase in the utilization of computing resources aboard the cloud platform.

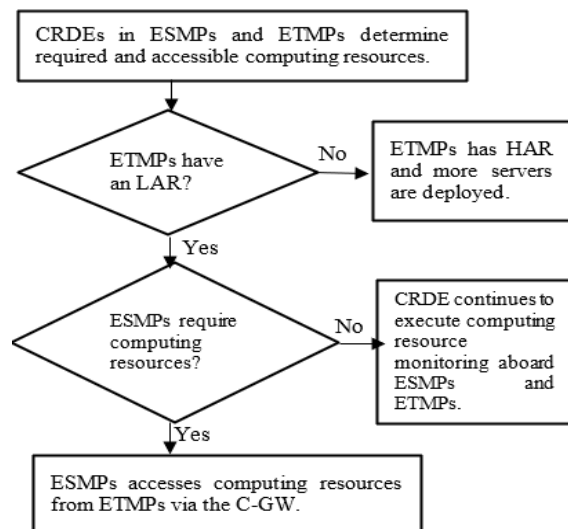


Figure 5: Flowchart showing the relations between ETMP, ESMP and associated entities.

V. PERFORMANCE FORMULATION

The formulation of the performance metrics i.e., the PUE and CRU is considered in this section. This is done for cases with and without the incorporation of the proposed architecture.

The performance formulation recognizes that there are multiple aspects associated with the description of a data center. However, the focus in the presented research is on formulating the PUE. In addition, the power components are those concerned with operating the server and the cooling system in the data center.

Let $\gamma(\alpha_a)$ be the set of servers in the ESMP datacenter α_a such that:

$$\gamma(\alpha_a) = \{\gamma_1(\alpha_a), \dots, \gamma_M(\alpha_a)\} \quad (11)$$

The servers in $\gamma(\alpha_a)$ are networked to realize a data center and computing platform.

Let $P_1(\gamma_m(\alpha_a), t_y), \gamma_m(\alpha_a) \in \gamma(\alpha_a)$ and $P_2(\gamma_m(\alpha_a), t_y)$ denote the power required to operate and achieve the cooling of the m^{th} server of the a^{th} ESMP at the epoch t_y , respectively. The activity state of $\gamma_m(\alpha_a)$ at the epoch t_y is denoted $I_A(\gamma_m(\alpha_a), t_y) \in \{0,1\}$. The server $\gamma_m(\alpha_a)$ is active and inactive at the epoch t_y when $I_A(\gamma_m(\alpha_a), t_y) = 1$ and $I_A(\gamma_m(\alpha_a), t_y) = 0$, respectively.

The PUE in the existing case θ_1 for multiple servers in the data center being used by the a^{th} ESMP at multiple epochs can be given as:

$$\theta_1 = \sum_{m=1}^M \sum_{y=1}^Y \sum_{k=1}^2 \frac{P_1(\gamma_m(\alpha_a), t_y)}{P_k(\gamma_m(\alpha_a), t_y)} \quad (12)$$

In (12), the numerator is a single term and describes the power required to operate the server (computing payload). The denominator describes the sum of the power required to operate and cool the server. Considering the influence of the activity status $I_A(\gamma_m(\alpha_a), t_y)$, θ_1 can be re-written as (within the context of for multiple servers in the data center being used by the a^{th} ESMP) θ'_1 and given as:

$$\theta'_1 = \sum_{m=1}^M \sum_{y=1}^Y \sum_{k=1}^2 \frac{P_1(\gamma_m(\alpha_a), t_y) I_A(\gamma_m(\alpha_a), t_y)}{P_k(\gamma_m(\alpha_a), t_y)} \quad (13)$$

$$|I_A(\gamma_m(\alpha_a), t_y = 1)| < |I_A(\gamma_m(\alpha_a), t_y = 0)| \quad (14)$$

The relations in (13) – (14) is for an ETMP with a low activity ratio (LAR). Hence, the number of idle epochs exceeds the number of active epochs. This is because more users are emigrating from the ETMP. In this case, more energy is expended storing and maintaining the profiles of users who are no longer onboard the ETMP. These are non-active user profiles that utilize cloud computing resources.

In the case of the proposed network architecture, the number of active epochs is increased as ESMPs make use of ETMP's servers (data centers).

The PUE θ_2 (formulated under the same context as (12)) is given as:

$$\theta_2 = \sum_{m=1}^M \sum_{y=1}^Y \sum_{k=1}^2 \frac{P_1(\gamma_m(\alpha_a), t_y) I_A(\gamma_m(\alpha_a), t_y)}{P_k(\gamma_m(\alpha_a), t_y)} \quad (15)$$

$$|I_A(\gamma_m(\alpha_a), t_y = 1)| > |I_A(\gamma_m(\alpha_a), t_y = 0)| \quad (16)$$

In addition, the computing platforms of the ETMP can be utilized in a manner wherein the number of idle and active epochs are equal. In this case, the PUE θ'_2 can be re-written as:

$$\theta'_2 = \sum_{m=1}^M \sum_{y=1}^Y \sum_{k=1}^2 \frac{P_1(\gamma_m(\alpha_a), t_y) I_A(\gamma_m(\alpha_a), t_y)}{P_k(\gamma_m(\alpha_a), t_y)} \quad (17)$$

$$|I_A(\gamma_m(\alpha_a), t_y = 1)| = |I_A(\gamma_m(\alpha_a), t_y = 0)| \quad (18)$$

The CRU metric is also formulated for the proposed and existing mechanisms. The CRU before and after incorporation of the proposed architecture are denoted as θ_3 and θ'_3 , respectively.

$$\theta_3 = \frac{|I_A(\gamma_m(\alpha_a), t_y = 1)|}{|I_A(\gamma_m(\alpha_a), t_y = 1)| + |I_A(\gamma_m(\alpha_a), t_y = 2)|} \quad (19)$$

$$|I_A(\gamma_m(\alpha_a), t_y = 1)| < |I_A(\gamma_m(\alpha_a), t_y = 0)| \quad (20)$$

θ'_3 is the same as (19) but with the relation in (20) changed to $|I_A(\gamma_m(\alpha_a), t_y = 1)| > |I_A(\gamma_m(\alpha_a), t_y = 0)|$.

VI. PERFORMANCE EVALUATION

The performance evaluation is done for a context when there is an ETMP with a reducing number of subscribers. The ETMP has a datacenter comprising the multiple servers. An ESMP has multiple users and requires additional computing resources. The ETMP has a centralized cooling system comprising fans chillier, pipes, pumps, and capital-constrained a central management system. Two contexts are considered. In the first context, servers that are unutilized have their data moved to other servers and are switched off. In the second context, there are servers having a low utilization due to users migrating from the ETMP to the ESMP. The simulation parameters are in Table 1.

TABLE 1: PARAMETERS USED IN THE SIMULATION PROCEDURE

S/N	PARAMETER	VALUE
1	Total Number of Servers	40
2	Maximum Server Operational Power	380.6 W
3	Minimum Server Operational Power	1.78 W
4	Mean Server Operational Power	192.2 W
5	Maximum Proportion of Power used in Cooling	92.7%
6	Minimum Proportion of Power used in Cooling	3.3%
7	Mean Proportion of Power used in Cooling	48.1 %
FIRST CONTEXT		
8	Number of Active Servers	23
9	Number of Inactive Servers	17
SECOND CONTEXT		
10	Maximum Server Utilization	16%
11	Minimum Server Utilization	0.41%
12	Mean Server Utilization	7.8%

The results for the PUE, CRU (first context), and CRU (second context) as regards the performance simulation and evaluation are in Figure 6, Figure 7, and Figure 8, respectively. The results in Figure 6 show that the PUE exceeds a value of unity (ideal). This is because the simulation has not focused on improving the PUE. However, the proposed architecture has a lower PUE than the existing approach. Hence, the PUE performance is enhanced.

Analysis shows that the incorporation of the proposed mechanism and architecture enhances the PUE by an average of 31.2%. The use of the proposed mechanism improves the CRU as seen in Figures 7 and 8. Analysis shows that the incorporation of the proposed mechanism in the first context and second context enhances the CRU. The CRU is enhanced due to the use of the proposed mechanism in the first and second contexts by an average of 32.8% and 50.5%, respectively.

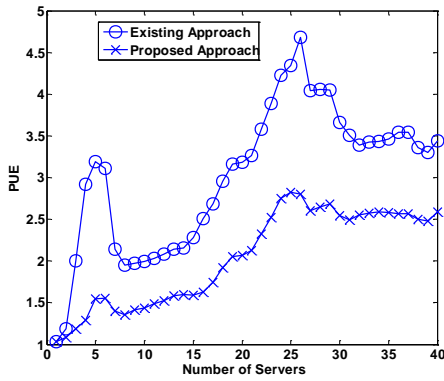


Figure 6: Performance evaluation results of the PUE obtained via simulation for the existing approach and proposed approach.

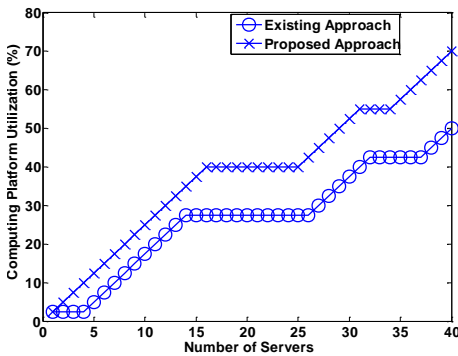


Figure 7: Performance evaluation results of the CRU in the first context obtained via simulation for the existing approach and proposed approach.

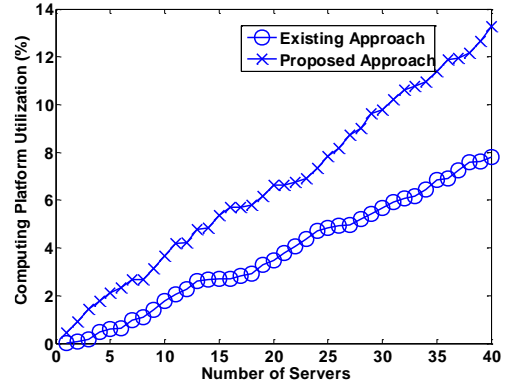


Figure 8: Performance evaluation results of the CRU in the second context obtained via simulation for the existing approach and proposed approach.

VII. CONCLUSION

The presented research recognizes that user emigration and immigration influence the resource utilization of computing resources in cloud computing platforms and data centers of social media platforms. It is recognized that this transition provides an opportunity for emerging social media platforms to make opportunistic use of idle and unutilized computing resources in the computing platforms of established social media platforms. Such a use of computing resources is beneficial to established social media platforms owning and operating cloud computing platforms i.e., data centers. In the performance analysis, the use of the computing resources in the proposed manner is noted to enhance the power usage effectiveness and the computing resource utilization. Furthermore, the established social media platforms can realize benefits by providing an additional service (for emerging social media platforms). However, it is noted that the security of information associated with user profile is a challenge. This can be addressed by ensuring that the emerging social media providers are hosted in a partition where there is no access to established social media provider operational related data. In addition, the proposed architecture enables emerging social media platforms with an increasing number of users to deliver services and required functionality to their subscribers. Furthermore, this sharing is shown to enhance the power usage effectiveness and computing resource utilization for computing platforms of established (existing) social media platforms experiencing user emigration to emerging social media platforms. Nevertheless, the concern of designing robust security systems for the concerned application is a subject of future research. Furthermore, the design of an intelligent network architecture considering subscriber profiles is also a subject of future work.

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