DewMetrics: Demystification of the Dew Computing in Sustainable Internet of Things

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1 Introduction

The personalization aspect is indispensable for the engrossment of the users in any computing genus. Dew computing is an emerging paradigm that inherits a flexible and super hybrid methodology to afford personal information to users' self-regulating Internetwork connectivity [1, 2]. Dew computing encompasses a set of innovative design attributes in terms of hardware and software prototypes that includes the dew computer, dew server, dew site, dew database, dew domain name

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system, dew domain name redirection, Software-as-a-Dew Product, Infrastructure-as-a-Dew service and super-hybrid-peer-to-peer network [3, 4]. The foremost indication behind dew computing is to minimize the dependency on obtainable Internetwork backhaul, thus reducing network traffic, indirect overall power consumption of the network system as well as data dependency over cloud-fog-edge services [4, 5]. Dew computing provides augmentations of real-time personalized services to users employing instantaneous web data that is surf-ready. Further, transparency and lose coupling with the Internetwork configuration are envisioned [4].

Most people refer to modern mobile and wireless ubiquitous solutions as the Internet of Things applications. The encroachments of the technology and establishment of cloud-based systems emerge the idea of a connected world over the Internet based on distributed processing frameworks [5, 6]. We illustrate in this contribution the dew computing architectural approach for sustainable IoT solutions and give an organizational outline of the dew server and its connections with IoT devices in the overall cloud-based solutions. Dew servers act as another computing layer in the cloud-based architecture for IoT solutions [7, 8], and we are going to demonstrate its specific goals and requirements. This is compared to fog computing and cloudlet solutions with an overview of the overall computing trends [8, 9]. The dew servers are analyzed from architectural and organizational aspects as devices that collect, process, and offload streaming data from the IoT sensors and devices, besides the communication with higher level servers in the cloud [10, 11].

The dew computing concept is on the edge of the Internet network means that the analyzed devices and systems will work only as a part of a general common integrated system, such as in the case of cyber-physical systems and various devices that act as an Internet of connected Things [5, 6]. The dew computing implementation in cyber-physical systems allows autonomous devices and smart systems, that can collaborate and exchange information with the environment, still, be independent of other external systems, or perform in a connected more complex cyber-physical system of systems [5].

The Internet of Things is a promising paradigm that integrates additionally a plethora of heterogeneous computational devices, incorporating the crowd, frameworks, additional system elements, and infrastructure [12]. Information sensing, modeling, retrieval, and distribution perform an emerging role in the Internet of Things network [13]. Dew computing is a challenging research issue, which needs to demonstrate its impact on the sensor data in the domain of parallel and distributed

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computing [14]. The crowdsourcing paradigms are efficient to collect and analyze billions of information efficiently with a diminutive cost. In this promising paradigm, participated sensing devices sense information from the environment; transmit the sensor data to associated edge and fog computing devices through a dew repository, and eventually, the cloud data center stores the processed data for providing aggregated information and relevant services to the end-users [10].

Technological innovations have brought revolutionary modifications in terms of information storage and its accessibility both in subjective and business-related domains. The Internet facility helps everybody to fetch their information requirements without any location, or timeframe constraints. There are fundamentally three subdomains, i.e., cloud, edge, and fog computational paradigms that exist in brain-computer interfaces. Information can be stored and transmitted whenever required from the cloud data center. These Internet-enabled features untangle the optimum usage of physical IoT devices. Along with the immense benefits in the context of contemporary digital transformations, cloud data servers, and data centers may suffer from certain issues in terms of constricted bandwidth, latency, and cost [15].

1.1 Motivations

We depict that the cloud, edge, and fog computing paradigms flop principally to convey the Internet-free computing prototypes [2, 3], near-optimal scalable explanations, and reliable service concerns [14, 16]. To avoid these restraints in the conservative cloud, fog, and edge computing archetypes, the integrated or disseminated information storage is desirable to specify copious facilities to those who are availing the services, where the expedients will be within the Internet-dependent zone may be active or inactive genre [7, 10]. Hence, in the progressive mobile edge computing framework [11, 13, 15], the authors projected an emerging computational and session-based data repository platform, titled dew computing [4, 7]. The dew takes care of the existing peripherals in a collective network, although the surroundings are somehow Internet dependent [2, 3]. By adopting dew computing, diverged set of services, for example, distributed networks are strictly dependent on locations, facilities dependent on information dissemination, network latency, and cyber-physical combined interfaces, which are mostly decentralized and aid energy-efficient protocols [5, 8–10]. The projected dew-induced sustainable IoT paradigm also sets provisions in smart information sensing and confined data analytics [10, 11]. The incorporation of information sensing arrangements and widespread computing Intra-network-based apparatus occasioned the sustainable Internet of Things (IoT) advancement [10]. The sustainable IoT devices and paradigms are assiduous which specify voluminous applications and put together massive data volumes [12]. We can claim that dew computing is not a surrogate paradigm for depicting influences on the sustainable IoT, rather this newly emerged computing schema is an expanded augmentation over the conventional schemas of information processing and system evaluations.

1.2 Chapter Contributions

The significant contributions of DewMetrics are mentioned in the following:

(a) We depict a systematized study on the potential Dew computing framework aiming toward sustainable IoT applications.
(b) We attempt to focus on unfolding the concept of dew computing by illustrating the background infrastructures, system architectures, and a set of potential application areas where the minimized Internet-dependent schemas are significant enough.
(c) We discuss the agglomerative real-time case studies, such as the cache computing framework for the dew devices, the reduced Internet dependency-induced decision-making processes, the crises, and the humanitarian Internet of Music Things.
(d) This chapter provides a deep insight into upcoming tools and technologies which can be incorporated with the traditional dew computing archetype to acquire supplementary efficiency in the Internet-dependent distributed prototypes.

1.3 Chapter Organization

We organize the remaining DewMetrics chapter as follows: Sect. 2 presents the potential state-of-the-art on dew computing architectures, systems, and applications. We illustrate the summarized outline of dew computing in Sect. 3. We demonstrate a Dew Computing-induced prototype in Dealing with Crisis Situations in Sect. 4 along with the crisis management through the dew-cloud architecture. We explain a procedural schema in the context of reduced Internet-dependency-aware consumer decision-making procedures in Sect. 5. Dew computing-inspired Computational finance outline is presented in Sect. 6. We additionally propose a systematic summary to define Dew Computing paradigms for Quantum Machine Learning and Quantum Cryptography in Sect. 7. We append the influence of Dew computing in the congregating paradigms of Computational musicology and sustainable Internet of Things in Sect. 8. We discuss several topics of interest in Sect. 9 which have significant applicability in the dew-driven sustainable Internet of Things paradigms. Eventually, we conclude the chapter with the concluding remarks in Sect. 10.

2 Related Works

As we have highlighted Dew Computing is relatively a new post-cloud computing paradigm that was introduced in 2015. While the conventional cloud computing framework utilizes centralized servers for providing numerous services, dew computing utilizes on-premises computational devices to provide decentralized, contemporary cloud-friendly, and collaborative services to the end-users.

Researchers have illustrated a set of dew-induced system architectures for providing distributed and collaborative services and application domains.

In the paper [1], the authors have demonstrated the concept of newly emerged dew computing, the significant dew computing paradigms, and a set of future research challenges. Researchers projected dew computing as the ubiquitous and permeating computational framework to enable secretive networks to depict processed sensor data orchestration [2, 3]. Working principles, methodologies, large application paradigms, and a set of future research scopes had also been outlined in [2, 4]. Taxonomical representation has been depicted in the dew computing context that can be a significant component for the dew-cloud-induced future research direction [2, 3, 16, 17]. Authors have projected three diverged schemas where the future IoT applications may proceed for real-time data analytics [3], such as the multi-operations, cloud-centered IoT information processing, and contextual dew computing framework [6, 9, 16, 17]. Researchers have also depicted that service models, such as SaaS and SaaP can be associated with the dew-based framework [7]. Key advantages and limitations had additionally been outlined. Moreover, in [12] a schematic demonstration of web surfing has been presented when the Internet connectivity is lost or inactive which is a challenging real-time application scenario of dew computing. In [8], the preliminary demonstration of hierarchical connexions has been framed among the conventional computational artifacts, such as the cloud, fog, and dew, where they have proposed that the dew computing layer can be set up as the ground-level tier of edge, fog, and cloud computing hierarchy.

In [14] Information privacy-related concern has been represented in the accessible dew-cloud design. A cloud computing-inspired multi-agent scenario has been executed for postulating healthcare services using neural networks where the custom-made web resource has been acquired to shrink the access to large data volume to be processed through the cloud [8]. An illustration of the dew computing paradigm for cyber-physical systems has been introduced in [5] that encompasses autonomous systems for collaboration and exchanging system information. In [18], a dew-induced trace-driven validated framework has been projected to quicken resource management. The researchers have framed an efficient resource allocation paradigm to assign time-astute tasks by the appropriate allotment of Virtual Machines [16, 17]. Moreover, they have anticipated a comprehensive task distribution order among cloud-dew-edge-fog computation archives by evaluating performance time, transmission and service latency, and network usage. Authors proposed a paradigm in [19], titled, DC-Health, an emerging dew computing-enabled sustainable IoT healthcare solution for decisions with offline and ultra-low latency. The projected endeavor incorporates several healthcare peripherals and is provisioned in user-specific domains even when Internet connectivity is not active [20]. In the recent research contributions [21], the researchers have presented profound insight into machine learning-inspired diverge archetypes for detecting intrusion in edge-induced IoT networks. Paper [22] depicted the query optimization on graph database in a dew-cloud environment along with the performance metrics in terms of memory usage and execution time. Articles [23, 24] illustrate a set of future research challenges and projected solutions in the domains of next-generation IoT-driven fog computing and analytics. In [25], the researchers have proposed to allocate tasks in Dew computing paradigms using an artificial intelligent agent, named, Proximal Policy Optimization that acquires tasks in the simulated Dew ecosystem. The hierarchical artifact of cloud-fog-dew has been presented in [26] to overwhelm the restrictions of cloud computing in the real-time application environment, such as latency and resource management. They have verified the projected model using Non-dominated Sorting Genetic Algorithm II for analyzing the system scalability and a Mixed Integer Non-Linear Programming model for scheduling the real-time applications to lessen Internet data traffic and power dissipation. [27] demonstrates an archetype, titled as MedGini, which generates effective utilization of IoT and cloud-dew framework for monitoring a sustainable healthcare paradigm. They have used Wireless sensor nodes to monitor the dynamic bio-signals, the Gini index, and Shannon entropy for ensuring intelligent information synchronization in the cloud along with the evaluations of the cost and power consumption of the system. Mental health monitoring schema has been represented in [28] which was powered by a Lightweight Convolutional Neural Network. Demonstrations on the attack framework and required security characteristics for the dew computing paradigm have been presented in [29]. The authors have illustrated client–server security schemes and identified two specific criteria such as security point and key agreement protocols. The authors of the [30] have addressed the security issues, a reciprocated authentication framework for dew computing, which certifies authorized and secured session formation deprived of the necessity of a reliable server. Authors have implemented dew computing in cyber-physical systems that tolerate core appliances and smart peripherals which involved in information communication in the surroundings [31]. Their projected study aims at the demonstration of architecture to apply cyber-physical system-induced dew computing for setting up new characteristics and peripheral services and compared with additionally comparable system architectures. The chapter [32] illustrates an AI-induced self-monitoring potential healthcare application in edge and dew computing. He elaborated a use-case schema for serving as an AI-based cardiologist for the end-user expending a smart device and an electrocardiogram sensor along with the future challenges, advantages, and limitations of the proposed paradigm. A precise review of the blockchain implementations in cyber security perception and energy information protections of smart grids has been illustrated in [33] with the depiction of the key security issues of smart grid environments with big data and blockchain. In paper [34], a content-based Dew-Cloud-inspired framework has been modeled for enabling a hierarchical federated learning approach and to provide a higher level of data privacy with significant availability of Internet of Medical Things critical scenarios. Authors have depicted a blockchain and dew computing-inspired converged framework for the smart city application with the evaluations of performance metrics of the proposed model [35]. The researchers in [36] have highlighted the lacking of Saurabh et al.'s strategy in the context of forward security and user anonymity and introduced an authenticated key agreement (AKA) protocol, titled e-SMDAS. Researchers have stated that there are numerous solutions offered to enhance system performance in Cloud healthcare computing domains, such as Edge, Fog, Mist, and Dew computing [37]. The proposed article studied Fog computing schema, its benefits, and qualitative system architecture. Authors [38] presented an emerging distributed edge framework pointing to analyzing and storing the Internet of Things [39] and multimedia information in modern application scenarios. A systematized case study on healthcare cyber-physical systems has been illustrated along with the characteristics, the task of diverged technologies, and the implementation of cyber-physical medication Paradigms [40]. Researchers have discussed a dew-induced and blockchain-inspired Internet of Things, termed BCoT, that shows the convergence phenomena in the reformation of Industry 5.0 along with some typical future research challenges of industrial IoT applications [41]. In [42], the contribution illustrates a comprehensive study to realize scalable Blockchain storage systems for dealing with the ambiguity among the redundancy and decentralization characteristics, based on scalable Blockchain storage systems (SMBSS).

3 Dew Computing: The Infrastructure Outline

With the increase of end-users and readily available computing devices such as mobile, portable laptops, tablets, etc., dew computing has become a very useful technique to balance the load sharing between the end-user and the cloud. Most of the current services such as mobile apps, google documents, presentations, GitHub, and YouTube videos are on the cloud and users need steady Internet connections to access these services which might increase the load over the Internet which in turn leads to network congestion and the need for more bandwidth. However, there are many places where data and service availability, network latency, and throughput quality are limited and restricted [43]. Regions affected by natural calamities or disasters might face Internet loss and loss of other dedicated connectivity like GSM, PSN, etc. for a prolonged duration [44]. Dew computing architecture can be an alternative in certain situations where establishing direct communication to the cloud is improbable.

By the definition, Dew computing depends on two basic entities: Independence and collaboration. Independence relates to the mutually exclusive service to every user. Collaboration indicates synchronization to local and remote data. This computing includes six fundamental features Rule-based Data Collection, Synchronization, Scalability, Re-origination, Transparency, and Any Time Any How Accessibility. The model includes predefined policies to save end-users' data to its database which is addressed in Rule-based Data Collection. Synchronization deals with the organization of local and distributed data with integrity. The data stored needs to be minimum taking the mobile users into account and that is addressed by scalability. The data loss policy is managed by Re-origination. Dew transparency deals with data replication and distribution. Lastly and most importantly, the service should be available to everyone with or without the Internet which is tackled by Any Time Any How Accessibility. These methods will decrease the dependency on the cloud as well as reduce the load over the Internet connectivity. As of now, there are seven service models available in the literature [4, 5].

Infrastructure-as-dew (IAD) [7] demands that the end-user is supported by cloud services either by Dew virtual machines or by saving the data and setting the service from the local device to the cloud. The advantage of such a system is that data and devices will be completely independent of each other. If the device is damaged, another new device can take the place of the old device and the user just needs to log in to its account where all possible data can be accessed. Nowadays many mobile companies are providing such services. Web in Dew (WiD) [12] is a dew computing category where end-user hardware contains a fraction of duplicated or modified world wide web depending on their frequent usage or important service category. Since it is available locally, without an Internet connection also, the information can be browsed as per capacity. Since this is the exact copy of the original one, it satisfies the collaborative property too. Software in Dew (SiD) [45] is a dew computing category where the end-user owns a certain piece of software in his/her local devices. Additional information or portions of the application can be acquired as per requirement and further downloaded or real-time data transfer-based communications also can be possible. The best examples are the iPhone app store and google play store. For certain applications, a set of information is available offline (saved maps, train time table or standard non-dynamic fare charts of buses, trains, etc.), while the app goes online, additional activities can be done (e.g., downloading the further portion of the maps, know the current running status of trains, book tickets). Platform in Dew (PiD) [46] is a dew computing category where development and operational software are installed in the end user's hardware; the setting and application data are dynamically synchronized as per available connection. GitHub qualifies for such a service. Storage in Dew (STiD) [47] is a dew computing category where the stored data in end-user hardware is duplicated in the cloud service and get updated automatically. A common existing STiD service is Dropbox. The files/folders in Dropbox are available to users at any time with or without the Internet. Hence, it satisfies the independence feature. Moreover, these files/folders are automatically synchronized with cloud services when the Internet is available so that it satisfies the collaboration property. Database in Dew (DBiD) [48] is a dew computing category where a local database is kept which is a replication of the original cloud database. The local database can be synchronized on-roll, periodically, or dependent on an Internet connection. As discussed before, it follows both the properties of Dew computing. Data in Dew (DiD) [17] is a dew computing category where data such as email, messaging, calendaring, contact management, and scheduling are kept locally and for personal usage, and with the availability of the Internet, those are synchronized in the cloud with global sharing. The summary of the Dew service models has been depicted in Table 1.

Dew computing is distinguished by its minimal reliance on the Internet, extreme user control flexibility, and proximity to the end-user. Dew computing attempts to provide a variety of services, such as (1) densely distributed service, (2) awareness of one's location, (3) support for heterogeneity, (4) reduction of network-service latency, (5) facilitation of any time, anywhere access, and (6) quality of service that uses little energy. Infinite applications can benefit from its faultless security services, including

Table 1 Summarized representation of the essential dew computing services

Services	Illustrations
Infrastructure-as-dew (IAD)	User is supported by cloud services either by dew virtual machines or by saving the data and setting the service from the local device to the cloud
Web in dew (WiD)	End-user hardware contains a fraction of duplicated or modified local world wide web depending on their frequent usage or important service category. It won't require Internet connectivity
Software in dew (SiD)	End-user owns a certain piece of software in his/her local devices. Additional information or portions of the application can be acquired on the requirement and downloaded or real-time data transfer-based communications also can be possible
Platform in dew (PiD)	Development and operational software are installed in the end user's hardware; the setting and application data are dynamically synchronized as per the available connection
Storage in dew (STiD)	Dew computing category where the stored data in end-user hardware is duplicated in the cloud service and get updated automatically
Database in dew (DBiD)	Dew computing category where a local database is kept which is a replication of the original cloud database
Data in dew (DiD)	Dew computing category where data such as email, messaging, calendaring, contact management, and scheduling are kept locally and for personal usage, and with the availability of the Internet, those are synchronized in the cloud with global sharing

smart retail, e-healthcare, real-time data analytics, localized industrial automation, and smart sensing and actuation (Fig. 1).

With this knowledge, the importance of dew computing in distressed areas can be apprehended easily. Dew computing can be helpful for those end-users dealing with the absence or limitation of Internet connectivity. Now, the question lies in how the dew computing services, models, and architectures can be found resourceful in dealing with crisis response situations. That is, how the offline and online services of Dew computing can be utilized simultaneously in IoT devices and applications for effective data flow to retrieve real-time crisis information. In a crisis, it might be possible that (a) the Internet connectivity gets disrupted in the affected regions due to loss of communication infrastructures or (b) the connectivity might present in some small pockets. In such circumstances, the Dew computing infrastructure should be helpful in storing, processing, and analyzing the locally generated data in offline mode and sending the information periodically whenever Internet connectivity is available to the users' devices.

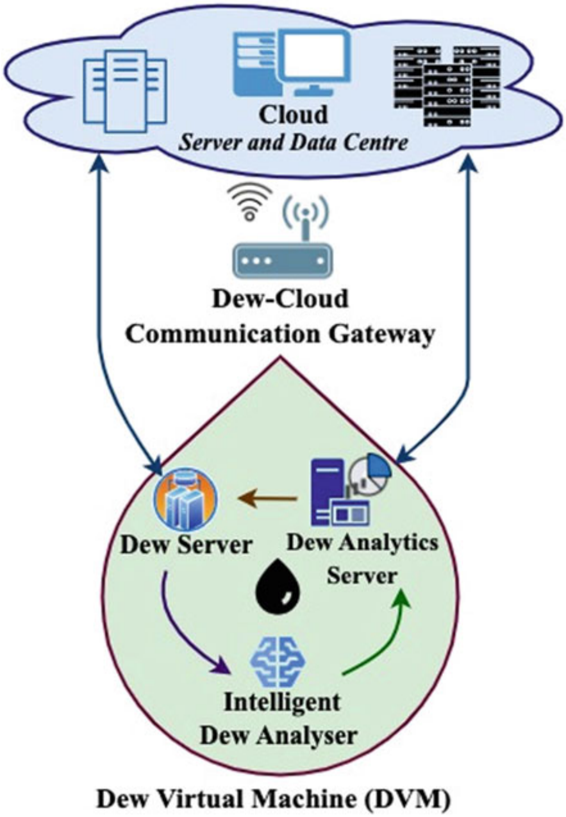

Fig. 1 Representation of the dew-cloud integration infrastructure

4 Crisis Environments and Significance of Data Flow for Response

Acquisition, analysis, and processing of the large volume of raw data germinated from various data generation platforms, i.e., Web applications, Online Social Networks [49, 50] like Twitter, WhatsApp, Facebook, etc., SMS generated in GSM services and real-time testbeds and applications (portable devices and applications used for establishing communication in opportunistic environments) for extraction of comprehensive information remain a considerable challenge. With the advent of the enormous amount of raw data generated from these data sources, different sectors (E-services, Business, Agriculture, Disaster Management, Health, Education, etc.) are currently focusing on data mining steps for extracting comprehensive knowledge from the data. From the "Crisis Management" viewpoint, one of the prime goals is to perform effective crisis response and recovery which solely relies upon real-time analysis and processing of situational data and proper dissemination of information acquired from data. The crisis management operation also involves the participation of diverse stakeholders like Government Personnel, NGOs, Rapid Action Forces, etc. consuming data from heterogeneous sources for real-time situation analysis and resource management. Therefore, the overall information and communication technology (ICT) plays a critical role in coordination among the stakeholders through a constructive flow of information [51]. Any ICT-based crisis response can be characterized in two ways (also depicted in Fig. 2): (a) Handling the data flow through deploying the hybrid Ad Hoc communication infrastructure with the help of low-cost portable devices (Smartphones, Single Board Computers, UAVs, etc.) and protocol stacks [52, 53] when the existing communication services like GSM, Internet, Satellite, etc. are limited in use and (b) Utilization of data received through news reports, press releases, social media posts (Facebook, Twitter, WhatsApp, etc.) through the Internet, emergency calls, etc. when the existing communication persists into crisis zones or regions [54, 55]. These diverse data sources contribute to real-time damage and require assessment for obtaining effectual crisis retaliation and recuperation.

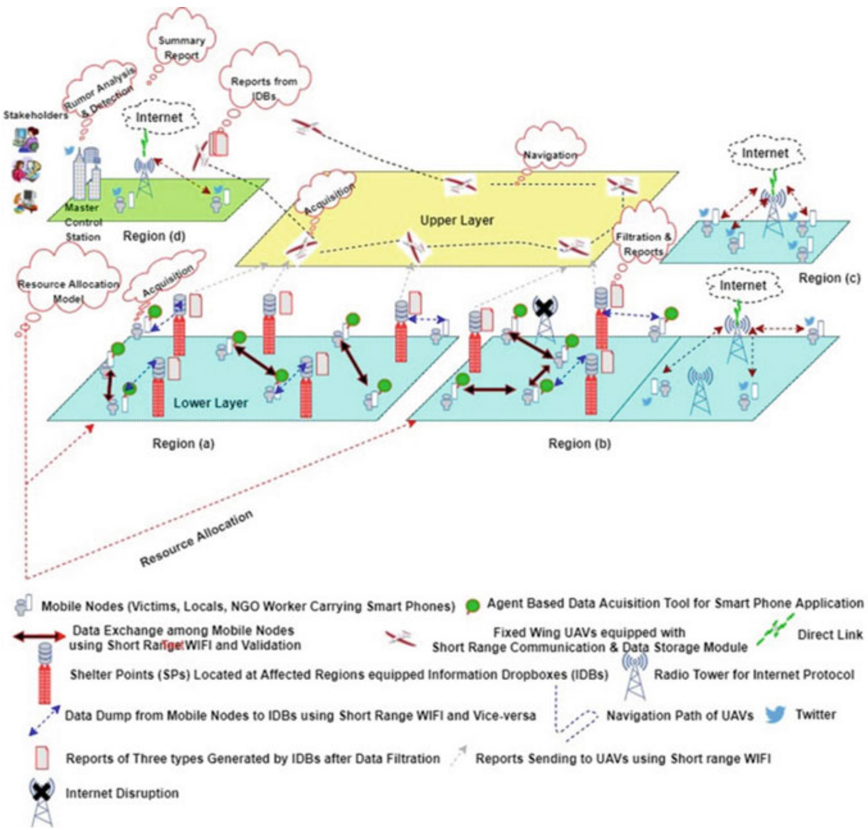

Fig. 2 Framework of data-driven ICT-based crisis management

From the above study, it can be comprehended that data dissemination sources can be multimodal and subject to the status of conventional network infrastructure in any crisis response situation. For developing overall ICT-based services, equivalent utilization of such data sources both for opportunistic and traditional network environments (i.e., GSM, Internet, etc.) is required. Depending upon the status of the crisis regions in terms of the Internet accessibility, both offline and online data sources should be made useful intermittently for real-time information extraction. Besides, through exploiting the data acquisition and mining steps, proper collection, the realization of association rules, and processing of such data are also essential for representation in a standard periodic report format that satisfies the interests regarding the "damage and needs assessment" of crisis management stakeholders. Moreover, such regular reports should also be made utilizable for designing real-time decision support tools for resource management. In Sect. 4.1, the utilization of the Dew computing component in crisis management has been discussed in greater detail.

4.1 Utilization of Dew Computing in Crisis Situations

Dew computing models can be considered ubiquitous, pervasive, and convenient ready-to-go, plug-in facilitated computing that empowers personal hybrid peer-to-peer communication links. Such networks comprise low-cost scalable devices like PC, laptops, tablets, high-end Smartphones, and software protocol stacks. The prime objective of such an arrangement is to efficiently collect, process, store, and utilize raw data in the offline communication environment. Such communication can help to run data mining applications in a distributed manner without the intervention of stable Internet connectivity. In Fig. 3, the probable generic Dew architecture has been depicted that might be helpful in establishing post-crisis communication for information flow. The Dew cloud architecture has been used in several application domains like healthcare, cyber-physical systems, air quality monitoring, disaster management, and many more. Since Dew is a newborn baby, therefore, it's yet to be applied to such real-life application domains mentioned above. Here, in this section, we specifically discuss the usage of Dew architecture for crisis mitigation.

4.2 Dew-Cloud Architecture for Crisis Management

The intermittent integration of Dew clients like wireless sensor networks (WSN), Smartphones with applications, Single board computers, etc. with dedicated cloud architecture can be considered as an ICT-based data communication and mining tool which can further augment the crisis management services. In [56], a 3D-based cloud platform has been built utilizing the wireless censored data for an effective disaster response, i.e., optimal allocation of resources like (robots, drones, firefighters, etc.).

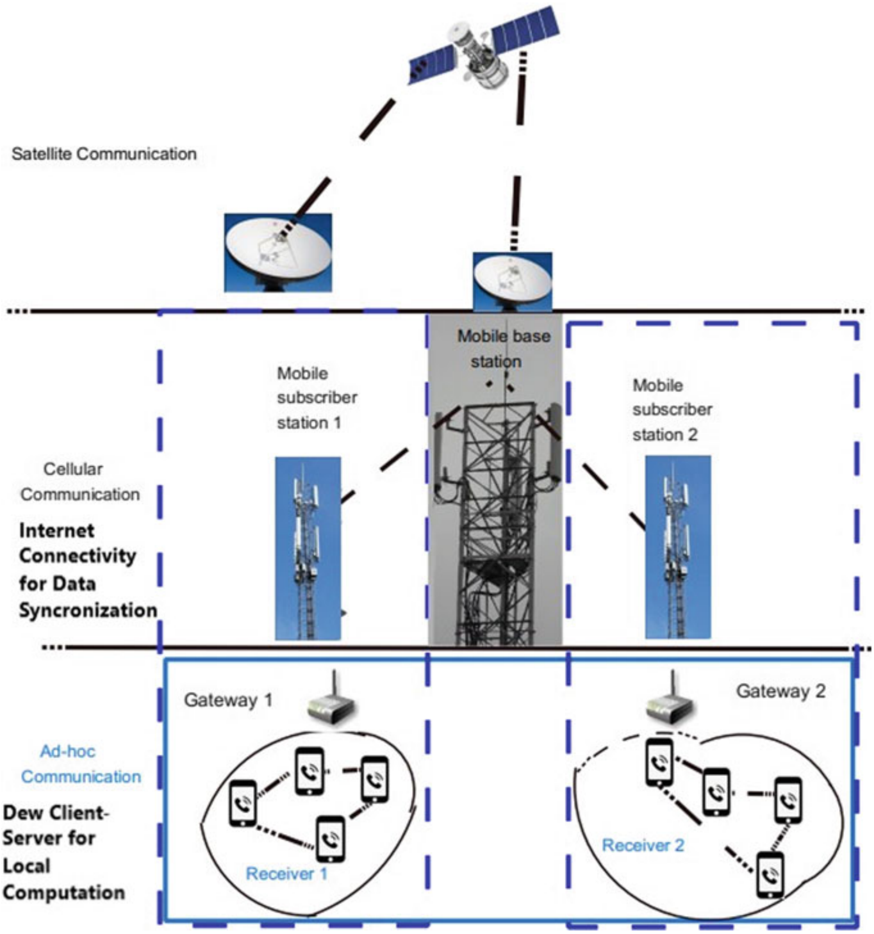

Fig. 3 Proposed dew computing-based communication architecture

The system's purpose is to be used as a training environment for a rescue team to develop various rescue plans before they are applied in real emergency situations. The proposed cloud architecture combines 3D data streaming and sensor data collection to build an efficient network infrastructure that meets the strict network latency requirements for 3D mobile disaster applications. As compared to other existing systems, the proposed system is truly complete. In [57], proposed a scheme called MGRA for the allocation of computing nodes which takes into account different issues like the users' mobility, inefficacy in resource allocation, and handling of failure situations. Experimentation was carried out using a Dew computing testbed comprising low-cost android devices connected with Wi-Fi Direct protocol. MGRA exhibited significant improvement in terms of time for application completion, amount of battery usage, and time required for recovering from failure as compared to present-day approaches.

4.3 Internet of Drone Things

UAVs can play a major role in crisis management in terms of data collection, communication establishment, surveillance, etc. These few design frameworks have been proposed for crisis management through utilizing IOT devices and drones in the past literature. In [58], a distributed architecture of clusters of UAVs and IoT devices located on the ground is proposed which will monitor various disaster management applications and do real-time surveillance. Here, each UAV has been considered as a Dew client which involves the computation of real-time route prediction, object detection, obstacle avoidance, etc. The authors in [59] proposed a Dew cloud computing framework adjoined with the UAV networks known as "DewDrone" for providing opportunistic network connectivity for smart cities, rural sectors, etc. Also, a robust disaster management framework has been considered for the design of an IoT infrastructure with UAVs to generate an Internet of drone things for establishing communication between electricity service and smart city.

4.4 Dew Robotics Applications

In [60], a cloud robotics application has been developed named Dew Robotics which allows the development of solutions that do not rely completely on the Cloud but whose computational capabilities are distributed among different devices. Dew Robotics exploits the intelligence of edge devices to change the operating conditions of our applications and adapt them to the system's status.

5 Reducing the Dependency on Internetwork During Consumer Decision-Making

From the inception to the latest, most frameworks related to consumer decision-making are fully interconnected and hugely interdependent. If any problem or frustration arises at any level, it propagates to all the consequent steps and finally hampers consumer decision-making. Especially when purchases are made on online platforms, consumers are the utmost sufferers. Internet connection loss or Internetwork-free orientation completely exhausts the information and decision-making flow of these frameworks. Although cloud computing comes with a huge opportunity for users, like universal access and scalability, some challenges are present, like all resources located remotely, far from the user's machine and control. For this, if the Internet connection goes off, all access to those resources is completely lost. This is the thrust area where dew architecture intervenes [1]. In the cloud-dew architecture, installed websites are always available to the users irrespective of

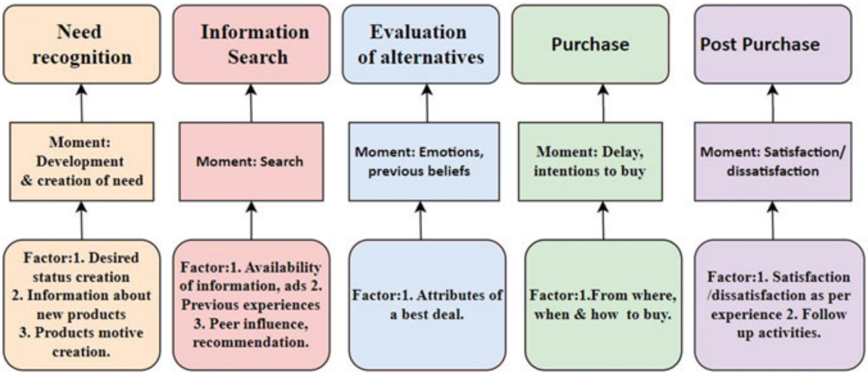

Fig. 4 Traditional framework of consumer decision-making

the Internet connection. When the Internet connection resumes, it starts synchronizing with the cloud server. In the beginning, dew computing was started as a web application [4]. Dew computing is characterized as a software organization paradigm for personal computers through this definition. Through this architecture, the local computers offer rich capability independent of the cloud services, and local computers collaborate with cloud services when the network connection resumes [5, 6]. Numerous frameworks related to consumer decision-making have been present in the literature since 1960. Most of these frameworks are also applicable to online consumer decision-making. One of the traditional online consumer decision-making frameworks has been presented in Fig. 4.

This traditional framework has been developed in [61]. There are a total of five steps present in the framework. Along with the steps, the moment and all the factors are also present. The moment is representing the thrust area of the step and the factors are broadly capturing the responsible criteria that are driving the concerned step. All the steps are interdependent and hugely dependent on the Internet while making online purchase decisions. For example, All the responsible factors for need recognition, i.e., information about new products, are mostly driven by online platforms, the social media can influence desired status creation. Next, if the information search online is satisfactory, the evaluation of alternatives will be complete. If the evaluation of the alternatives is not complete, the purchase experience will not reach a satisfactory level. Each step has a huge dependency on the network connection. Suppose the Internet connection fluctuates or becomes off frustrations of consumer increases. In such a situation, dew computing through reducing the interdependency on the Internet widens a huge scope for the users. Not only traditional or root decision-making models but also the latest or modified decision-making models have shown strong dependency on the Internet connection if the consumer purchases online. One of the latest another framework of consumer decision-making is McKinsey's dynamic model of consumer decision [62]. Figure 5 shows this framework. This framework also consists of highly interconnected steps and depends on the network connection.

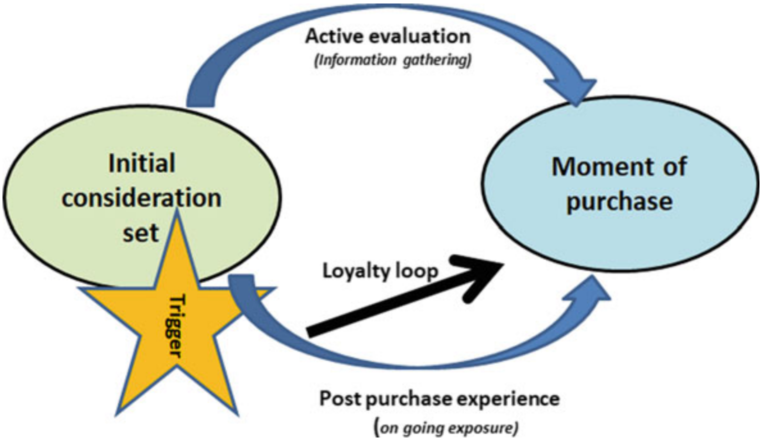

Fig. 5 McKinsey's dynamic model of the consumer decision journey

Just like the previous framework, the loss of an Internet connection creates frustrations. Here also, dew computing can be a solution through which customer loyalty can increase significantly.

5.1 Intervention of Dew Computing

There are some other areas where dew computing can enhance performance such as:

(a) The operational efficiency of retail businesses.
(b) Improvised and customized consumer experiences.
(c) Helps to determine consumer trends.
(d) Provide hassle-free consumer services to those places/retail stores where Internetwork connection is not present/disrupting.

In this regard, the advantage of dew computing can be utilized by integrating the decision-making models in the cloud-dew architecture. The interlinkage between cloud-dew architecture and consumer decision-making traditional funnel is presented in Fig. 6.

The Dew server is an essential part of the proposed framework. The server must be equipped with many adaptive technologies. The four main co-servers are Database, Mobile Information, Application, and POP/IMAP message protocols. There are some pre-installed websites present on the dew server. When a user searches some website contents, the dew server provides all the responses. Internet connection is not at all an issue. After searching, the dew server creates a dual copy of the visited website on the user's local machine. This dual copy is called Dew Site. The dew scripts generally take care of the modifications of dew sites. The supervisor of the dew scripts is called the dew analyzer. The user can access the website or modify the contents through

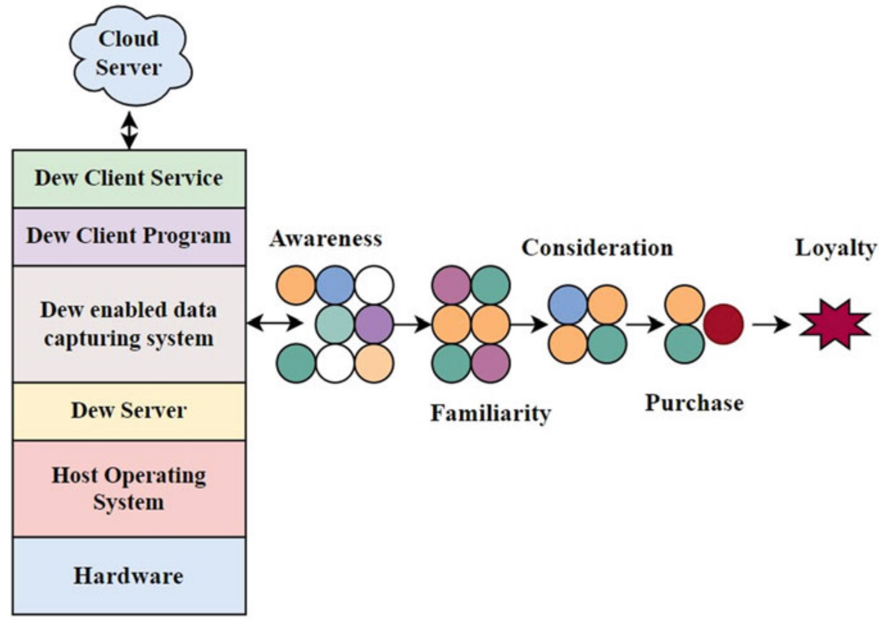

Fig. 6 Demonstration of the projected dew-assisted consumer decision-making paradigm

the dew server without any Internet presence. Once the Internet connection resumes, the dew server synchronizes with the cloud server.

6 Dew in Computational Finance Theories

The process of computational finance with the behavioral components causes complex problems. Agent-based computational finance can be defined as bottom-up approaches that use computer technology to simulate financial environments [63]. The decision-makers called agents, interact with individual rules of behavior and the trading mechanism [64]. In this model financial market is the interacting group of learning, heterogeneous and bounded-rational agents, including the financial market's efficiency and rationality, Time series data remain a curious puzzle to understand and Financial data provides a wealth of price and volume of data that can be analyzed [65]. So, several models of the Artificial Finance Markets (AFM) have increased the discussion on the research literature and problems of the models. According to [14, 15] agent-based computational finance (ACF) can be classified into three most important components such as few-type model, a dynamic model under learning, and a many-type model and its emergence. In this model, agents usually follow two base strategies called technical analysis and fundamental analysis.

In the few-type model, technical analysis follows a historical pattern and trend in data to predict future trends, in which the future replicates itself. Fundamental analysis is more complicated in determining the trends, as it determines the internal value of the securities. If the agent finds bias in its intrinsic value and the face value, then they find an opportunity to develop a path strategy [66].

A dynamic model under learning includes the generic algorithm methods [63], in which optimal risk and risk-free rate are considered to measure the overlapping of price in the exchange rate and its conversion to a single value [67].

The emergence and many-type model determines the expected value in a dynamic environment and confirms that the markets evolve into an efficient market which means price reflects on all available information.

Based on the above context we can call an agent of the financial phenomenon a fundamental/rational agent, noise agent, and technical agent to simulate or integrate the financial data in the computational process. In other words, it is a method that guides the science of complexity based on multi-agent computer simulation technology with financial theories [68]. This model indicates how market forces influence and impact stock prices.

6.1 Relational Agent's Decision Model

In finance, we believe that "investors behave rationally and they are rational agents" most of the time [69, 70]. These rational agents' are the new computational financial agent (CFA) that are evolving as autonomous interacting system agents.

The trade network game model and the computational decision in finance are broad categories in three strategic decision functions [71].

(a) First, the agent's decisions are heterogeneous in a character who interacts with other agents by initializing their initial data and the behavioral pattern, i.e., making a protocol to communicate with other traders, for trade partner search and matching or to trade interaction.
(b) Second, the agent predicts and makes the association or relationship between the price and the number of different asset classes based on the information gathered, attributes, beliefs, and preferences of the agents.
(c) Third, creating a new model of agent behavior and their interaction by gathering new information, determining trade behavior, update in investors' preferences, and modifying the fitness level.

6.2 Technical Agents

The technical agent is usually called momentum traders, they use historical market data to forecast the trend of price. They buy (sell) when the price goes up (down). They follow a simplified way of trading in technical analysis and traders follow a hard behavior [63, 72]. In this model T_i is assigned each momentum trade at the beginning of the simulated random walk model, following a normal distribution of the time-series data, which is subjected to the Markowitz portfolio model. This model also used in genetic networking programming (GNP) or the Genetic algorithm (GA) Model and the reinforcement algorithm model defined by [63].

6.3 Noise Trader/Agent

Noise agents are irrational investors who do not follow the common trading mechanism, technical analysis methods, and portfolio optimization methods. Such traders do not have access to inside information about the stock. Irrational behavior acts as noise traders with an assumption of expecting biases in stock trading [63, 73, 74]. The bias follows a normal distribution with a constant variance in their expected price.

6.4 Reinforcement Learning

Reinforcement learning is the framework or deterministic approach in financial computation that tells the agent is the software portfolio manager performing trading actions in the financial market or in the financial environment [67]. These financial comprises all financial assets and the expectations of the participants toward them. It describes how an agent can learn an optimal action policy in a sequential decision process [66]. It creates a feedback loop between the learning system and the experience gained from the environment. It treats the time t period as:

(a) The agent can take an action ($a_t \in A$).
(b) The agent obtained a reward as ($r_t \in R$) for short-run.
(c) The State becomes ($s_{(t-1)} \in S$).

Starting from using online platforms for investing to capturing financial information through system programming or mathematical formula, everything is dependent on an Internet connection. Loss or disturbance of Internet connection hampers real-time data capturing, data fetching, and transactions and creates huge dissatisfaction among investors. It increases the risk factor among the investors, which may restrict them from investing. Under such circumstances, dew computing can be an excellent solution. The dew server resides in the investor's local machine and consists of four components, such as (1) Dew Server, (2) Dew data capturing system, (3) Dew Client program, and (4) Dew Client Service Application. This server helps serve the requested service to the investors by correlating the local with the remote data. The dew server keeps track, based on the configuration of the investors or self-motivated, of all the visited websites (investment platforms) and creates a dual copy. One or multiple dew sites can be mapped with one dew server. At first, an

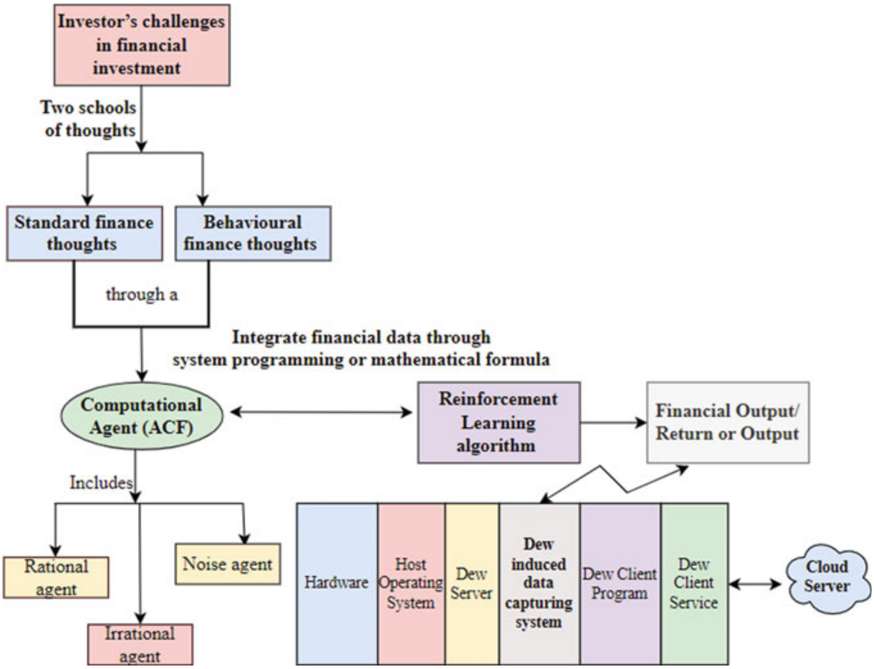

Fig. 7 Interconnection between ACF and cloud-dew architecture

investor login into a website as well as the dew site. The dew site does systematic rule-based data collection. Now if the Internet connection disrupts, the dew script analyzer starts and generates the required files. Next, an acknowledgment was sent to the dew client program and the updating of the master mapping table took place. With the resume of the Internet connection, the synchronization took place and any ordinary user can access the dew investor's data in read mode. The following flowchart presents all the interconnections between the dew-cloud architecture and agent-based computational finance (ACF). Figure 7 depicts the interconnection paradigm in the dew-cloud-assisted ACF.

7 Dew Computing Paradigms for Quantum Machine Learning and Quantum Cryptography

Machine learning and dew computing both are the most powerful emerging technologies in the present era. These technologies contribute a crucial role in the development of modern science and have advantages in their domains. But when they merge it produces a significant advantage. Machine learning algorithms are primarily used to learn and improve machines from experience. It provides the capability to the machines so that they can learn automatically without any human intervention or assistance and adjust actions according to necessity. There are different types of machine learning algorithms and many algorithms have already been developed. Most of these algorithms required a huge amount of storage to execute, which is a primary point of concern to most people. This is the place where dew computing walks in. It is the outsourcing technology, which enables us sufficient space to access applications and data remotely through Internet connectivity. Besides this, the technology has a tremendous advantage in terms of flexibility, availability, accessibility, cost-effectiveness, and so on [17, 16]. These things make this field an obvious choice for every sector. With the advancement of time machine learning algorithms are becoming more powerful and complex and demanding better computational power than every previous day. Besides this, the security of the system is also facing challenges every day. Quantum technology offers a way that the introduction of this technology can address the aforementioned issues.

7.1 Quantum Machine Learning in Dew Computing

Quantum machine learning [75] is such a domain that connects two fields machine learning and a new kind of computing device known as a Quantum Computer. This domain mainly focused to find the complex models in machine learning, which can't be calculated using classical computing methods. It also concentrates to find a way to invent and apply quantum software that enables the machine learning faster than classical computers. Machine learning is mainly used to train machines using data. To minimize the training time CPUs and GPUs are used in the classical computing method. But if the data is too large it will take a huge time to train a machine. Here quantum machine learning comes forward. It can compute multiple states at the same time. Besides this quantum machine learning uses quantum data for operation and during the processing, it follows the laws of quantum physics. For this reason, it is found that quantum machine learning algorithms can exponentially reduce the training time of a machine. It also improves the learning capacity and efficiency of a machine [76]. It is found that quantum computing devices (Quantum Computers) can produce patterns that are very difficult for classical computing devices (Classical Computers). This is another reason which shows that machine learning based on quantum computing can outperform the domain based on classical computing.

Quantum machine learning algorithms execute on quantum computing devices (Quantum Computers). This is the main challenge in this field. Because quantum computers are not fully developed yet. It is also not possible to set up these currently available quantum computers everywhere or at very frequent intervals. Because there are some serious challenges with these quantum computers. One of the major challenges is quantum computers need very low temperatures and isolation. Normal temperature and interaction with other particles cause the increment of the decoherence rate of computer qubits very fast. It will cause the loss of the quantum properties of computer qubits which will further be pointed toward the loss of data stored in the computer qubits. On the other side, rotations can affect the computer qubits, which can cause a crucial error in the circuit. Another challenge comes in this field with the development of algorithms. The development of quantum algorithms is a very critical task because, during the development, the developer has to be very concerned about the background physics. These challenges can impact quantum machine learning very deeply. Dew computing offers a partial solution to these challenges. Few quantum computers can be developed with high capacity and proper precaution. These few computers can be used from anywhere using Internet connectivity through dew computing technology. This emerging technology also offers proper resource management of accessible quantum computers.

7.2 Quantum Cryptography in Dew Computing

The security of the domain of dew computing has become a point of concern with the advancement of technology. In the classical cryptographic method, the primary drawback is that there is no way to exchange the keys with full security. It is impossible to address whether the exchanged key has been revealed or not in the journey. An asymmetric key encryption method has been introduced to solve this problem but this method also has its drawback. It is a very slow method, and it can't be applied to a large size of data. Besides this, the development of quantum technology directly challenges the modern cryptographic technique. Computes based on quantum technology can decrypt classical encryption in a limited time. For any classical modern computers, this time amount is impractical. The introduction of quantum technology in cryptography can address these problems [77, 78]. The no-cloning theorem is the fundamental concept of the quantum cryptographic technique. According to this theorem, quantum states can't be copied. Since quantum states are used in the quantum cryptographic technique so, as per the no-cloning theorem they can't be intercepted during transmission. If anyone tries to intercept information, it will be detected, and the signal will be destroyed. Quantum cryptography is not a new technique as a whole, it doesn't develop from scratch. The working principle of this cryptographic technique is similar to the classical asymmetric cryptographic system. The only difference is that a quantum Cryptographic system uses the properties of quantum physics for the transmission of key. This method is termed Quantum Key Distribution (QKD).

7.3 Quantum Key Distribution (QKD)

Quantum Key Distribution (QKD) is the central technique of quantum cryptography. This technique is used to generate and share random keys between the sender and receiver. There are different types of schemes for QKD, i.e., BB84 [79], Silberhorn, Decoy state, KMB09, E91, etc. Among these BB84 is the most commonly discussed

Table 2 Demonstration of quantum key-distribution indexes

Basis	0	1
+	↑	→
x	/	\

Table 3 Representation of quantum key-distributions

1	0	1	1	0	0	1	0	1	1	Random code
+	x	+	+	x	+	x	x	+	x	Alice's basis
→	/	→	→	/	↑	\	/	→	\	Polarized photons sent by Alice
x	x	+	x	+	+	x	+	+	+	Bob's measurement basis
\	/	→	\	→	↑	\	→	→	↑	Polarized photons measured by Bob
w	r	r	w	w	r	r	w	r	w	Classical channels discussion
	0	1			0	1		1		Final shared secret key

QKD protocol scheme. In this protocol, binary information is encoded on photons using their different properties (i.e., polarization, spin, etc.) and sent these encoded photons to the receiver.

Let Alice and Bob agree to share their secret key using QKD (BB84). At first, Alice choose any random bit as her secret key and two bases (rectilinear basis [+] and diagonal basis [x] as mentioned in Table 2) to encode the secret key. Then she encodes the secret key on photons by the preparation of the polarization state of it using the considered basis randomly. After that, she sent the encoded photons to Bob using quantum channels. As Bob does not know the sequence of encoding basis, after receiving the encoded photons he measures these photons using any random basis. After completing the measurement, Bob contacts Alice by any classical channel and discusses the sequence of his basis of measurement. Now Alice compares her basis sequence with Bob's basis sequence and discards the mismatch basis. After removing the mismatched basis, the matched basis's information formed the communication secret key between Alice and Bob (Table 3).

According to the no-cloning theorem, quantum states can't be copied. So if anyone tries to intercept the encoded photons between transmissions, then he has to measure these. As others (except Alice) don't know the basis sequence of encoding photons, when he tries to measure these photons the information in the state will be destroyed.

7.4 Application of QKD in Dew Computing

Kerberos [80, 81] is a widely used secure authentication technique in cloud computing including dew. In this technique, the Key Distribution Center (KDC) plays a significant role to provide the secure key to the user. The user uses this secure key to access the cloud server safely. Applying QKD in KDC introduces a tremendous advancement of security in this technique over the classical approach. QKD can also be used in asymmetric cryptographic systems for different applications.

8 Dew Computing in Sustainable Internet of Music Things

The usability of Information and Communications Technology in music education displays the signs of existence to provoke conventional music teaching and learning strategies. This projected contribution will assert the advancement of new conceptions of music teaching–learning, music composition, and reconstruction paradigms through the application's congenital applications to the Information and Communication framework. The device-oriented music composition and reconstruction in the Internet-dominant era is usually participant-specific musical information recognition and analytical strategies which incorporates the devices, i.e., the mobile phones, sound sensor devices, and the Cloud-Dew-Edge-Fog (CDEF) peripherals. These smart devices intensify the succession of the Internet of Things (IoT), largely, the Internet of Everything (IoE), where they sense the information from the environment in a collective concern as end-users require. Data sensing through sensors, framing, information retrieval, and dispensation accomplish a significant benefaction on the IoT network. The projected contribution will analyze a set of fruitful music reconstruction and composition applications in the IoT context, which we titled the "Internet of Music Things (IoMT)". The proposed framework will illustrate that the involved individuals who will have the information sensing devices, will be qualified for musical data sensing and composition tasks, which may be shareable for experience within the group and recoup the required information for advanced music analytics and reconstruction operations of common attentiveness. The Internet of Things is a propitious framework that amalgamates the plethora of diversified computational gadgets, assimilating the crowd, substructures, supplementary system ingredients, and organizational structures.

8.1 System Outline: Dew-Induced Internet of Music Things

We demonstrate the system outline of the Dew-induced IoMT into two distinct subsections. The outline of the anticipated architecture is presented in subsection 8.1.1. We depict the modeling assumptions in the Sect. 8.1.2 of estimated dew-induced schema for efficient IoMT.

8.1.1 The System Architecture

This subsection deals with a five-layered ordered dew-induced IoMT schema. Figure 8 consists of five assorted layers, (a) Data Sensing layer, (b) Dew computing layer, (c) Edge computing layer, (d) cloud computing layer, and (e) Application layer. Distinct layers of the projected and ordered framework are illustrated in the following:

(a) Data Sensing Layer: The data sensing layer is the lowermost layer of the provided dew-induced IoMT archetype. This layer comprises numerous virtual segments that embrace the music sources and physical sound sensors. Sound sensing peripherals are capable to sense and accumulate the unprocessed and pre-processed musical data from the musical environments [15]. The data sensing layer also comprises the connected and active microcontrollers for communicating with the associated computing systems and additional microcontrollers to sense the information transmission.
(b) Dew computing Layer: The dew computing layer accumulates the ordinary sound sources, physical peripherals, sensors, and connected microcontrollers. It involves the agglomerative and virtual dew clusters. Dew clusters comprise a minimum of three crucial components, such as the (i) dew server, which enables interactions with upper layered computing devices and sporadic synchronization of information; (ii) dew analyzer amasses the sensor information and explores local computations; (iii) dew storage stores pre-processed sensor data for Internet-independent settings [10].
(c) Edge computing Layer: Proposed system transmits the pre-processed sensor information to the immediate next layer from the dew layer when the Internet connectivity is ON. This layer is titled the edge computing layer. Modules of this layer are the decision-making edge instances, that consist of computing tools, storage, and edge-cloud communication gateways [10]. The available devices are proficient for information evaluations, processed information accumulation, and information transmission to the higher layer. It additionally contains the communication networks for interacting within themselves and/or among edge and cloud computing layers.
(d) Cloud computing layer: The adjacent next to the edge layer in the projected architecture hierarchy in Fig. 8, the cloud computing layer encompasses data centers and essential services. This layer necessitates music resource managing and handling musical compositional activities for the level of data aggregation assignments. It comprises cloud resources dealing with the competencies of predetermination and authorized service excellence of edge computing implementations.
(e) Application Layer: The uppermost layer in the proposed dew-music architecture approaches the processed musical presentations from the cloud data center. End-users in the application layer are efficient in assembling musical compositions, combinations, and reconstruction assignments as the audiences prefer. Eventually, the uppermost layer of the hierarchy grasps the user-requester performances

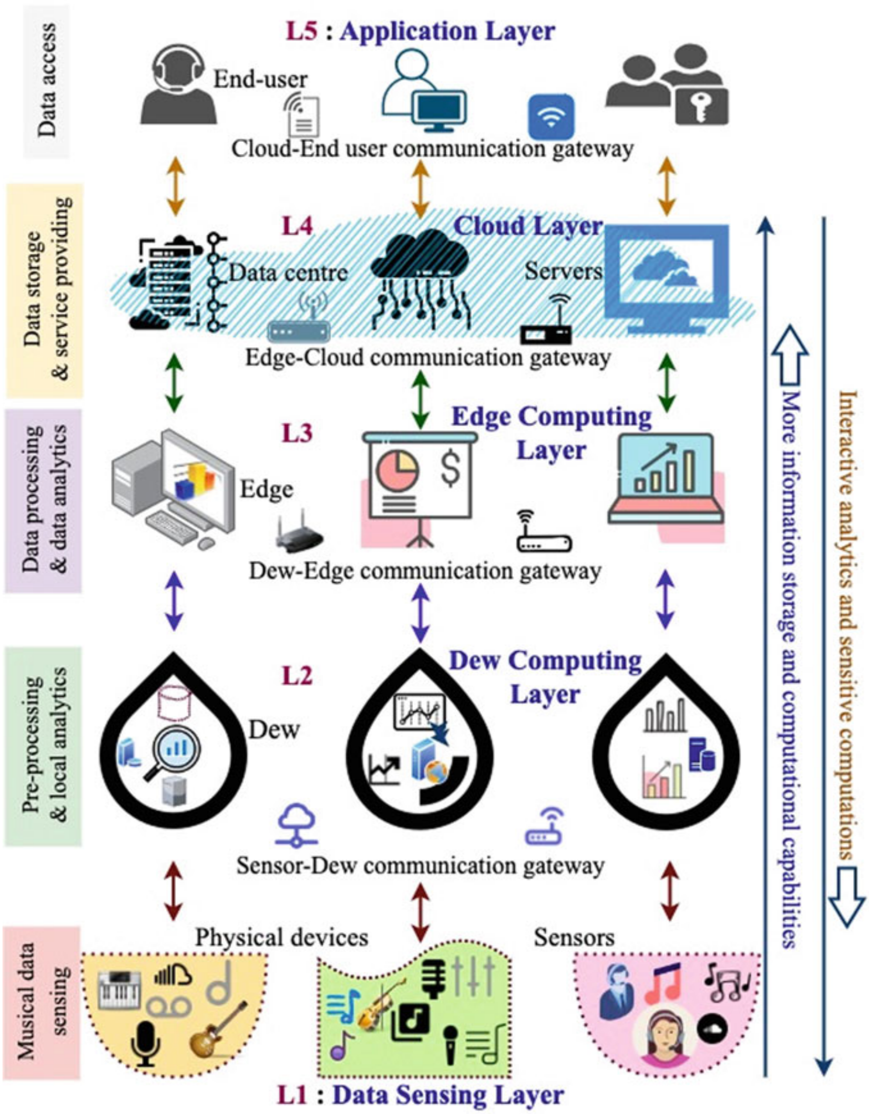

Fig. 8 Representation of the anticipated dew-induced sustainable internet of music things schema

that effects the dew-cloud-based musical information approachability to convey inventive and smart music arrangements of the music auditors and the composers as well.

8.1.2 System Assumptions for Dew-Driven IoMT Schema

We are to depict numerous methodical assumptions centered on the real-time dew-cloud computing consequence. We denote the useful hypotheses over the projected scheme state-of-the-art in the following:

(a) We categorize all peripherals and nodes in the data sensing layer into two all-inclusive segments: the sources of music pieces and partaken in sound sensing equipment.
(b) We assume the musical performances as the sound repository in our projected endeavor and a set of vocal and instrumental music enactments. We also undertake that all information demands pre-processing.
(c) Sensing peripherals are smart gadgets and real-time sound sensors that appreciate optimal pre-processed and unprocessed information. We additionally assume that sensors are positioned in outright Geospatial locations.
(d) In Dew peripherals assemble the sensor information as the restricted sources to evaluate the locale and when the Internet connectivity status is inactive.
(e) Edge computing gadgets are disseminated in a tier within a distributed network to accomplish computational assignments based on the crowdsourcing policy.
(f) Cloud server represents the accumulated music analyzer in which the information summarization and storage of managed information-allied undertakings are achieved.
(g) The end-users in the application layer are authenticated in accessing information from the cloud data center. The users, music composers, and audience are capable to approach public data centers for music information retrieval, qualitative music composition, and reconstruction of the music pieces.

8.2 Connection Strategies for Scheming an Efficient Dew Computing Framework for IoMT

As we discussed earlier, musical information is diffused to associated computational devices with the assistance of a cloud server. The networks can be overcrowded and integrated peripherals may be overburdened owing to viscous bottlenecks. To reduce, the transmission-related latency and to enhance the performance, information is scattered to the cloud server as well as the edge devices. Dew computing conglomerates the underlying perception of the cloud and edge computing, which feeds access to the cloud data, and sustains duplicates on the local repositories. This suggestive schema in the anticipated framework is essentially contingent upon diminishing the duration of data transmission, latency, system power dissipation, and energy depletion. We assume the projected system can be Quality of Service (QoS) and Quality of Experience (QoE), evaluating dual-fold aspects: (a) Reduce the response time of the system, lessen the information transportation time within intermediate computing nodes, and shrink system the service latency that can make a system energy-efficient; and (b) Minimize the intermediate gaps between the sensor devices to the active dew nodes, dew nodes to the adjacent edge, and integrated edge to the cloud data center, that may correspondingly expose toward developing an effective dew-induced IoMT framework.

9 Topics of Interest: Application Domains and Future Research Challenges of Dew Computing-Assisted Sustainable Internet of Things

We illustrate numerous application domains of the Dew Computing in the Sustainable IoT perspectives in the following, although the projected dew computing paradigm can conceptually be depicted in the contexts of large-scale human-centric Internet of Things application domains.

9.1 The Dew-Assisted IoT in Computational Musicology

The research in the context of computational musicology is typically an interdisciplinary research area where systematic analytics, information representation, and humanized creation interact. The technological advancements draw on and significantly contribute to our understanding, perceptions, and visions of the physics and psychophysics of sound. Computational Musicology is always an interdisciplinary or to some extent, a multidisciplinary domain for methodical music analysis, musical patterns identification, and humanized musical information retrieval which is a comprehensive amalgamation of Person Intelligence (PI), Artificial Intelligence (AI), typical programming languages, algorithms, representation learning; additionally, the psychology, music theory, acoustics, signal processing, multimedia information systems, engineering, physics, performance practice, library science, applied mathematics, statistics, and so forth. Systematized technology is perpetually confounding and altering the landscape of human beings' musical experiences as music creators, participants, music listeners, and consumers. Music theorists, musicologists, vocal and instrumental performers, and music composers are habitually meeting with real-world challenges as musical compositions are largely dependent on human perceptions. Apart from the conventional methodologies to retrieve elementary musical components, we apply heuristic and representation learning approaches to recognize or extract the higher level musical features from symbolic musical information, intending to automate or expedite real-world musical tasks, in terms of music generation, composition, and substantial music reconstruction. In the remote and scattered musical performances concern, the dew-assisted IoMT framework can be significant enough to compose specific and smart musical compositions without much-reliant on Internetwork connectivity. Projected phenomena will additionally illustrate the major implications for the music teaching–learning and composition in the subordinate smart classroom with IoT, inclusive of the significance of rigorous proposition, crowd inclusion, paradigms of learning objectives, methodical and pervasive music learning, evaluation, and system integration.

9.2 Dew Computing in Sustainable Internet of Music Things

In the dew-music computational paradigm, future endeavors can be involved in: (a) the illustration of participatory crowdsensing in CDEF framework (b) bandwidth allotment; (c) service and resource virtualization in Internet of Sounds; (d) Performance metrics in low-resource settings.

9.3 Sustainable and Humanized Internet of Music Things

In the contexts of the humanistic-care inspired IoMT schema, we may highlight the following scopes for the further researches, as (a) Dew-driven music crowdsourcing architecture, and (b) modeling of dew-assisted humanized music information fusion.

9.4 Dew-Osmosis: Convergence of Dew and Osmotic Computing in Human-Centric IoT

It is a promising Internet-independent technology, which requires demonstrating parallel and distributed computing over the heterogeneous network. The integration framework of dew and osmotic computing in the context of the Internet of Music Things (IoMT) can be illustrated for framing heterogeneous musical data migration within a dynamic and distributed infrastructure. This work aims to intellectualize, how audiences can be benefited from the osmotic computing-based dew-induced IoMT system analytics. The scope of the future research of the projected Dew-Osmosis computational paradigm may be (a) illustration of participatory and opportunistic crowdsensing and crowdsourcing perceptions, (b) energy-efficient dew-inspired osmotic computing paradigm, (c) performance visualization and virtualized service monitoring for IoT applications, (d) cluster computing in the context of heterogeneous and distributed systems, and (e) dew-osmotic convergence architecture for Industrial IoT (IIoT) applications.

9.5 Communication and Computational Intelligence in Dew-Assisted IoT

Computational intelligence assessments, correctness, and meticulousness at distinct layers in IoT paradigms are verbalized by computational intelligence strategies, which are capable of data collection, the interconnection among the devices and Internet, data processing, intelligent analytics, and decision-making, exclusive of direct human interactions with the systems.

9.6 Cloud-Dew-Edge-Fog (CDEF) and Sustainable Internet of Musical Things: The Convergence

The traditional cloud computing paradigm along with the extended performance-driven computational strategies such as the dew, edge, and fog computing frameworks provide the efficient and smart mechanisms of musical compositions in the domain of the (a) Remote musical performance control and organization, (b) Remote Recording environment, (c) Auto-tuning of the smart musical instruments and Remote Live Mixing, (d) Generative Music and Algorithmic Composition within the shared network.

9.7 Dew-Assisted Big Data Analytics and Industrial Automation

The Network infrastructure in the age of Big data, Industry 4.0, sustainable IoT, and Artificial Intelligence enhance the restrictions of information availability, system scalability, strategic reliability, optimum bandwidth, and less latency. This stemmed from an emerging schema of cloud computing offering centralized information storage, efficient resource balancing, and software-based consequences promoted in the as-a-Service policy. Conversely, there are still a lot of QoS-aware use cases, such as sufficient information and service availability, network delay, jitter, and throughput requirements to be additionally addressed. Limited outcomes to these challenges are solved by the Fog and the Edge computing, offering computing and information closer to the end-user network peripherals. Although these conceptions do not optimally address the concerns of offline information availability and Inter-network latency. A hypothetical response to those challenges could be the conception of dew computing—a supplementary tier in the obtainable client–server framework, functioning on end-users devices to succeed at the optimum level of information synchronization among the data in the cloud and the local devices, that makes a system reliant in the typical Cloud-Fog-Edge schema in the context of network connectivity. Dew-assisted paradigm can address the efficient system modeling in the context of the industrial automation and big data analytics evaluated in the cloud server, with local accomplishment by lessening the network delay and affording offline information availability, specifying the significant data synchronization among the local and cloud databases.

9.8 Influence of Dew Computing on Human–Computer Interaction

Human–Computer Interaction is the key finding procedure of interactions of human beings with computing systems, specifically, as it communicates the technological innovations. The User-centered design, UI, and UX are coalesced with the Human–Computer Interaction to afford the intuitive technology and outcome. Human–Computer Interaction analysts reflect on how to establish and adopt computing systems that can provide satisfactory products to human beings. Nowadays, when we are majorly dependent on the Internet, human-centric applications and outcomes should be offered to the end-users without much interruptions of the Internetwork, and hence, the expected outcome can be achieved shortly. In this scenario, the projected dew computing schema can play a significant role to provide services and to maintain the Quality of Experience.

9.9 Integration of Dew and Affective Computing

Recently, affective computing has acquired admiration and has been harnessed extensively in numerous domains, including marketing, e-learning management, financial and economic behaviors, smart healthcare, assistive tools, and human–machine interface design. Artificial Intelligence plays a pivotal role in the context of designing affective computing schemas and is mainly utilized for decision-making systems. Advancements in artificial intelligence, CDEF, and IoT research have empowered researchers to articulate cost-efficient and robust tools for a diversity of application scenarios. Specifically, the arrival of the machine, deep, and representation learning strategies have crafted it feasible to implement proficient effective computing artifacts for potential healthcare, humanitarian, agricultural, and additional sustainable applications.

9.9.1 Dew-Assisted Sonification in Internet of Humanitarian Things

Sonification refers to the utility of non-speech audio to put across information or perceptualized data. To date, the researchers have carried out a few findings on the applicability of the Internet of Things (IoT) paradigm to the context of interactive sonification. IoT has the promise of facilitating the emergence of emerging outlines of interactive sonification which are the outcome of the shared expertise of interactive sonification artifact by both the presenters performing gestures locally within the infrastructure and with the set of remote users. The dew-assisted interactive sonification in the IoT context may have a large impact on smart healthcare and the Internet of Medical Things. Researchers can additionally utilize the interactive sonification in the Internet of Behaviors, Internet of Sounds, and Internet of Music Things which can be remotely controlled and can be capable to sense the analyzing data based on the implementation requirements.

9.9.2 Dew-Inspired Tactile Internet of Things

One of the foremost Tactile Internet applications is the sustainable Tactile Internet of Things (IoT) which enables human beings to control the desired systems remotely and construct a new-fangled generation of cyber-physical systems, with the significant assistance of haptic technologies. The future research challenges of the dew-inspired Tactile Internet of Things can be the (a) Remote Presence: The interactions of Human-Agent to Human-Agent in the contexts of virtual and augmented reality, (b) Telerobotics: the interactions from Human-Agent to the Working Robot, (c) Remote Robotics: The task flows from a Human-Agent to the Robot-Agent, (d) Extended Reality: A potential task transformation from the Human-Agent to the Virtual Agent.

9.9.3 Cloud-Dew-Edge-Fog-Roof (CDEFR) Computing Strategies for Internet of Risky Things

Along with the traditional computing paradigms, such as cloud, edge, and fog computing, new-age computing technologies like the dew and roof have been introduced to enhance the service providing schemas in IoT applications. If dew computing highlights (a) lessening the network latency, (b) affording offline data availability, and (c) specifying qualitative data synchronization between the local and cloud databases, simultaneously the roof computing emphasizes as an emerging federated computing and networking schema to operate the constrained tools in IoT which offers (i) connectivity, (ii) context assembling, (iii) data and service management, and (iv) majorly the issues of security and privacy.

Conventional IoT conveys computerization and connectivity to billions of performing devices worldwide. We are concerning vehicles, drones, healthcare systems, smart homes, and smart cities. Although the major threats in these disciplines are attacks, the security on the Internet significantly relies on the security of Internet-assisted devices. By specifying visibility in real-time systems and at the granular level, the research challenges should be (a) to securely connect Inter-networks the authorized “risky” IoT devices and (b) to recognize and retort to all vulnerability topics, which can cause when the unauthorized and “risky” devices for communicating through the cache-driven network.

10 Conclusions

In this chapter, we have illustrated a personalized dew-cloud-based sustainable Internet of Things framework. The dew computing schema enables contextual collaboration between the local computing resources and the contemporary cloud infrastructures. The local analyzers stipulate the essential data transmission and analytics functionalities being independent of the integrated Internetwork when in offline mode, synchronize the processes automatically, and update the modifications performed during offline mode with the cloud when the Internet connectivity is restored. This chapter depicts a set of dew-supported diverged IoT and consumer behaviors-oriented paradigms with concepts, system architectures, and systematized service-oriented outlines. Additionally, we have discussed numerous application-oriented case studies and future research challenges in dew-assisted IoT perspectives. We have incorporated the dew computing schema into perception-driven information sensing, data synchronization, system scalability, and distributed information accessibility individualities. Likewise, the dew computing-enabled devices embrace the answerability of human–computer interactions that exist at the derived level in the projected dew-edge-cloud-based computing archetype. We can measure the dew-assisted system performance evaluations, in terms of the network latency, information transference, service, and transportation time delay, system and integrated information entropy, power dissipation, energy consumption, bandwidth allocation and service virtualization, jitter, analysis of QoS and QoE-aware system depiction, resource provisioning, secured communication outlining, scalability, and so forth.

References

1. Olabisi, D., Abubakar, S.K., Abdullahi, A.T.: Demystifying dew computing: concept, architecture and research opportunities. Int. J. Comput. Trends Technol. **70**, 39–43 (2022). https://doi.org/10.14445/22312803/IJCTT-V70I5P105
2. Ray, P.P.: An introduction to dew computing: definition, concept and implications. IEEE Access **6**, 723–737 (2018). https://doi.org/10.1109/ACCESS.2017.2775042
3. Ray, P.P.: Minimizing dependency on internetwork: is dew computing a solution? Trans. Emerg. Telecommun. Technol. (2018). https://doi.org/10.1002/ett.3496
4. Wang, Y.: Definition and categorization of dew computing. Open J. Cloud Comput. **3**, 1–7 (2016). urn:nbn:de:101:1-201705194546
5. Gushev, M.: Dew computing architecture for cyber-physical systems and IoT. Internet Things (Elsevier) (2020). https://doi.org/10.1016/j.iot.2020.100186
6. Gusev, M.: A dew computing solution for IoT streaming devices. In: Information and Communication Technology, Electronics and Microelectronics (MIPRO) , pp. 387–392. IEEE (2017). https://doi.org/10.23919/mipro.2017.7973454
7. Wang, Y., LeBlanc, D.: Integrating SaaS and SaaP with dew computing. In: IEEE International Conferences on Big Data and Cloud Computing (BDCloud), pp. 590–594 (2016). https://doi.org/10.1109/bdcloud-socialcom-sustaincom.2016.92
8. Axak, N., Rosinskiy, D., Barkovska, O., Novoseltsev, I.: Cloud-fog-dew architecture for personalized service-oriented systems. In: 9th International Conference on Dependable Systems,

Services and Technologies (DESSERT), pp. 78–82. IEEE (2018). https://doi.org/10.1109/dessert.2018.8409103
9. Frincu, M.: Architecting a hybrid cross layer dew-fog-cloud stack for future data-driven cyber-physical systems. In: Information and Communication Technology, Electronics and Microelectronics (MIPRO) , pp. 399–403. IEEE (2017). https://doi.org/10.23919/mipro.2017.7973456
10. Roy, S., Sarkar, D., De, D.: DewMusic: crowdsourcing-based internet of music things in dew computing paradigm. J. Ambient. Intell. Humaniz. Comput. **12**, 2103–2119 (2021). https://doi.org/10.1007/s12652-020-02309-z
11. Roy, S., Mukherjee, A., De, D.: IoHMT: a probabilistic event-sensitive music analytics framework for low resource internet of humanitarian musical things. Innov. Syst. Softw. Eng. **1–24**,(2022). https://doi.org/10.1007/s11334-022-00499-7
12. Wang, Y., Skala, K., Rindos, A., Gusev, M., Shuhui, Y., Yi, P.: Dew computing and transition of internet computing paradigms. ZTE Commun. **15**(4), 30–37 (2019). https://doi.org/10.3969/j.issn.1673-5188.2017.04.004
13. Roy, S., Sarkar, D., De, D.: Entropy-aware ambient IoT analytics on humanized music information fusion. J. Ambient Intell. Hum. Comput. **11**(1), 151–171 (2020). https://doi.org/10.1007/s12652-019-01261-x
14. Patel, H., Suthar, K.: A novel approach for securely processing information on dew sites (Dew computing) in collaboration with cloud computing: an approach toward latest research trends on Dew computing. In: Engineering (NUiCONE), pp. 1–6 (2017). https://doi.org/10.1109/nuicone.2017.8325622
15. Roy, S., Sarkar, D., Hati, S., De, D.: Internet of music things: an edge computing paradigm for opportunistic crowdsensing. J. Supercomput. **74**, 6069–6101 (2018). https://doi.org/10.1007/s11227-018-2511-6
16. Khan, F.A., Shaheen, S., Asif, M., Rahman, A.U., Imran, M., Rehman, S.U.: Towards reliable and trustful personal health record systems: a case of cloud-dew architecture based provenance framework. J. Ambient Intell. Hum. Comput. **10**(10), 3795–3808 (2019). https://doi.org/10.1007/s12652-019-01292-4
17. Khan, M.S.H., Roy, P., Khanam, F., Hera, F.H., Das, A.K.: An efficient resource allocation mechanism for time-sensitive data in dew computing. In: 2019 International Conference of Artificial Intelligence and Information Technology (ICAIIT) , pp. 506–510. IEEE (2019). https://doi.org/10.1109/icaiit.2019.8834633
18. Hirsch, M., Mateos, C., Rodriguez, J.M., Zunino, A.: DewSim: a trace-driven toolkit for simulating mobile device clusters in Dew computing environments. Softw. Pract. Exp. (Wiley) (2019). https://doi.org/10.1002/spe.2696
19. Medhi, K., Ahmed, N., Hussain, M.I.: Dew-based offline computing architecture for healthcare IoT. ICT Express **8**(3), 371–378 (2022). https://doi.org/10.1016/j.icte.2021.09.005
20. Ray, P.P., Dash, D., De, D.: Internet of things-based real-time model study on e-healthcare: device, message service and dew computing. Comput. Netw. (2018). https://doi.org/10.1016/j.comnet.2018.12.006
21. Kaura, S., Bhardwaj, D.: A comprehensive review on intrusion detection in edge-based IoT using machine learning. Intell. Commun. Technol. Virtual Mob. Netw. **615–624**,(2023). https://doi.org/10.1007/978-981-19-1844-5_48
22. Alyas, T., Alzahrani, A., Alsaawy, Y., Alissa, K., Abbas, Q., Tabassum, N.: Query optimization framework for graph database in cloud dew environment. CMC-Comput. Mater. Contin. **74**(1), 2317–2330 (2023). https://doi.org/10.32604/cmc.2023.032454
23. Bhatia, J., Italiya, K., Jadeja, K., Kumhar, M., Chauhan, U., Tanwar, S., Bhavsar, M., Sharma, R., Manea, D.L., Verdes, M., Raboaca, M.S.: An overview of fog data analytics for IoT applications. Sensors **23**(1), 199 (2023). https://doi.org/10.3390/s23010199
24. Roman, R., Lopez, J., Mambo, M.: Mobile edge computing, fog: a survey and analysis of security threats and challenges. Fut. Gen. Comput. Syst. **78**, 680–698 (2018). https://doi.org/10.1016/j.future.2016.11.009

25. Sanabria, P., Tapia, T.F., Toro Icarte, R., Neyem, A.: Solving task scheduling problems in Dew computing via deep reinforcement learning. Appl. Sci. **12**(14), 7137 (2022). https://doi.org/10.3390/app12147137
26. Javadzadeh, G., Rahmani, A.M., Kamarposhti, M.S.: Mathematical model for the scheduling of real-time applications in IoT using Dew computing. J. Supercomput. **78**(5), 7464–7488 (2022). https://doi.org/10.1007/s11227-021-04170-z
27. Karmakar, A., Banerjee, P.S., De, D., Bandyopadhyay, S., Ghosh, P.: MedGini: Gini index based sustainable health monitoring system using dew computing. Med. Novel Technol. Dev. **100145**,(2022). https://doi.org/10.1016/j.medntd.2022.100145
28. Podder, T., Bhattacharya, D., Majumdar, A.: Dew computing-inspired mental health monitoring system framework powered by a lightweight CNN. In: Disruptive Technologies for Big Data and Cloud Applications, pp. 309–319. Springer, Singapore (2022). https://doi.org/10.1007/978-981-19-2177-3_31
29. Braeken, A.: Authenticated key agreement protocols for dew-assisted IoT systems. J. Supercomput. **1–21**,(2022). https://doi.org/10.1007/s11227-022-04364-z
30. Rana, S., Obaidat, M.S., Mishra, D., Mishra, A., Rao, Y.S.: Efficient design of an authenticated key agreement protocol for dew-assisted IoT systems. J. Supercomput. **78**(3), 3696–3714 (2022). https://doi.org/10.1007/s11227-021-04003-z
31. Raza, H., Amjad, M., Muneer, S.: IoT based cyber-physical system in automobile devices with dew computing architecture. J. NCBAE **1**(1) (2022)
32. Gusev, M.: AI cardiologist at the edge: a use case of a dew computing heart monitoring solution. In: Artificial Intelligence and Machine Learning for EDGE Computing, pp. 469–477. Academic Press (2022). https://doi.org/10.1016/B978-0-12-824054-0.00020-4
33. Alorf, A.: Blockchain and Dew computing for secure energy trading in smart grids: a profit-aware approach. SSRN 4088660
34. Singh, P., Gaba, G.S., Kaur, A., Hedabou, M., Gurtov, A.: Dew-cloud-based hierarchical federated learning for intrusion detection in IoMT. IEEE J. Biomed. Health Inform. (2022). https://doi.org/10.1109/JBHI.2022.3186250
35. Hati, S., De, D., Mukherjee, A.: DewBCity: blockchain network-based dew-cloud modeling for distributed and decentralized smart cities. J. Supercomput. **78**(6), 8977–8997 (2022). https://doi.org/10.1007/s11227-021-04203-7
36. Ma, Y., Ma, Y., Cheng, Q.: Cryptanalysis and enhancement of an authenticated key agreement protocol for dew-assisted IoT systems. Secur. Commun. Netw. **2022**,(2022). https://doi.org/10.1155/2022/7125491
37. Kaur, N., Mittal, A., Kumar, A., Kumar, R.: Healthcare monitoring through fog computing: a survey. ECS Trans. **107**(1), 7689 (2022). https://doi.org/10.1149/10701.7689ecst
38. Debauche, O., Mahmoudi, S., Guttadauria, A.: A new edge computing architecture for IoT and multimedia data management. Information **13**(2), 89 (2022). https://doi.org/10.3390/info13020089
39. Lee, K., & Man, K.L.: Edge computing for internet of things. Electronics **11**(1), 1239 (2022). https://doi.org/10.3390/electronics11081239
40. Verma, R.: Smart city healthcare cyber physical system: characteristics, technologies and challenges. Wirel. Pers. Commun. **122**(2), 1413–1433 (2022). https://doi.org/10.1007/s11277-021-08955-6
41. De, D., Karmakar, A., Banerjee, P.S., Bhattacharyya, S., Rodrigues, J.J.: BCoT: introduction to blockchain-based internet of things for industry 5.0. In: Blockchain based internet of things, pp. 1–22. Springer, Singapore (2022). https://doi.org/10.1007/978-981-16-9260-4_1
42. Fan, X., Niu, B., Liu, Z.: Scalable blockchain storage systems: research progress and models. Computing **104**(6), 1497–1524 (2022). https://doi.org/10.1007/s00607-022-01063-8
43. Maheshwari, S., Raychaudhuri, D., Seskar, I., Bronzino, F.: Scalability and performance evaluation of edge cloud systems for latency constrained applications. In: 2018 IEEE/ACM Symposium on Edge Computing (SEC), pp. 286–299. IEEE (2018). https://doi.org/10.1109/SEC.2018.00028

44. Jarwan, A., Sabbah, A., Ibnkahla, M., Issa, O.: LTE-based public safety networks: a survey. IEEE Commun. Surv. Tutor. **21**(2), 1165–1187 (2019). https://doi.org/10.1109/COMST.2019.2895658
45. Ahammad, I., Khan, M.A.R., Salehin, Z.U.: Software-defined dew, roof, fog and cloud (SD-DRFC) framework for IoT ecosystem: the journey, novel framework architecture, simulation, and use cases. SN Comput. Sci. **2**, 1–51 (2021)
46. Brezany, P., Ludescher, T., Feilhauer, T.: Cloud-dew computing support for automatic data analysis in life sciences. In: 2017 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), pp. 365–370. IEEE. (2017). https://doi.org/10.23919/MIPRO.2017.7973450
47. Suwansrikham, P., Kun, S., Hayat, S., Jackson, J.: Dew computing and asymmetric security framework for big data file sharing. Information **11**(6), 303 (2020). https://doi.org/10.3390/info11060303
48. Ageed, Z.S., Zeebaree, S.R., Sadeeq, M.A., Ibrahim, R.K., Shukur, H.M., Alkhayyat, A.: Comprehensive study of moving from grid and cloud computing through fog and edge computing towards dew computing. In 2021 4th International Iraqi Conference on Engineering Technology and Their Applications (IICETA), pp. 68–74. IEEE (2021). https://doi.org/10.1109/IICETA51758.2021.9717894
49. Bramer, M.: Principles of Data Mining, vol. 180, p. 2. Springer, London (2007). https://doi.org/10.1007/978-1-4471-7493-6
50. Chen, M.S., Han, J., Yu, P.S.: Data mining: an overview from a database perspective. IEEE Trans. Knowl. Data Eng. **8**(6), 866–883 (1996). https://doi.org/10.1109/69.553155
51. Li, T., Xie, N., Zeng, C., Zhou, W., Zheng, L., Jiang, Y., et al.: Data-driven techniques in disaster information management. ACM Comput. Surv. (CSUR) **50**(1), 1–45 (2017). https://doi.org/10.1145/3017678
52. Saha, S., Nandi, S., Paul, P.S., Shah, V.K., Roy, A., Das, S.K.: Designing delay constrained hybrid ad hoc network infrastructure for post-disaster communication. Ad Hoc Netw. **25**, 406–429 (2015). https://doi.org/10.1016/j.adhoc.2014.08.009
53. Hazra, K., Shah, V.K., Bilal, M., Silvestri, S., Das, S.K., Nandi, S., Saha, S.: A novel network architecture for resource-constrained post-disaster environments. In: 2019 11th International Conference on Communication Systems & Networks (COMSNETS), pp. 328–335. IEEE. https://doi.org/10.1109/COMSNETS.2019.8711166
54. Zhang, C., Fan, C., Yao, W., Hu, X., Mostafavi, A.: Social media for intelligent public information and warning in disasters: an interdisciplinary review. Int. J. Inf. Manag. **49**, 190–207 (2019). https://doi.org/10.1016/j.ijinfomgt.2019.04.004
55. Mondal, T., Pramanik, S., Pramanik, P., Datta, K. N., Paul, P. S., Saha, S., & Nandi, S.: Emergency Communication and Use of ICT in Disaster Management. Emerging Technologies for Disaster Resilience: practical Cases and Theories, pp. 161–197 (2021). https://doi.org/10.1007/978-981-16-0360-0_10
56. Sharma, K., Anand, D., Sabharwal, M., Tiwari, P.K., Cheikhrouhou, O., Frikha, T.: A disaster management framework using internet of things-based interconnected devices. Math. Probl. Eng. **2021**, 1–21 (2021). https://doi.org/10.1155/2021/9916440
57. Savyanavar, A.S., Ghorpade, D.V.R.: Resource allocation scheme for Dew computing paradigm using mobile grids. Int. J. Innov. Technol. Explor. Eng. **199–203**,(2019). https://doi.org/10.35940/ijitee.H6545.078919
58. Mukherjee, A., De, D., Dey, N., Crespo, R.G., Herrera-Viedma, E.: DisastDrone: a disaster aware consumer internet of drone things system in ultra-low latent 6G network. IEEE Trans. Consum. Electron. (2022). https://doi.org/10.1109/TCE.2022.3214568
59. Mukherjee, A., De, D., Dey, N.: Dewdrone: dew computing for internet of drone things. IEEE Consum. Electron. Mag. **12**(1), 52–57 (2021). https://doi.org/10.1109/MCE.2021.3139306
60. Stanco, G., Botta, A., Ventre, G.: Dewros: a platform for informed dew robotics in ros. In: 2020 8th IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud), pp 9–16. IEEE (2020). https://doi.org/10.1109/MobileCloud48802

61. Belch, G.E., Belch, M.A.: Advertising and Promotion: an Integrated Marketing Communications Perspective, 6th edn. McGraw-Hill, New York
62. Court, D., Elzinga, D., Mulder, S., Vetvik, O.J.: The consumer decision journey. McKinsey Q. 3(3), 96–107 (2009)
63. Chen, Y., Xu, Z., Yu, W.: Agent-based artificial financial market with evolutionary algorithm. Econ. Res.-Ekonomska Istraživanja **35**(1), 5037–5057 (2022). https://doi.org/10.1080/1331677X.2021.2021098
64. Sachs, J., Meng, Y., Giarola, S., Hawkes, A.: An agent-based model for energy investment decisions in the residential sector. Energy **172**, 752–768 (2019)
65. Anufriev, M., Radi, D., Tramontana, F.: Some reflections on past and future of nonlinear dynamics in economics and finance. Decis. Econ. Financ. **41**, 91–118 (2018). https://doi.org/10.1007/s10203-018-0229-9
66. Charpentier, A., Elie, R., Remlinger, C.: Reinforcement learning in economics and finance. Comput. Econ. 1–38 (2021)
67. Jiang, Z., Xu, D., Liang, J.: A deep reinforcement learning framework for the financial portfolio management problem (2017). arXiv:1706.10059. https://doi.org/10.48550/arXiv.1706.10059
68. Wang, Y., Xu, T., Niu, X., Tan, C., Chen, E., Xiong, H.: STMARL: a spatio-temporal multi-agent reinforcement learning approach for cooperative traffic light control. IEEE Trans. Mob. Comput. **21**(6), 2228–2242 (2020). https://doi.org/10.1109/TMC.2020.3033782
69. Panda, B., Leepsa, N.M.: Agency theory: review of theory and evidence on problems and perspectives. Indian J. Corpor. Gov. **10**(1), 74–95 (2017)
70. Kumala, R., Siregar, S.V.: Corporate social responsibility, family ownership and earnings management: the case of Indonesia. Soc. Responsibil. J. **17**(1), 69–86 (2021). https://doi.org/10.1108/SRJ-09-2016-0156
71. Adhikari, R.: Foundations of computational finance. Math. J. **22**, 1–59 (2020). https://content.wolfram.com/uploads/sites/19/2020/08/Adhikari-1.pdf
72. Tran, M., Pham-Hi, D., Bui, M.: Parameter optimization for trading algorithms of technical agents. In: 2022 RIVF International Conference on Computing and Communication Technologies (RIVF), pp. 689–694. IEEE (2022)
73. Zubillaga, B.J., Vilela, A.L., Wang, C., Nelson, K.P., Stanley, H.E.: A three-state opinion formation model for financial markets. Phys. A **588**, 126527 (2022). https://doi.org/10.1016/j.physa.2021.126527
74. Granha, M.F., Vilela, A.L., Wang, C., Nelson, K.P., Stanley, H.E.: Opinion dynamics in financial markets via random networks. Proc. Natl. Acad. Sci. **119**(49), e2201573119 (2022)
75. Biamonte, J., Wittek, P., Pancotti, N., Rebentrost, P., Wiebe, N., Lloyd, S.: Quantum machine learning. Nature **549**(7671), 195–202 (2017)
76. Phillipson, F.: Quantum machine learning: benefits and practical examples. In: QANSWER, pp 51–56 (2020)
77. Pandya, M.: Securing Cloud-The Quantum Way (2015). arXiv:1512.02196
78. Sharma, G., Kalra, S.: A novel scheme for data security in cloud computing using quantum cryptography. In: Proceedings of the International Conference on Advances in Information Communication Technology & Computing, pp. 1–6 (2016)
79. Bennett, C.H., Brassard, G.: Quantum cryptography: public key distribution and coin tossing (2020). arXiv:2003.06557
80. Baliello, C., Basso, A., Giusto, C.D.: Kerberos protocol: an overview. Distributed Systems, Italy, Fall (2002)
81. Fan, K., Li, H., Wang, Y.: Security analysis of the kerberos protocol using BAN logic. In: 2009 Fifth International Conference on Information Assurance and Security, vol. 2, pp. 467–470. IEEE (2009)