Dew Computing: A New Era of Computing Implying Minimization Over Internetwork Backhaul

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Abstract

Grid Computing, Cloud Computing, and Fog Computing and Edge Computing have catered various services toward digitization of ICT-based aspects. Although, these technologies are still in very good shape they do heavily rely on connectivity issue i.e. internet. To cover up this challenge, Dew Computing (DC) paradigm is proposed. DC relies over the Dew-Cloud architecture that brings the power of Cloud Computing together with the Dew Computing. Originally, the Dew-Cloud architecture is an extension of existing Client-Server architecture where two servers are placed at both ends of the communication link. With help of Dew Server, user holds more control and flexibility to access his/her personal data in absence of internet connection. Primarily, the data is stored at Dew Server as a local copy which upon instantiation of internet, is synchronized with the master copy at the Cloud-side. User can browse, read, write, or append data on the local Dew Site which is a local web form of an actual web site. The aim of the DC are as follows: (i) minimization of internet-backhaul dependent services, (ii) provide extreme flexibility to the Dew users in terms of web-data access and visualization, and (iii) leverage an internet-free ecosystem toward achieving green-computing through less use of data center and middle-tiers of communication-infrastructure of existing network.

Keywords: *Dew Computing, Dew Site, Dew Server, Dew System.*

A. Dew Computing as Post-Cloud Computing Paradigm: If in a stage of computing the following two conditions hold, this stage of computing could be called post-cloud computing era [1][2]:

(i) Cloud computing is not dominant.
(ii) The relative importance of cloud computing is not increasing.

Cloud computing obtained widely acceptance in the past decade; its usage was increasing quickly. But we believe that cloud computing has never dominated the computing world. With the quick development of Internet of Things, wireless devices, and artificial intelligence, the relative importance of cloud computing is increasing slowly or not increasing at all. Thus, we believe that post-cloud computing era is coming or has already come. Post-cloud computing is not a specific computing paradigm; instead, it covers a few computing models that are related to cloud computing and remedial to cloud computing in the post-cloud computing era. Major post-cloud computing models include CDEF, i.e. Cloudlet, Dew computing, Edge computing, and Fog computing.

Since cloud computing has been widely accepted, progress in research and development enriched the landscape of this area. Such progress can be summarized in the following way: From cloud to CDEF, where C represents Cloudlet, D represents Dew Computing, E represents Edge Computing, and F represents Fog Computing. CDEF starts with C also implies that these four models all started from Cloud Computing.

The cloudlet model promotes to put small-scale cloud data centers at locations where they are closer to users [3][4].
The key features of dew computing are that on-premises computers provide functionality independent of cloud services and they also collaborate with cloud services. Dew computing promotes that all on-premises computer applications get support from cloud services, if possible. With dew computing, cloud computing can reach its greatest popularity. Dew computing is complementary to cloud computing [5][6][7].

Edge computing pushes applications, data, and services away from central servers (core) to the edge of a network; it is based on the core-edge topology. Edge Computing refers to the enabling technologies allowing computation to be performed at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services [8][9][10][11].

Fog computing is a scenario where a huge number of heterogeneous devices communicate and potentially cooperate among them and with the network to perform storage and processing tasks without the intervention of third-parties.

Fog computing extends cloud computing and services to devices such as routers, routing switches, multiplexers, and so on [12][13][14].

All these computing models share a common feature: they all perform computing tasks at devices that are closer to users [15].

CDEF (Cloudlet, Dew computing, Edge computing, and Fog computing) appeared after cloud computing was widely accepted; they could be called *post-cloud computing models*. CDEF is an unofficial, easy-to-remember way to refer to these models. CDEF starts with C also implies that these models all started from cloud computing.

CDEF originated from different background, proposed to solve different problems, related to different disciplines/industries, involved different devices, and have different methodologies. The relationships among CEDF are similar to the relationships among different programming languages: although each programming language has full computing power of a Turing Machine, each language has its own style, strength, and characteristics. In the similar way, although the definitions of each of these CDEF computing models may be expanded to cover wider application areas, each of these models are more suitable to be used in some specific areas. From cloud to CDEF, the landscape of post-cloud computing is more versatile and prosperous.

B. Definition of Dew Computing: The definition of dew computing may be presented as follows: "Dew Computing is a programming model for enabling ubiquitous, pervasive, and convenient ready-to-go, plug-in facility empowered personal network that includes Single-Super-Hybrid-Peer P2P communication link. Its main goal is to access a pool of raw data equipped with meta-data that can be rapidly created, edited, stored, and deleted with minimal internetwork management effort (i.e. offline mode). It may be specially tailored for efficient usage, installation, and consumption of local computing (i.e. on-premises) resources like PC, Laptop, Tablet, high end Smart Phone. This computing model is composed of six essential characteristics such as. Rule-based Data Collection, Synchronization, Scalability, Re-origination, Transparency, and Any Time Any How Accessibility; three service models such as Software-as-a-Dew Service, Software-as-a-Dew Product, Infrastructure-as-a-Dew; and two identity models (e.g. Open, Closed). All such efforts shall be made towards running of applications in a purely-distributed and hierarchical manner without requiring continuous intervention from remotely located central communication point e.g. cloud server etc." [16].

C. Objectives of Dew Computing: Dew computing brings the centralized core cloud services nearest to the user. The objectives of bringing complex computational part from the remote cloud platform to end-user via DC are as follows [17]:

a. **Internet access minimization:** Dew computing is envisaged to minimize the usability of internetworking facility such that user specific instantaneous supple service could be provided.

b. **Personal service provisioning:** Unlink other computing paradigms, dew computing handles the higher expectation of user services at user's end. Without or minimal use of internetwork facilitates user in form of a true personal digital assistant.

c. **User flexibility maximization:** Existing computing solutions provides pre-defined set of services to user. Dew computing benefits user with unlimited amount of user-willed performances.

d. **Backhaul traffic reduction:** In reality, the overloading minimization effort on the network backhaul depends on data-traffic in average duration. A dew user relies upon localized services that requires minimum network intervention. Moreover, the dew computing paradigm encourages its user to stay with the user's prioritized data pre-saved as dew copy in local dew database. In most of the cases dew user utilizes personalized data to surf over dew sites rather on real web sites. If a required data is not present in the dew computer, the dew server first fetches from nearby dew cluster upon a dew permission over local network communication protocols. Only when a data is not present in the dew machine as well as dew cluster, it may require access to remote cloud for which actual internetwork backhaul will be responsible. Thus, minimum usage of internetworking is needed in reality, resulting optimal access over existing network traffic.

e. **Bandwidth saving:** As dew computers impose over self-system self-service notion, hence communication bandwidth is minimally utilized.

f. **Carbon footprint minimization:** Less implications over current network assets lowers down dependency over physical establishments such as base stations, enterprise fog, big-data centers etc. Indirect reduction of power consumption is thus evitable which may proportionally help to minimize the carbon foot print.

g. **Utility maximization:** The Quality of User Experience (QoX) can be improved. Dew computers can fetch and provide the information from low-end network hierarchy. Cloud and fog services can be effectively use dynamically with the requirement of information in real-time. The overall difference between other computing paradigms and DC is presented in Table I [17].

TABLE I

DIFFERENCE AMONG CLOUD, FOG, EDGE AND DEW COMPUTING

Parameters	Cloud Computing	Fog Computing	Edge Computing	Dew Computing
Service location	Within the Internet	Within the Internet	In edge network	In edge network
Distance (number of loops)	Multiple loops	Multiple loops	Single loop	No loop
Latency	Very high	High	Low	Negligible
Jitter	Very high	High	Low	Negligible
Location awareness	No	No	Yes	Yes
Geo-distribution	Centralized	Semi centralized	Distributed	Highly distributed
Mobility support	Very limited	Limited	Semi supported	Highly supported
Data reroute attacks	Very high probability	High probability	Low probability	Very low probability
Target users	General internet users	General internet users	Semi mobile users	Purely mobile users
Service scope	Global	Semi global	Semi limited	Purely limited
Hardware	Scalable capabilities	Scalable capabilities	Limited capabilities	Very limited capabilities
User experience	Very normal	Normal	Good	Highly satisfactory
Internet dependency	Every access time	Every access time	Every access time	Not essential
Client-Server connectivity	Yes	Yes	Yes	No
Synchronization feature	Not essential	Not essential	Not essential	Always essential
Green energy compliant	Very Low	Very Low	Low	High
Delay tolerant	No	No	No	Yes
Computational offloading	Very Less	Less	High	Very High
Deployment scenario	Large enterprises	SME	Router, gateway	PC, laptop, smart phone

D. Key Enabling Technologies of Dew Computing: The assimilation of dew computing may be attributed to the recently proposed key enablers as presented follows [17]:

a. **Dew Site:** It is a localized copy of actual web site that has complete read, write, append and delete access to dew user. Every frequently visited or prompted web site should have a corresponding dew site at on-premises dew computer. For example, if *www.abc.com* is the actual web site then its dew site may be designed *wid.abc.com*. Here, *wid* resembles to the *www* protocol, but in on-premises dew devices.

b. **Dew Script:** It is a scripting tool available to dew user for possible modifications in the dew site placed at the dew device. For instance, user can change the formatting of *instagram* personal profile which is only visible to the dew user at the dew computer (*wid.instagram.com*). Upon access rights from user, the same could be synchronized with the actual web template for global visibility. If *partha* has user prfile for *instagram*, then a remote shadow copy of local dew site could be positioned at the *instagram* cloud i.e. *partha.wid.instagram.com*.

c. **Dew Analyzer:** This is a software package meant to coordinate and control over all task and assignments performed by dew script on a specific dew site. When a user does any changes in a file of a dew site, the dew client program activates the dew analyzer to create, delete or append the local dew script file names like *file1.dewscript* in absence of internet. When internet resumes, the modifications of *file1.dewscript* could be interleaved with the *partha.wid.instagram.com.* The authorization related issues could be solved by incorporating a master mapping table between dew site and actual web site.

d. **Dew DBMS:** As an original web site needs to have a set of database for storing and logging of activity records, the same is essential for the dew site. The dew database management system is essentially a personalized copy of personal database to provide personal dew site surfing experience in reality.

e. **Dew DNS:** It is assumed that a dew server will host multiple dew sites in one dew computer. Hence, a sophisticated and unique page naming mechanism is evitable. Dew domain naming service shall provide such on-device dew site searching and access features that can be achieved by the host-to-IP mapping. For example, if *wid* is mapped to *127.0.0.1* then other dew sites could be mapped with *127.0.0.1* i.e. All local URLs could be mapped to localhost e.g. *wid.abc1.com, wid.abc2.com,…, wid.abc10.com* to *localhost -127.0.0.1*. Dew domain naming redirection (Dew DNR) could be another technique by which such redirection could be possible.

f. **Dewlets:** It is an extended dew service to a dew computer by which associated dew supported equipment could receive “let services”. In this context, multiple things of Internet of Things (IoT) could be associated with one or more dew computers. Self-explanatory dew computing architecture is presented in Fig. 1 [16].

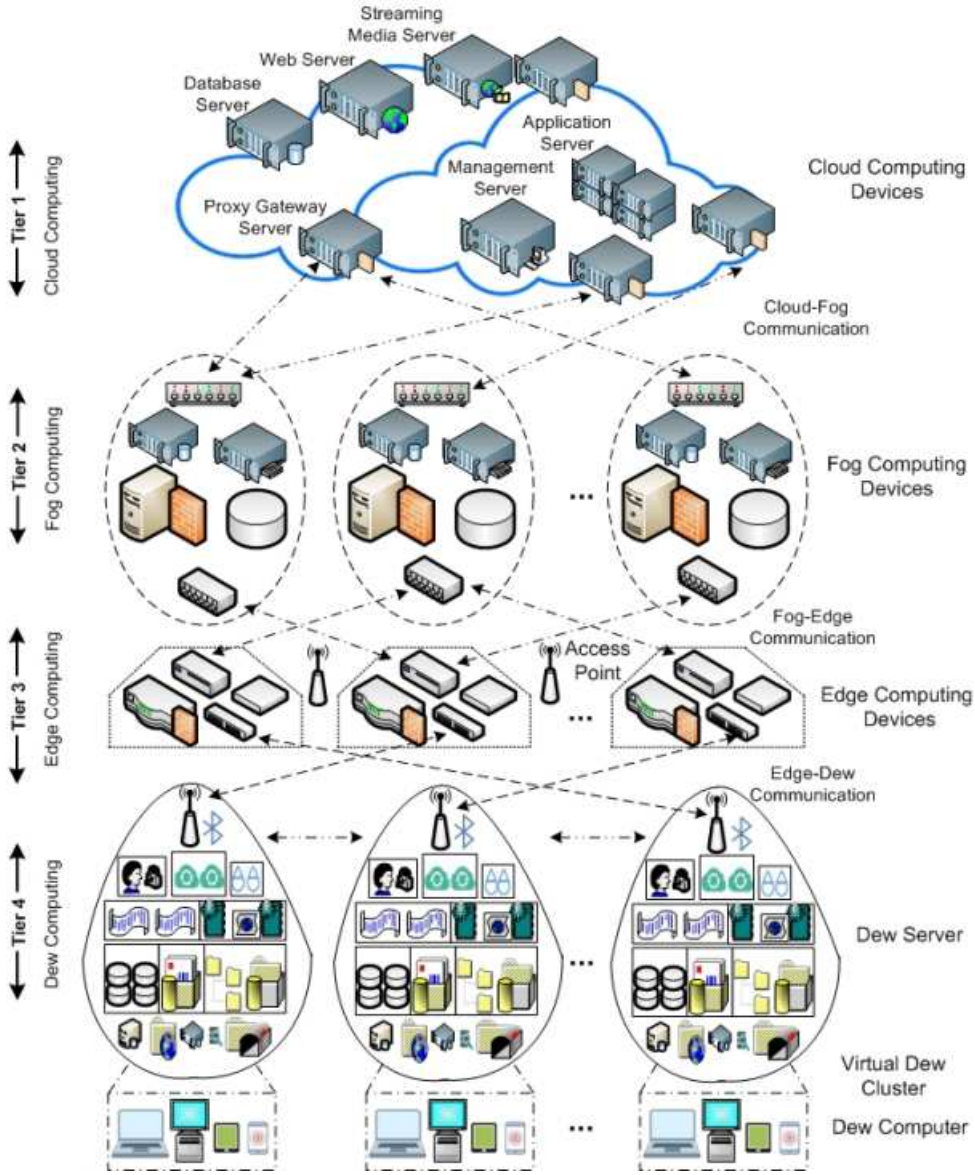

Fig. 1. Hierarchical dew computing architecture.

E. IEEE DewCom STC: In 2018, IEEE has constituted a Special Technical Committee i.e. STC under the purview of the IEEE Computer Society to cultivate and disseminate the novel opportunities and research inclusiveness by incorporating the Dew Computing i.e. DewCom STC. It is a new worldwide Open Community on Dew Computing within IEEE. Dew Computing is an emerging research/application area that is the complementary piece of cloud computing. The goal of dew computing is to fully realize the potentials of on-premises computers and cloud services. The vision of the Dew Computing Special Technical Community is that its efforts shall facilitate dew-computing research and dew computing application, for the benefit of all users and providers of the future global cloud-dew computing environment [18].

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