The Rainbow Global Service Ecosystem

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Abstract—**A Rainbow is a complex service ecosystem of interdependent components of Cloud–Fog–Dew Computing paradigm layers that all work together to enable a seamless system of global services.**
This paper widely and freely (technological and the Philosophical) considers visions and perceptions in order to liberate conceptual scintillation or imagination. The main aim is not to give strict solutions, but to point towards the extreme broadness of present day Computer Science and computer/digital electronics usage, to point towards some possible future development avenues, and to give a simple analogy as a broad conceptual systematical overview, but including some concrete architectural guidelines. The paper presents the IEEE Dew Computing Special Technical Community (IEEE DewCom STC) as a virtual scientific-research and development environment for Dew Computing platform and application development as well as a collaboration model consideration.

Keywords—Cloud computing, Fog Computing, Dew Computing, Rainbow Service, serveware

I. INTRODUCTION

There are generally two main questions, or better to say problems, to be answered and solved in Computer Science. The one often tackled is "How do we do it?". In this area our civilization is in early stage, as much effort is put into imagining gadgets of all sorts and then solving the "Hows".
However, a much more rarely asked question indicates a big generic problem, spreading from philosophy to psychology and from societal behavior to the very physical – the soil we live on and the air we breathe. This over important and often under regarded question is actually "What do we want to achieve as a civilization?" "What is our final goal?" "What kind of human living environment do we wish?" "What are our civilization aims?"
It is the direct responsibility of us Computer Scientists and of the Computer Science itself to involve itself in the philosophy and ethics of what we do. It is also our direct responsibility to find proper means of education of future generations towards the vast possibilities of proper, ethically and philosophically correct computer usage for the benefit of not only humankind, but also of our own planet and its environment. We may not forget that "empathy", "ethics", "love", "heart", "soul" are notions without which we Humans would not be able to live properly in a civilized society, together with "imagination" and "intuition", and that all those properties are not existing in the computer hardware/software we develop. Will we ever be able to properly "programme" love or empathy or ethics or intuition into future computers? But without those prerequisites we have to be extremly careful of how much power over our own lives and our living environment we give to pure "technical" solutions.
Consequently in addition to a lot of "hows", we also have to solve a lot of "whys"! Or, actually, presently it is the moment to put much more intellectual effort in the "whys".
So, actually there are two major aspects of future development of Computer Science: The Technological and the Philosophical. In this article we will take a slightly unconventional approach, using Cybernetic principles, to shed some light on the overall area which in present day must be covered by Computer Science. We will talk about Ecosystems, EMV spectrum and Rainbows using these analogies to state the necessity of integrating various fields of human endeveaours regarding the present day spread of, primarily, digital electronics. Though the basic components are in the very field of Electronics, digital technology, and therefore actually Computer Science, covers a huge area from interconnecting those electronic components into active units, up to enabling free telephone and videophone conversations through free wireless connection points.
In nature, an ecosystem is composed of living and nonliving entities that are connected and work together. Natural ecosystems are stable, as there is a homeostatic loop system between all their components (as said, living and nonliving). The second and even more important component of ecosystem stability is the self-organization, and between it and its wider environment. However, the area of usage of digital electronics and internetworking of all kinds of things grows stochastically, without regard to global inter-compatibility, and even less with regard to possible unknown unwanted consequences on our lives and our environment.
As already said, it is the role and responsibility of Computer Science to propose, test and apply a consistent cybernetic system which would enable stable development of the future Global Services Ecosystem, representing the Smart Service

System, which would integrate Human Knowledge and Intelligence and Computer Stubbornness and Exactitude, for the benefit of the human civilization and all individuals, by enabling but not forcing, giving more liberty and freedom and not less, to be a fascinating and powerful tool in our hands, but not by forcing itself onto us as a master.
Let us call this ecosystem The Rainbow Computing Ecosystem.

II. DISTRIBUTED SYSTEM EVOLUTION

Modern day computing paradigms foster for a huge community of involved participants from almost the whole spectrum of human endeavour. For computing and data processing there are; individual computers, their clusters, scientific Grids, and, finally, the Clouds/Fogs/Dews. For pure data communication there is the Internet, and for the Human-understandable Information Communication is the World Wide Web. The stunning development of actually extremely powerful hand-held mobile devices connected to the Internet enabled the "lowering" of certain parts of Clouds into the so called 'thin clients', and led to the development of the Fog Computing paradigm as well as to the ideas of Internet of Things (IoT) and the wish towards the Internet of Everything (IoE) what we propose to cowering by new Dew Computing paradigm. The tendency toward Dew computing is force by dynamic development of mobile computing, the decreasing availability and cost of computers and the huge number of networked components, devices and sensors in the networked environment. Dew computing is a distributed service technology as a ground part of architecture in cloud/fog/dew service which client data/info is processed at the periphery of the network, of source/process close as possible.

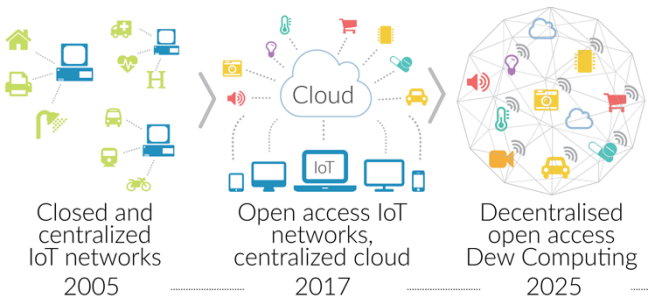

Fig 1 Distributed operation network evolution

Dew computing is a new computing paradigm appeared to fulfill applications at the edge of network in widely acceptance of cloud computing vertical hierarchy. Dew computing concerns the distribution of workloads between Cloud/Fog servers and local computers, and its focus is the application software organization of local computers. The goal of Dew computing is to fully realize the potentials of local computers in Cloud -Fog-Dew symbiosis [1].

Fig 2 presenting a complex service ecosystem of compatible federated components of Cloud – Fog – Dew Computing layers that all work together to enable a seamless system of global *Smart Service System* (SSS), proposed name *Rainbow*.

The Rainbow global service ecosystem will offer new applications and respond to changing business needs and support new business models, it will offer new possibilities of service processes development and information usage for a very broad user base, it will enable proper maintenance of essential natural and human-generated ecosystems, and enable huge savings and optimization in many areas of living and effort. Well integrated traffic systems, well cared for plants, efficient usage of energy, higher health level of general population, disease prevention, catastrophe warning/prevention, faster essential services,... all can be achieved by proper architectural means inside a Rainbow Service Ecosystem[2,3].

However the most significant amount of information processing all around us is done on the lowest possible computing level, outright connected to the physical environment and mostly directly controlling our human immediate surroundings. These "invisible", "embedded" information processing devices we find in everything from our car's motor, over air-conditioners, wending machines up to traffic-controls and wood-burning stoves, and ubiquitously all over the industry. These devices, which are neither at the Cloud/Fog edge, nor even at the mobile edge, but rather at the physical edge of computing are the basis of the Dew-Computing Paradigm.

The merits of including those "dew" devices into the Cloud - Fog - Dew hierarchy are huge, for individuals, the public and industrial sectors, the scientific community and the commercial sector, by bettering the physical and communicational, as well as the intellectual, immediate human environment.

III. WHY RAINBOW?

As the Sun by seemingly white light shines on Earth and gives it life, so the idea of *Rainbow* global distributed service is to incorporate all fields and segments of Computer Science into a unified entity, which will bring advancement and betterment of the quality of life of all people and our Planet.

As different frequencies of the Sunlight give different colours (spectrum), so different segments of Computer Science have important roles for the whole to function harmoniously. So let us borrow the analogy of Rainbow and its Colours for specific fields of Computer Science.

It is important to note here, that, in accordance with what was said before, in *Rainbow Computing* we necessarily include both the “technical” and the “philosophical” aspect, or, in other words, both the Machines and the Humans.

In the following two sections we will describe the overall Ecosystem from two major aspects: an integrated living social (human and machine) system, which we will visualize using the analogy of a Rainbow, i.e. sunlight Spectrum, and an architectural, more technically oriented, viewpoint.

The Colours of Rainbow

Red – *Basic Hardware*.

The general machine architecture layer, including hardware and associated machine code programming principles, partly also firmware and operating systems.

Present day computing hardware is mostly based on principles and architectures developed in the early days of computing, when many obstacles were to be overcome to get a viable computing machine. Nowadays it is essential to rethink much of the present day hardware platforms, as many possible avenues of computer architecture have not yet been experimented with, and the present day independent multicore serial processors approach, specifically due to a complete lack of proper human-oriented multi-processor/multi-computer programming principles and languages, is in many cases very inefficient.

Orange – *The Creativity Pool*.

Collection of creative ideas, with specific attention on novel approaches to teaching and education.

Many a problem, first regarded as separate and nonsolvable, suddenly got solved through some solution in a completely different area. Only if people have developed Creativity it is possible to have such insights, and Creativity is the main driving force of our civilization. But for proper and safe future the Creativity shall be primarily oriented towards high level integrated visions and properly established "why" and "do we really want/need/wish it", and only consequently the "hows". Education has also to be oriented towards the development of Creativity.

Yellow – *The Appropriateness Filter*.

Weighting of the level of concrete contribution of some advancement.

An idea, coming from the Orange layer must pass through the Appropriateness Filter, to test if its usage really contributes to concrete betterment of a specific field, or not, or could it in a wider context even be counterproductive or dangerous. Some ideas can be fanciful, exciting, beautiful, but it is not necessarily that they contribute in a positive sense to the civilisation changes, they may even be counterproductive in societal or environmental sense, and leading to worse general human living conditions. Generally, it seems that this area of Computer Science is well underdeveloped, and rarely the philosophical and primarily ethical wider consequences of introduction and interconnection of different new ideas and technologies are seriously considered, as they should be, at least scientifically, and consequently by recommendations and standards, in the most serious cases even by laws.

Green – *Environment and Health*.

Computer Science in the area of care for the general environment, environment control and maintenance and improvement of population health and general wellbeing.

This area involves health oriented devices and small gadgets, environmental sensors (and effectors), for example sensors in waterways reacting on specific unwanted chemicals, rain-composure sensors (e.g. rain acidity), light, humidity, temperature etc. sensors for closed environmental control, etc.
On the architectural plan, this area would be primarily covered by Dew Computing, due to the fact that most of these devices directly sense and influence the physical state of human and environmental well-being.

Blue – *Communication*.

This is the area of all kinds of communication and communication networks, including, naturally, the communication between computers and humans and vice versa.
Although generally it is that Computer Science is closely related to Cybernetics and Information Science, modern day development is aimed primarily towards Data. Data is, naturally, not Information, as it lacks the context/meanining, or, if you prefer, the Meta-Data. Present day communication both between humans and computers and between computers themselves lacks generic compatibility on the level of *what is exchanged*, as well as *what is to be done*.

Indigo – *Cooperation and Ethics*.

This area covers high level services based on compex communication interactions, the collection of huge quantities of Information (not Data, as is presently in vogue!) and the usage of that Information storage and processing.
An important aspect of future Computer Science development in this area will be the "pruning" of redundancy, and definition of long term safe redundancy levels of information important to our civilisation.

Violet – *Interference, Optics, Quanta*.

Protection and Expansion.

Our civilization is every day more and more, in some areas even already completely, dependent on computers and networks. We live in a world where even shorter disruptions of energy or information distribution systems can lead towards huge problems, from industry and traffic down to simple life at home. However, much of our electronic equipment is very suspect able to failure due to electric or electromagnetic discharges.
This failure suspectability, and its prevention is an extremely important area of future research and development due to our overall dependence on electrical systems, computer systems, wireless and satelite communications.

IV. THE ARCHITECTURE OF RAINBOW SERVICE

Architecturally speaking, Computer Science has already developed necessary defined notions and is intensively exploring necessary principles and solutions for a generic layered approach which can be developed into a firm fundament of the Rainbow Computing Ecosystem, as explained metaphorically through the above cited Colours of a Rainbow Spectrum.

In the area of Basic Hardware, those are presently primarily Clusters, Grids and GPU. However, a huge lack of a simple and consistent approach towards programming parallel distributed systems has a consequence of necessitating huge human efforts for attaining wished results. A generic ontology, as proposed for the Rainbow Ecosystem, with an appropriate high level human oriented language based on this ontology, with well defined grammar and semantics, and with a human approachable large dictionary (amount of recognized defined words) would allow proper integration of a myriad of generically heterogeneous devices, human users and the natural environment.

As basic architectural components presently we have the Cloud, Fog and Dew Computing layers. A *Rainbow* is a complex service ecosystem of interdependent components of Cloud – Fog – Dew Computing layers that all work together to announce the possibility of global services. As already mentioned, in nature an ecosystem is composed of living and nonliving entities that are interactively interconnected and work together to perform as a stable homeostatic and selforganising cybernetic system. The Rainbow service Ecosystem consists of hardware and software platforms/infrastructures/serveware[1], as well as service customers, engineers, consultants, integrators, providers and users, together with the human and natural environment. To achieve the homeostatic balance and selforganisation between those extremely differing components, consisting of three major groups – human made machines, natural humans and the planet Earth's nature (and with space exploration and satellite overcrowding even part of the outer space), each of them with their hugely different own specificities inside each group, it is essential to define a consistent system of future development towards the computing/services infrastructure being a simple and consistent, non-obtrusive and benevolent helper for human-oriented technical civilisation development.

Now time Cloud-Fog-Dew Computing defines important principles, but is usually thought of in terms of three broad service areas -- infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) and software-as-a-service (SaaS). However, these are not integrated as a unified "Smart Services System", and even less as a "Global Services Ecosystem". Naturally, the huge effort put into the development of these basic components promises a solid base for the high level integration provided by the Rainbow Service Ecosystem.

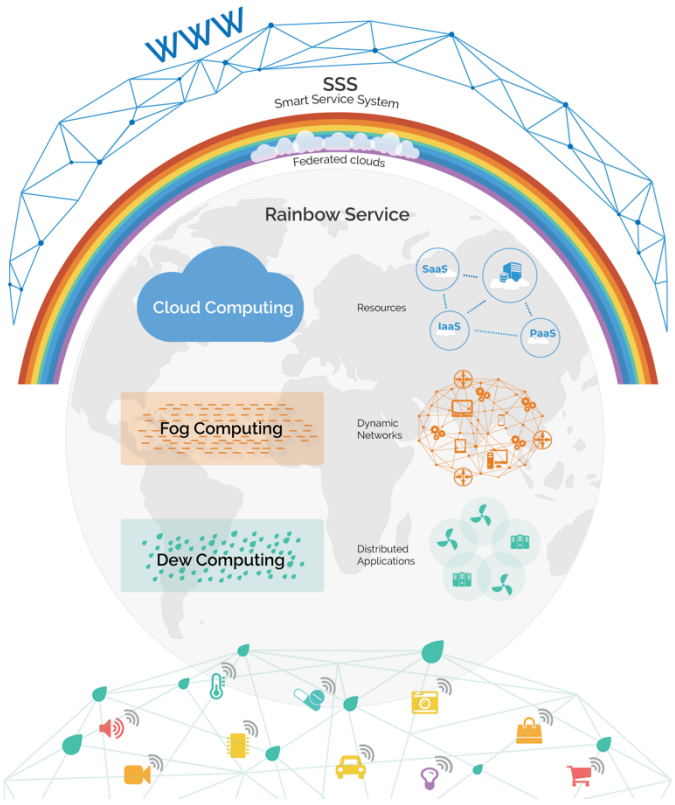

Figure 2 . Global Distributed Service Hierarchy

All three architectural machine levels – the Cloud, the Fog and the Dew have to grow into a compatible and inter-understandable Information System, integrated through ergonomics and linguistics with the other two essential components of our civilisation: the human world, society, production, consumption, politics, economy, and the natural world, wellbeing of all other inhabitants of our Planet, and non-interference into freedom of living and expression, both human and non-human (i.e. animals, plants, the Planet etc.).

Even today the Cloud services are really more complex then their generic descriptions, and the description of Cloud Computing also needs to include the vast array of service providers, service federations, harmonizations and orchestrations, i.e. the human component.

The Fog system, based primarily on an almost uncountable amount of individual programmable devices, has to provide seamless integration of both Dew Computing layer devices, Cloud Computing and individual Humans. Hierarchically, most of the ergonomics, language usage, information filtering and distribution shall be done in this layer, as it is the prime Rainbow Ecosystem layer connected directly to the Humans, in constant communication with them.

The Dew Computing components are, rather than communicating with Humans, actually the most sensitive area of Computing, as they are directly communicating, by sensing and effecting, with the physical and natural environment, often being able to directly change certain living conditions. The enormous vastness of very different sensing and effecting conditions and principles will necessarily generate an overwhelming amount of individual data. If we do not introduce a consistent ontology of meta-data and a linguistical framework of coordination

1 To enable the proper integration of all components "serveware", a service operational middleware, will have to be developed.

programming, filtering and sending/receiving, that is, if we do not start to use Information communication, providing each set of Data with appropriate Context, it will be impossible to properly integrate the Dew, Fog and Cloud Computing layers in a machine basis of the Rainbow Service Ecosystem.

Generally the full Ecosystem architecturally consists of five basic layers: Nature-Dew-Human-Fog-Cloud.

To enable the proper integration of all components by "serveware", a service operational middleware, will have to be developed. This serveware would be the prime information access, filtering and distribution component, and would include the full Rainbow Global Services Ecosystem ontology, as well as necessary linguistic elements (language) for human-computer and computer-computer communication (which shall be compatible, i.e. understandable by both humans and computers), and by which Information can be retrieved, processed and used. This may be achieved by selforganising autonomous service, which would organise the upward and downward information and request flow from Nature to Dew to Human to Fog to Cloud and vice versa.

In the previous section of this article a much more thorough description of scientific and human efforts, and the principles of proper integration of the human and natural world was done on a basis of analogies with Colours of a Rainbow. It is essential to mention that, similar to the Cloud-Fog-Dew layerisation of the machine aspect of a Global Services Ecosystem, or, as we call it poetically the Rainbow Ecosystem, it is necessary to do proper layerisation and define efficient interaction and intercommunication principles for the human components of the emerging Global Ecosystem.

Generally speaking we could enlist several layers of human-computer interaction levels: Users (simple or power), Scientists (innovators, researchers, students...), Infrastructuralists (networking, clustering...), Applicationists, Producers (in any production area), Companies (which necessary follow Economic trends), Societies (usage in Politics, everyday life, well-being etc.). These layers, though it may not be obvious from the first, are an essential field area of Computer Science, as the development of the future computing infrastructure has to be driven by and has to be controlled by these (broadly stated) "layers" of human society.

Therefore it is necessary to have an architectural system, which includes individual layer architectures (models) for all machine and human Computer Science fields, and includes an overall architecture, defining a viable selforganising cybernetic eco-system of the future human civilization.

V. IEEE DEWCOM STC COLLABORATION MODEL

IEEE Computer Society Dew Computing Special Technical Community (DewCom STC) under coordination of Y. Wang and K. Skala represent an open community and forum for researchers, professionals, and students in the area of Dew Computing and related distributed computing/service topics.

Figure 3 STC Collaboration model

The development of the Dew Computing paradigm as well as the vision of establishing a global smart service system (SSS) will be considering, developing, implementing through the IEEE DewCom Special Technical Community. For now STC has 43 members from 14 countries, presenting in fig.4. These virtual scientific research community establishing a collaborative platform for the realization of the *Dew Computing* paradigm and possibly *Rainbow* vision.

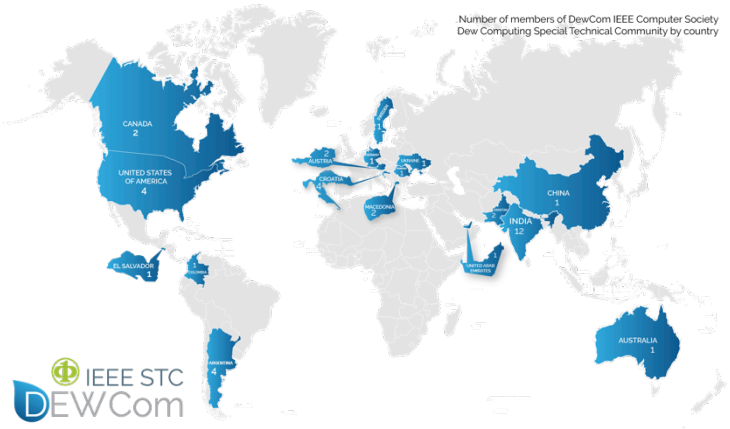

Fig 4 Membership distribution map

The Dew Computing development in organized manner intends, through Research, Innovation and Development, to ***explore*** the realm of possibilities of Dew-Computing, ***solve*** the basic problems of integration of the "dew" level with the higher level Dew-Fog-Cloud hierarchy, with special attention to the necessity of information (and not data) processing and communication, and ***demonstrate*** the

viability and high effectiveness of the developed Architecture in several areas of human endeavor through real life implementations. Finally, the IEEE STC collaborative action will ***define*** and, in cooperation with standardization/dictionary bodies, try to ***standardize*** the basics necessary for the seamless integration of the emerged Information Processing Architecture into the Dew, Fog and Cloud Paradigms, as a way towards the abovementioned civilization goals. Our intention is to work together as an virtual Research and development group to create, organize, share, and collaborate on projects and articles and develop our effective IEEE DewCom STC collaboration model.

VI. CONCLUSION

A robust *Rainbow Ecosystem* will offer new life-business applications and respond to changing civilization processes, business models, it will offer new possibilities of knowledge development and information usage for a very broad user base, it will enable proper maintenance of essential natural and human-generated ecosystems, and enable huge savings in many areas of effort. Well integrated traffic systems, well cared for plants, efficient usage of energy, higher health level of general population, disease prevention, catastrophe warning/prevention, faster essential services, ease of knowledge learning and information collecting, higher level of creativity education... all can be achieved by proper architectural means inside a *Rainbow Service Ecosystem*.

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