Problem Driven Computing and Analytics

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***Abstract*—This article explores problem-driven computing and analytics. More specifically, it presents a disciplinary perspective on computing. It examines problem-driven computing and eSMACS computing. This research has three main contributions to the literature and the academia. The first contribution is that computing as a meta discipline consists of computing science, computing technology, computing engineering, computing system, computing intelligence, and computing management. The second contribution is problem-driven computing. The research demonstrates that a class of problems can be classified into four categories: descriptive problems, diagnostic problems, predictive problems, and prescriptive problems. Each of these problems drives a corresponding computing, that is, descriptive computing, diagnostic computing, predictive computing, and prescriptive computing. Descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics are examples of the mentioned four types of computing, correspondingly. The third contribution is that eSMACS computing as the digital computing and the example of problem-driven computing will play an important role in the digital age. The proposed approach in this research will facilitate the research and development of computing, big data analytics, intelligence, and data science.**

***Index Terms*—Computing, intelligence, analytics, problem-driven computing, eSMACS computing, DDPP computing.**

I. Introduction

Computing has revolutionized science, technology, engineering, system, business, management, and many other areas of human endeavor [1]. Computing has played a significant role in revolutionizing our work, life, society, and world in the past century. Computing is the foundation of the Internet, the Internet of Things (IoT), sharing economy, cloud computing, digital services, and web intelligence, all that we have witnessed and experienced in the digital society. However,

1. What is computing?
2. How can we look at computing and its relationship with problems?

This is still big issues for us to work and live in the digital world. The big issues include academic issues and disciplinary issues. This article will address these issues by presenting a strategic approach to computing. The strategic approach is a higher-level abstraction and generation of computing. The strategic approach includes a meta-approach because the latter normally focuses on the transformation of things and entities from a level to a higher level in the real world, logical world, and virtual world. This article explores problem-driven computing and eSMACS computing with examples. The core idea behind it is that problems, issues, challenges, and needs as well as demands from academia, industry, and society are always the motive for research and development of computing, science, and technology. In other words, the classification of problems corresponds to a class of computing. Furthermore, from a systemic viewpoint, problems are the input of the system, computing is the process of the system, and computing intelligence is the output of the system. The remainder of this article is organized as follows. Section II discusses the research methodology used in this research. Section III looks at what is computing and the web of computing. Section IV provides a discipline perspective or meta-approach to computing. Section V explores problem-driven computing, DDPP computing, and analytics. Section VI looks at eSMACS computing with examples. The final sections discuss the related work and end this article with some concluding remarks and future work.

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II. Research Methodology

From a viewpoint of research methodology, this article uses a multidisciplinary approach consisting of logical, algebraic, systemic methods, research as a search, and big data-driven small data analysis methods to support the mentioned strategic approach. For example, the principle of "research as a search" and big data-driven small data analysis [2] underpins the verification of statements, claims, and corresponding literature reviews.

This article uses Google to search for relevant publications, which reflect the state-of-the-art development of computing, analytics, and eSMACS computing worldwide. It uses Google Scholar search for corresponding items, which reflects the state-of-the-art research and development of relevant disciplines and/or research fields in academia. Both are a complement to each other for understanding state-of-the-art a variety of computing and analytics. This article also uses logical and systemic approaches, natural deduction, and natural association as research methods to examine problem-driven computing, analytics, and eSMACS computing.

Natural deduction originally is a part of mathematical logic. It is now a kind of practical intelligence. The natural association should have been studied in data mining. However, it is also a kind of advanced intelligence, research intelligence, which has been widely used in many research activities. Hereafter, natural deduction and natural association will be used as research methods in this research.

III. What is Computing?

Merriam-Webster Dictionary defines computing through compute [3]. Compute is defined as "to determine especially by mathematical means" in other words, compute is to find out something by using mathematics. Compute as a term is

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also to “determine or calculate by means of a computer”. However, Merriam-Webster Dictionary has not the term computing. Oxford Dictionary defines computing as “the fact of using computers” for example, scientific/network, scientific computing, computing power, services, skills/systems [4]. Computing refers to goal-oriented activities requiring, benefiting from, or associated with the creation and use of computers” [1].

The above three definitions of compute and computing imply that

1) Computing is determined by mathematical means. It is related to compute and calculation.
2) Computing is about computer-centered goal-oriented activities and facts.

These three sources provide the definition of computing to target the ordinary audiences rather than scholars, although the definition of ACM [1] for computing can be used in scholars' teaching and research and to develop the related undergraduate programs. This is because a great variety of existing computing has not been mentioned in [1].

Computing is underpinned by computing machinery, which was at least mentioned already by Alan Turing in his seminal article titled computing machinery and intelligence, published in 1950 [5]. Computing also originated from scientific computing, which has been developed since the 1940s [1].

In reality, computing is more difficult to be defined exactly in the digital age. For example, computers should include all related hardware, software, apps, and integrated machinery, devices, and systems. Therefore, computing includes a variety of interpretations. For example, from a software engineering perspective [6], computing includes activities of analyzing, designing, and constructing hardware and software systems for a wide range of scientific, engineering, mathematical, technological, and social purposes. From an information systems viewpoint [7], computing includes activities of processing, structuring, and managing various kinds of data, information, and knowledge. From a mathematics perspective [8], computing includes problem-solving by finding solutions to problems or by proving a solution does not exist. From a viewpoint of artificial intelligence and intelligent systems [9], computing includes research and development of making computer systems behave intelligently. In the digital age, computing includes all the activities of creating and using communications and entertainment media and finding and gathering information relevant to any particular purpose [1]. From a viewpoint of algorithm computing, computing includes the study and experimentation of algorithmic processes and the development of both hardware and software [10].

A google search for “computing” found about 340,000,000 results (accessed on May 11, 2022). These search results imply that computing has a significant influence on ordinary people's lives and societies. It seems that the above definition cannot reflect such a significant influence. In other words, it is too general so it cannot cover the impact of computing on our work, lives, industries, services, economies, and societies. In fact, we are living in the web of computing. The web of computing is equivalent to the web of science, the web of knowledge, and the web of services.

The web of computing at least consists of a great number of *x* computing, where x is a keyword that has appealed to a number of scholars, businessmen, industries, professionals, and others to incorporate it with computing, for example, cognitive computing and enterprise computing, where x = cognitive or enterprise. Furthermore, the web of computing includes ambient computing, client-server computing, cloud computing, cluster computing, distributed computing, edge computing, green computing, grid computing, internet computing, parallel computing, personal computing, predictive computing, quantum computing, robotic computing, service computing, social computing, ubiquitous computing, and time-sharing computing, to name a few [1]. Each of mentioned computing has gathered a number of researchers, scholars, developers, and business persons to develop corresponding knowledge, skills, dispositions, products, and services by addressing corresponding problems, issues, needs, and demands. The openness and inclusiveness of computing promote a digital economy, digital society, and digital age. The openness and inclusiveness of computing have been fostering new *x* computing emerging in the coming years.

IV. A Discipline Perspective on Computing

Computing is a big concept. Computing refers to computing science, technology, engineering, system, management, service, tool, and application that are concerned with gathering, manipulating, storing, retrieving, and classifying recorded information using computing machinery [11]. In other words, computing consists of computing science, computing technology, computing engineering, computing system [1], computing intelligence, computing management, computing tool, computing application, computing service, computing product, computing industry, and more. From a scientific perspective, briefly,

$$\text{Computing} := \text{computing science} + \text{computing technology} + \text{computing engineering} + \text{computing system} + \text{computing intelligence} + \text{computing management} + \text{computing X}. \quad (1)$$

where X = {*x* | a keyword together with computing that has a big impact on academia, industry, and society}. For example, X = {tool, service, application, product, industry, society}, based on the above analysis. Equation (1) is a unified representation of computing as a superdiscipline or as a meta discipline, a set of disciplines underpinned by computing [1], Meta as a term is a kind of abstraction and generalization, as shown in Equation (1).

From an epistemological perspective, Equation (1) implies that computing has put science, technology, engineering, system, intelligence, and management at the same (disciplinary) level. Therefore, whenever one thinks about computing, s/he should also think about corresponding science, technology, engineering, system, intelligence, management, and more. This is a kind of natural deduction and natural association (also see Section II).

Many years ago, the author read and studied a computing dictionary, which has not classified computing in the above way. However, it covered all the above items. In reality, two examples of computing science as disciplines are computer science and data science [1]. Two examples of computing engineering as disciplines are computer engineering and software engineering. An example of computing technology as a discipline is information technology. Three examples of computing management as courses offered by many universities around the world are data management, information management, and knowledge management. An example of a computing system as a discipline is information systems. Three examples of computing intelligence as courses or research fields are artificial intelligence, machine intelligence, and business intelligence [7], [9]. Artificial intelligence has become a discipline in many countries. Furthermore, for computing *x*, an example of a computing tool is Windows Office Suite. An example of a computing application is Tik Tok. An example of a computing service is social networking services such as WeChat and WhatsApp, both are popular in China and the world. Therefore, based on the Computing Curricula 2020 (CC 2020) of ACM (Association for Computing Machinery) and IEEE, computing, as a superdiscipline, consists of computer science, data science, computer engineering, software engineering, information technology, information systems [1]. Briefly, from a discipline perspective, at the moment,

Computing = computer science + data science + computer engineering + software engineering + information technology + information systems + cybersecurity. (2)

Computing disciplines have not followed equation (1) to develop the computing y in a unified way, where y = {science, engineering, technology, system, intelligence, management, …,}. Instead, its disciplines have not used computing as a part of their names at a discipline level. This might have some historical reason and be pragmatic. For example, in the 1970s. computer science, computer engineering, and information systems had become disciplines [1]. At that time, computers and information were the greatest expectations of human beings and society. Computers as computing machinery were the dream of ordinary people to have and to use. Therefore, ordinary people hoped to study science and engineering behind computers. Information systems as a discipline promotes the inception of information technology as a discipline. Software engineering is the response to the transformation of society and a new vision for the development of computing. Microsoft and other software's business success expedited the inception of software engineering as a discipline.

It should be noted that every element of the above-mentioned set y is used at a discipline level or higher level based on the expectation and dreams of human beings and society. One can find that the university of science and technology, the university of engineering, and the school of management…, all reflect the expectation and dreams of human beings and society for science, technology, engineering, and management, …, to the future generation. It is very regretful that there is still not yet a university of service, although the author has been calling for its founding since 2007.

In Equation (2), computing has been embodied in another way, that is, computers, information, data, and cybersecurity are at the center of computing. In the past two thousand years, human beings have really developed only two words, to some extent. One is information, and another is data because both terms had not been mentioned by Aristotle in his metaphysics [12].

The mentioned five disciplines except data science have been in the Computing Curricula of the ACM and IEEE at least since 2005 (ACM CC2005). Data science is the first time to become a discipline of the Computing Curricula of the ACM and IEEE in 2020, although database management has been popular since 1970. In addition, data science as a discipline also covers data engineering, data system, data service, big data, and data analytics [1]. The data system here at least includes a database system, data mining system, data warehouse system, data analytics system, and data management system [13], [14].

Data management, information management, and knowledge management have not yet been listed as disciplines in the Computing Curricula of the ACM and IEEE. However, they have been undergraduate or postgraduate computing degree programs or courses offered by many universities globally since the 1980s. Data management, information management, and knowledge management are also research fields for computing researchers, scholars, and beyond. In this direction, intelligence management and wisdom management might be degree programs or courses in the future if either of them has not yet been, because artificial intelligence is still in a stage of having intelligence without wisdom [15]. Wisdom to be engineered and managed has been the expectation and dream of human beings in the past more than two thousand years.

The evolution of computing in the past decades has demonstrated that one computing science can lead to J different computing technologies. One computing technology can require and lead to K different types of computing engineering. One computing engineering can require and lead to L computing tools. One computing tool can require and lead to M computing services. One computing service can lead to N computing applications. J, K, L, M, N are integers. Each of them might be dozens or hundreds, and more, as illustrated in Fig 1.

It should be noted that "informatics" or "information and communication technology (ICT)", "Informatique", and "Informatik" with a similar meaning to the term computing represent a field and a discipline [1]. However, to the knowledge of the author, European countries prefer "Informatique" in France (since 1964), "Informatik" in Germany, and informatics in the UK. More generally, "Informatics for All" is a new coalition involving ACM Europe, Informatics Europe, and the Council of European Professional Informatics Societies (CEPIS) [1]. This once again shows that European countries prefer informatics than computing. China prefers computer science and technology. The difference between informatics (also Informatique and Informatik) and computing is that the former emphasizes the information as the basis for developing a science and technology, while the latter emphasizes the compute, and calculation as the basis for developing the science and technology. In other words, computing is compute-centered science, engineering, technology, system, and management. Therefore, the former emphasizes the importance of artificial resources, that is, information, while the latter emphasizes the importance of compute as an artificial process. Both will be embodied by science, engineering, technology, system, intelligence, and management, and provide tools, products, and services to the people and society.

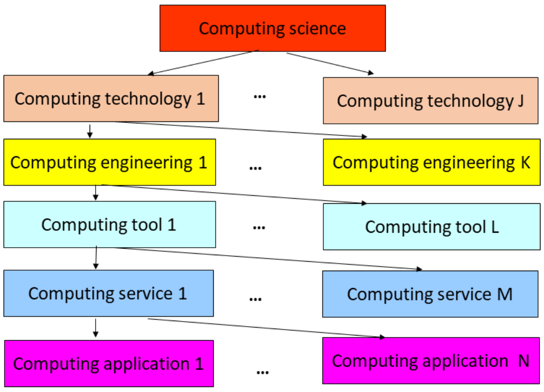

Fig. 1. A hierarchical perspective on computing science with applications.

V. Problem Driven Computing

Problems, issues, needs, and challenges are the most motives for social and technological development. An era has its own problems, issues, needs, and challenges. Research has a few research problems and issues to address. One has his or her own problems, needs, and challenges which are independent of whether one is rich or poor. It seems this is the problem law of a human's life.

Usually, we do not know the problems, issues, needs, and challenges around us. We do not care about problems, issues, needs, and challenges ahead of us. This makes us happy, and we enjoy a normal life in the competitive world except for suffering from the COVID-19 pandemic.

However, from a viewpoint of research and development, we have to identify the problem, classify the problem, assess the problem, and provide solutions to the problem. In what follows, we focus on the classification of problems and then look at problem-driven computing, based on the generalization and specification as a research method, illustrated in Fig. 2.

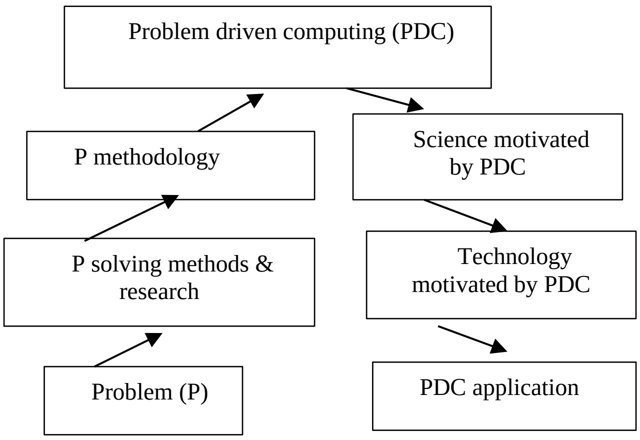

Fig. 2. The generalization and specification of problem-driven computing.

Problems can be classified into categories of scientific problems, mathematical problems, engineering problems, managerial problems, systems problems, intelligence problems, research problems, business problems, political problems, and international problems, to name a few. Science, engineering, and technology address each of these problem categories.

The artificial things' problems can be classified as data problems, information problems, and knowledge problems. Then problem-driven computing can include data computing, information computing, and knowledge computing. Although each of them has not become a computing discipline, it has been studied in academia as a research direction or it has become a subject or course in a computing discipline. A Google Scholar search for "data computing", "information computing", and "knowledge computing" found 41,600 results, 16,300 results, and 1,580 results respectively (accessed on May 13, 2022). This implies that data computing, information computing, and knowledge computing have been studied significantly by academia.

In business operation activities, system developments, and medical/clinical practices, a class of problems can be classified into four categories, that is, descriptive problems, diagnostic problems, predictive problems, and prescriptive problems.

The descriptive problems include what happened? What is happening [16]

The diagnostic problems include why did it happen? Why is it happening? [17].

The predictive problems include what will happen? What will it happen? What is likely to happen in the future?

The prescriptive problems include what should we do? What should I do it? How should we do optimally? How should I do it in order to realize my dream for the future? What is going on to achieve the best performance possible [16].

Descriptive, diagnostic, predictive, and prescriptive can be abbreviated as DDPP. Then all these classified problems can be abbreviated as DDPP problems. DDPP problems have been addressed by a great number of professionals and academia in the past centuries. Therefore, the problem-driven computing to address these four categories of problems are descriptive computing, diagnostic computing, predictive computing, and prescriptive computing. All these four types of computing are emerging research fields for competing for competitive advantages in the world. Then, the following holds.

$$\text{DDPP computing: = descriptive computing + diagnostic computing + predictive computing + prescriptive computing} \tag{3}$$

Equation (3) implies that computing as an operation satisfies the right distributive law.

DDPP computing or the four types of computing in equation (3) can be together named as meta-operation computing.

A Google Scholar search for "descriptive computing", "diagnostic computing", "predictive computing", and "prescriptive computing" found 61 results, 5610 results, 301 results, and 23 results, respectively (accessed on May 13, 2022). This implies that diagnostic computing and predictive computing have drawn significant attention in academia.

Prescriptive computing has not yet drawn a lot of attention so far, because no research publication's title has it as a keyword. Therefore, prescriptive computing is worth attention and deserves research and development in academia and industry.

Based on equation (1) (the x related part has been ignored in the equations from a disciplinary perspective, hereafter), the following also holds

DDPP Computing: = DDPP science + DDPP engineering + DDPP technology + DDPP system + DDPP intelligence + DDPP management (4)

Equation (4) theoretically shows that DDPP science, that is, descriptive science, diagnostic science, predictive science, and prescriptive science should draw much attention in academia and industry. A Google Scholar search for "descriptive science", "diagnostic science", "predictive science", and "prescriptive science" found 10100 results, 3490 results, 8840 results, and 1110 results, respectively (accessed on May 13, 2022). These search results demonstrate that

1) The scholars prefer science rather than computing. In other words, science has played more roles in research and development in academia.
2) Compared with DDPP computing, DDPP science has drawn mzuch more attention in academia.
3) Descriptive science and predictive science are two more productive research areas in academia.
4) Similar research methods can be extended to analyze the impact of DDPP engineering, DDPP technology, DDPP system, DDPP intelligence, and DDPP management on academia.

It should be noted that on the right side of equation (4), computing has been ignored from each item like DDPP science, that is, DDPP science is simplified from DDPP computing science. In fact, computing plays a foundational and underpinning role in developing each item on the right side of equation (4), but in an invisible way. If emphasizing the importance of computing, each of them can be represented computing driven DDPP science, technology, system, intelligence, and management. This representation and treatment of computing reflects the corresponding research fields more closely with computing. We will use this method hereafter, if necessary.

Data analytics and big data analytics have become a frontier in the research and development of big data and big data technologies [17]-[19]. An example of descriptive computing, diagnostic computing, predictive computing, and prescriptive computing is descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics, respectively. Descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics are a classification of analytics, abbreviated as DDPP analytics [17], [18]. This classification can be obtained by replacing computing in equation (3) with analytics, taking into account the right distributive law, as follows:

DDPP analytics: = descriptive analytics + diagnostic analytics + predictive analytics + prescriptive analytics (5)

More generally, based on equation (4), DDPP analytics can be represented as

DDPP analytics: = DDPP analytics science + DDPP analytics engineering + DDPP analytics technology + DDPP analytics system + DDPP analytics intelligence + DDPP analytics management (6)

This is because analytics science, analytics engineering, analytics technology, analytics system, analytics management, analytics service, analytics tool, and analytics application, have been mentioned in many research publications [20], [21].

In summary, problems are first classified into DDPP problems, and DDPP analytics addresses DDPP problems to produce DDPP intelligence. From a systemic viewpoint, DDPP problems should be the input of the system. DDPP analytics is the process of the system. DDPP intelligence is output of the system, as illustrated in Fig. 3. DDPP intelligence is the aim of using DDPP analytics to address DDPP problems.

It should be noted that in the business setting, DDPP problems can be considered operation problems. Therefore, DDPP computing and DDPP analytics can be operation computing and operation analytics. Operation analytics is a meta-analytics because it is a kind of analytics of descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics.

Fig. 3. DDPP problems, analytics, and intelligence.

VI. ESMACS COMPUTING

This section examines eSMACS computing as problem-driven computing in the digital age. This section can be considered an extension of problem-driven computing discussed in the previous section.

We are living in the digital age. eSMACS (electronic, social, mobile, analytics, cloud, security) services, introduced by Sun and Wu [22], have been ubiquitous in the world. In other words, social networking services, mobile services, analytics services, cloud services, and security services have been thoroughly revolutionizing our work, life, economy, and society [22]. At the same time, we have encountered a variety of eSMACS issues, that is, electronic issues, social networking issues, mobile issues, analytics issues, cloud issues, and security issues. All these issues require computing to address. Using a meta-approach and natural association from problem-driven computing, eSMACS services should be generalized to eSMACS computing, that is, electronic computing, social (networking) computing, mobile computing, analytics computing, and security computing. Simply, they can be articulated below in a unified way.

eSMACS computing = electronic computing + social (networking) computing + mobile computing + analytics computing + security computing. (7)

Based on Equation (1), eSMACS computing can be also articulated below:

eSMACS computing:= eSMACS science + eSMACS engineering + eSMACS technology + eSMACS system + eSMACS intelligence + eSMACS management (8)

In practice, eSMACS computing aims to create eSMACS intelligence to serve business, work, and life of the people in the world. In summary, the relationship between eSMACS services, eSMACS computing, and eSMACS intelligence is illustrated in Fig. 4 below.

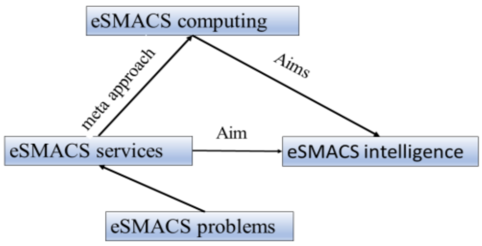

Fig. 4. The relationship between eSMACS problems, services, computing, and intelligence.

Fig. 4 shows that both eSMACS services and eSMACS computing aim to create eSMACS intelligence.

It should be noted that eSMACS computing is not based on the search and observation in the web world or physical world. It is directly based on eSMACS services, natural association, and deduction (also see Section II) as well as a meta approach. It is a transcendence from a service level to a computing level because computing is about computing science, computing technology, computing engineering, computing system, computing intelligence, and computing management, concerned with gathering, manipulating, storing, retrieving, and classifying recorded data, information, knowledge, experience, intelligence and wisdom using computing machinery [1], [11].

In order to address how the eSMACS computing ha impacted our lives, economies, academia and societies, we searched each of the eSMACS computing using Google and Google Scholar. The former can be considered as the state of the art the corresponding computing' influences on our lives, economies, and societies while the latter can be considered as the state of the art the corresponding computing' influences on the academia. Google (*m*) and Google Scholar (*n*) represent the results of a Google search and Google Scholar search. For example, a Google search for "electronic computing" found 613,000 results, while a Google scholar search for "electronic computing" found 16,200 results. These searches were conducted on May 12, 2022. The search results have been summarized in Table I.

In what follows, we will examine eSMACS computing in some detail using the principle of research as a search, to verify the soundness and rationale of eSMACS computing.

Electronic computing has not been independent definition. However, it has been used as a part of electronic computing machines since 1947. Furthermore, Google Scholar focuses on the search for electronic computing + x, where x consists of technique, machine, device, printing, publisher, copying, equipment, and digitalization, based on the search optimization, that is, we use the singular word in the process of search.

TABLE I: eSMACS COMPUTING AND ITS IMPACTS ON SOCIETY AND ACADEMIA

eSMACS	Google (m)	Google Scholar (n)
electronic	Electronic computing (613,000)	Electronic computing (16,200)
Social (networking)	Social (networking) computing (1,600,000)	Social (networking) computing – (167,000)
mobile	Mobile computing (14,700,000)	Mobile computing (917,000)
analytics	Analytics computing (26,800)	Analytics computing (709)
cloud	Cloud computing (354,000,000)	Cloud computing (941,000)
Security	Security computing (48,500)	Security computing (3,780)

Social computing can be defined as "interactive and collaborative behavior between computer users. Personal computing is an individual user activity in that one user generally commands computing" [23]. Google Scholar focuses on recommending the results based on the user's search for social computing x, where x consists of ACM, online communities, modeling and prediction, behavioral-cultural modeling, cooperative work, human-computer interaction. In addition, the recommended results include searching for pervasive "social computing" and CSCW "social computing".

Mobile computing is defined as "the set of IT technologies, products, services, and operational strategies and procedures that enable mobile end-users to gain access to computation, information, and related resources and capabilities" [24]. Google Scholar focuses on recommending the results based on the user's search for mobile computing x, where x consists of devices, communications, transactions, environments, data management, and security issues. In addition, the search results include searching for "wireless mobile computing" or "pervasive mobile computing".

Analytics computing has not been defined in the existing literature based on Google search. However, analytics is the systematic computational analysis of data or statistics. It is used for the discovery, interpretation, visualization, and communication of meaningful patterns in data. It also entails applying data patterns toward effective decision-making mentioned by Wikipedia (accessed on May 17, 2022). Based on equation (1) and discussion in Section V analytics computing can be defined as a research field about computing-driven analytics science, analytics technology, analytics engineering, analytics system, analytics intelligence, analytics management, and their applications [20]. The Google scholar search demonstrates that analytics computing has not drawn significant attention in academia. In addition, the search results include from searching for pervasive analytics data computing.

Cloud computing is defined by NIST as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [25]. This cloud model is composed of five essential characteristics, three service models, and four deployment models. Google

Scholar focuses on recommending the search results based on the user's search for cloud computing x, where x consists of security, scheduling, virtualization, load balancing, resource allocation, issues, and challenges. In addition, the search results include searching for "NIST cloud computing" or "SAAS cloud computing".

Security computing has not been defined in the existing literature based on the Google search (retrieved on May 27, 2022). Security computing can be defined as a research field for computing-driven security science, security technology, security engineering, security system, security intelligence, and security management. Google Scholar focuses on recommending the search results based on the user's search for x security computing, where x consists of cloud, cyber, transaction, cryptography, encryption, vehicular, dependable, and mobile. In addition, the results include searching for "security computing internal attacks" or "security computing pfleeger"(as a book [26]). Google searches, conducted on May 22, 2022, demonstrate that security science, security technology, security engineering, security system, security intelligence, and security management have drawn significant attention in academia and industry [26] [1]. Therefore, security computing can be briefly articulated as

Security computing: = security science + security technology + security engineering + security system + security intelligence + security management (9)

The above definitions and Google searched for eSMACS computing demonstrate that none of the eSMACS computing pursues computing science, engineering, or technology, … so that each of eSMACS computing can only be treated as a research field. It is difficult for each of them to become a discipline in the near future, although each of them or a few of them together can become a course or subject in existing computing disciplines such as computer science, data science, and information technology. Even so, analytics computing and security computing might become disciplines in the future, because analytics and security will become the center of the digital economy, life, and digital society.

In summary, eSMACS computing and services have been dramatically influencing the digital economy, life, and digital society, based on the research of Sun [11], eSMACS computing should be named digital computing, that is,

Digital computing = eSMACS computing (10)

Therefore, digital computing is a meta computing and an example of problem-driven computing.

VII. Related Work and Discussion

The classification of analytics into descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics motivates us to develop corresponding descriptive computing, diagnostic computing, predictive computing, and prescriptive computing [18] [17]. However, the classification of analytics cannot correspond to the classification of computing into the mentioned four types of computing. We can consider analytics as an example of special computing, based on our understanding and teaching experience of analytics and computing in the past few decades. This is also the reason why we mentioned computing is a big concept, at least it is bigger than analytics.

X computing and computing X have also been mentioned in [1], where 'X' is the established non-computing domain usually in science, business, or humanities from the discipline perspective of ACM, IEEE, and AIS, because these three organizations have played an overriding role in the development of Computing Curricula 2020 (CC 2020). However, in our research, X is a set of keywords *x*, that is, X = {*x*| *x* is a keyword that corresponds to a problem or a field where *x* requires science, engineering, technology, system, management, and intelligence to address, at least, from a researcher perspective}. Then *x* computing might be introduced by a researcher or an explorer when s/he undertakes or conducts a research project or publish a research article or book or other media. For example, intelligence is a lasting problem in the past, present, and future. It requires science, engineering, technology, system, management, etc. to work together to address this problem, then the researchers introduce intelligence computing in a unified way below.

Intelligence computing: = intelligence science + intelligence engineering + intelligence technology + intelligence system + intelligence management. (11)

The author used equation (11) to develop and teach a course for postgraduate students at a university from 2007 to 2009. In reality, researchers have not used this unified representation (11) to understand and identify their research and development. Intelligence science has been replaced by artificial intelligence and machine intelligence, intelligence engineering by intelligent engineering, intelligence technology by intelligent technology, and intelligence system by intelligent systems respectively.

eSMACS service and computing were first introduced in 2014 [11] [22]. SMAC (social media, mobility, analytics, and cloud computing) was introduced by Ghavami in 2020 [18]. Both use an acronym to examine either computing or analytics phenomena, but independently. eSMACS covers much more than SMAC in terms of not only analytics [18], but also computing, science, technology, system, intelligence, and management, as discussed in the previous sections. Moreover, the second S in eSMACS can use service as an alternative, because service in general, e-service, social networking service, mobile service, analytics service, cloud service, and service as a web service dominates the digital society [22]. Service computing can be an alternative of security computing in eSMACS computing [11]. Service computing can be defined as "a computing paradigm to develop software applications as "services", which are autonomous, platform-independent computational entities which can be combined in numerous ways to achieve business goals." [27]. Service computing is also a research field about service science, service technology, service engineering, service system, service intelligence, service management, and service application" (IGI, 2022) [1]. This definition is similar to that of analytics computing and security computing (see the previous section). Both are based on equation (1). This implies that equation (1) is not only a definition for computing but also a methodology for defining other computing concepts such as analytics computing, security computing, and service computing.

From a mathematical viewpoint, Equations (1) (4) (8) and (11) have mathematical beauty. This beauty lies in the beautiful relationships between Equations (1), (8), and (11). The beauty also lies in the beautiful application of natural deduction and natural association to develop problem-driven computing, analytics, intelligence, and eSMACS computing.

VIII. Conclusion

Computing is ubiquitous with applications in almost every field, visible, and imaginable. It has become more pervasive among a number of academic disciplines, beyond just the practical use of ubiquitous software tools [1]. This article explores a strategic approach to problem-driven computing and analytics. More specifically, it presents a disciplinary perspective on computing. It examines problem-driven computing, DDPP computing, DDPP analytics, eSMACS computing, intelligence computing, service computing and their problem-driven interrelationships. From a meta viewpoint, one of the main contributions of this research is that computing as a meta discipline consists of computing science, computing engineering, computing technology, computing system, computing intelligence, computing management and computing X. The second contribution of this research is problem-driven computing. This research demonstrates that a class of problems can be classified into four categories: descriptive problems, diagnostic problems, predictive problems, and prescriptive problems. Each of these problems drives the research and development of corresponding computing, that is, descriptive computing, diagnostic computing, predictive computing, and prescriptive computing, abbreviated as DDPP computing. DDPP computing is the example of problem-driven computing. The third contribution of this research is that analytics can be classified into descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics, abbreviated as DDPP analytics, each of them is an example of descriptive computing, diagnostic computing, predictive computing, and prescriptive computing, respectively. As a digital computing, eSMACS computing is also the example of problem-driven computing. The relationship between computing and analytics has methodological significance. It is significant to use a meta-approach to deeply investigate analytics computing, which consists of analytics science, analytics engineering, analytics technology, analytics system, analytics intelligence, and analytics tools [20].

In future work, we will elaborate on the abstraction and generalization of problems to problem-driven computing and the specification of problem-driven computing with real-world applications (see Figure 1). We will develop a unified computing and analytics for the Internet of Everything (IoE), the Internet of Things (IoT), the Internet of People (IoP), and the Internet of Services (IoS) based on IoE = IoT + IoP + IoS.

Conflict of Interest

The author declares no conflict of interest.

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