فضای سایبر

جلسه ۱۹

مدل‌سازی فضای سایبر

Cyberspace Modelling

کاظم فولادی قلعه
دانشکده مهندسی، دانشکدگان فارابی
دانشگاه تهران

http://courses.fouladi.ir/cyber

مدل‌سازی فضای سایبر

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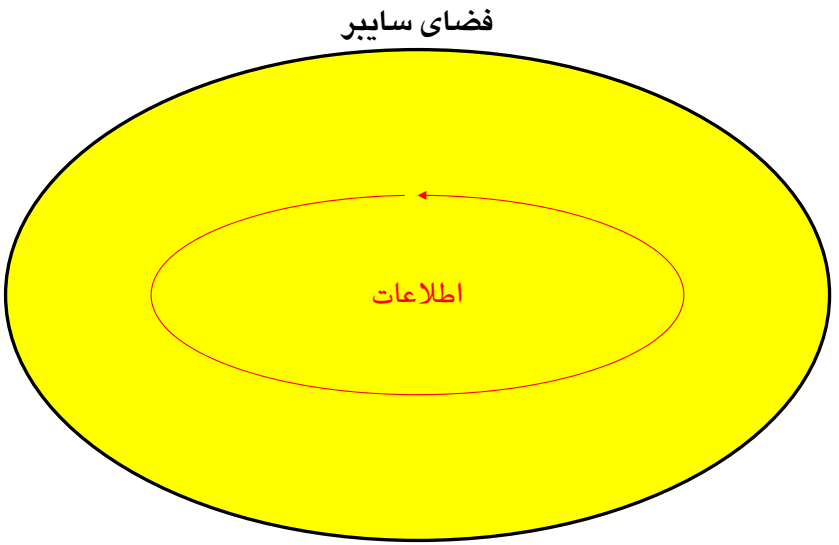
چارچوب مفهومی فضای سایبر

فضای سایبر

فضای سایبر *Cyberspace*	فضای کنترل = فضای تغذیه‌ی هدف‌مند اطلاعات



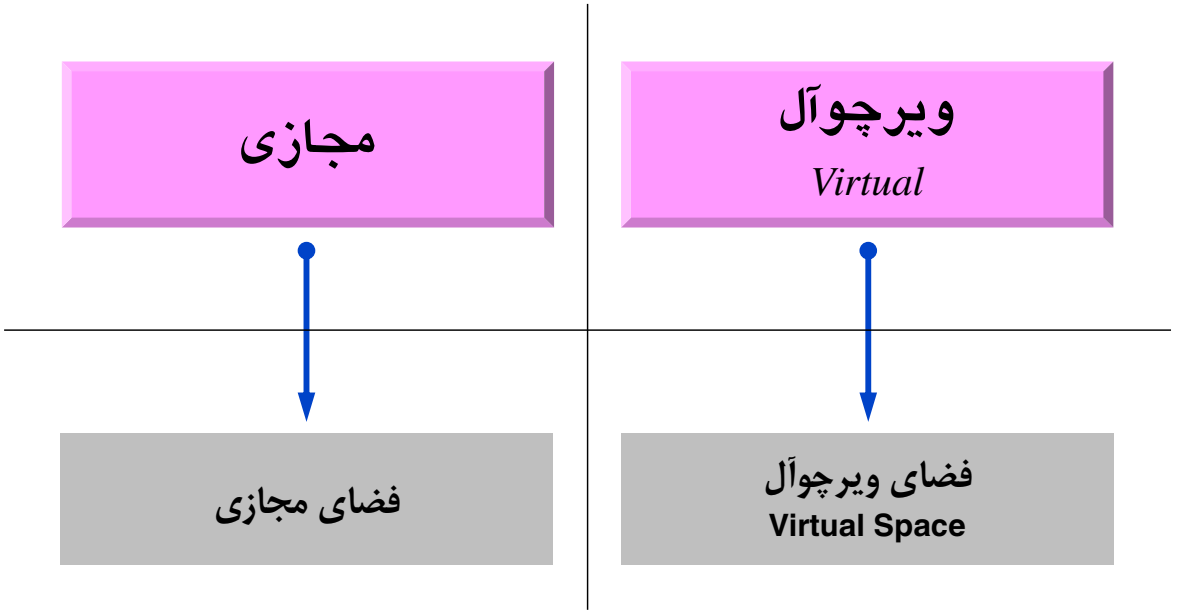
تعریف‌های رسمی از فضای سایبر

AN OVERVIEW OF OFFICIAL DEFINITIONS OF CYBERSPACE IN GOVERNMENTAL DOCUMENTS

"Cyberspace is the electronic world created by interconnected networks of information technology and the information on those networks. It is a global commons where more than 1.7 billion people are linked together to exchange ideas, services, and friendship." **—— Canada, "Canada's Cyber Security Strategy", 2010 [31].**
"Cyberspace is the virtual space of all IT systems linked at data level on a global scale. The basis for cyberspace is the Internet as a universal and publicly accessible connection and transport network which can be complemented and further expanded by any number of additional data networks. IT systems in an isolated virtual space are not part of cyberspace." **—— Germany, "Cyber Security Strategy for Germany", 2011 [32].**
"Cyberspace is the global network of interdependent information technology infrastructures, telecommunications networks, and computer processing systems in which online communication takes place." **—— New Zealand, "New Zealand Cyberspace Strategy", 2011 [33].**
"Cyberspace is an interactive domain made up of digital networks that are used to store, modify and communicate information. It includes the internet, but also the other information systems that support our businesses, infrastructure and services." **—— United Kingdom, "The UK Cyber Security Strategy", 2011 [34].**
"Cyberspace is the complex environment resulting from the interaction of people, software and services on the Internet by means of technology devices and networks connected to it, which does not exist in any physical form." **—— ISO/IEC, ISO/IEC 27032, "Guidelines for cybersecurity (DRAFT)", 2011 [35].**
"A global domain within the information environment consisting of the interdependent network of information technology infrastructures, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers." **—— United State, "DoD Dictionary of Military and Associated Terms", 2009 [36].**
"Cyberspace is a global domain within the information environment consisting of the interdependent network of information technology infrastructures and resident data, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers." **—— United State, "DoD Dictionary of Military and Associated Terms", 2013-2017 [37].**
"Cyberspace is the overall system of interconnected computer infrastructures, including hardware, software, data and users, as well as the logical relationships among them, regardless of how they are established." **—— Italy, "Decree of the President of the Council of Ministers (DPCM)", 2013 [38].**

Ref: Ning et al. "General cyberspace: Cyberspace and cyber-enabled spaces." IEEE Internet of Things Journal 5, no. 3 (2018): 1843-1856.

نسبت «ویرچوآل» با «مجازی»



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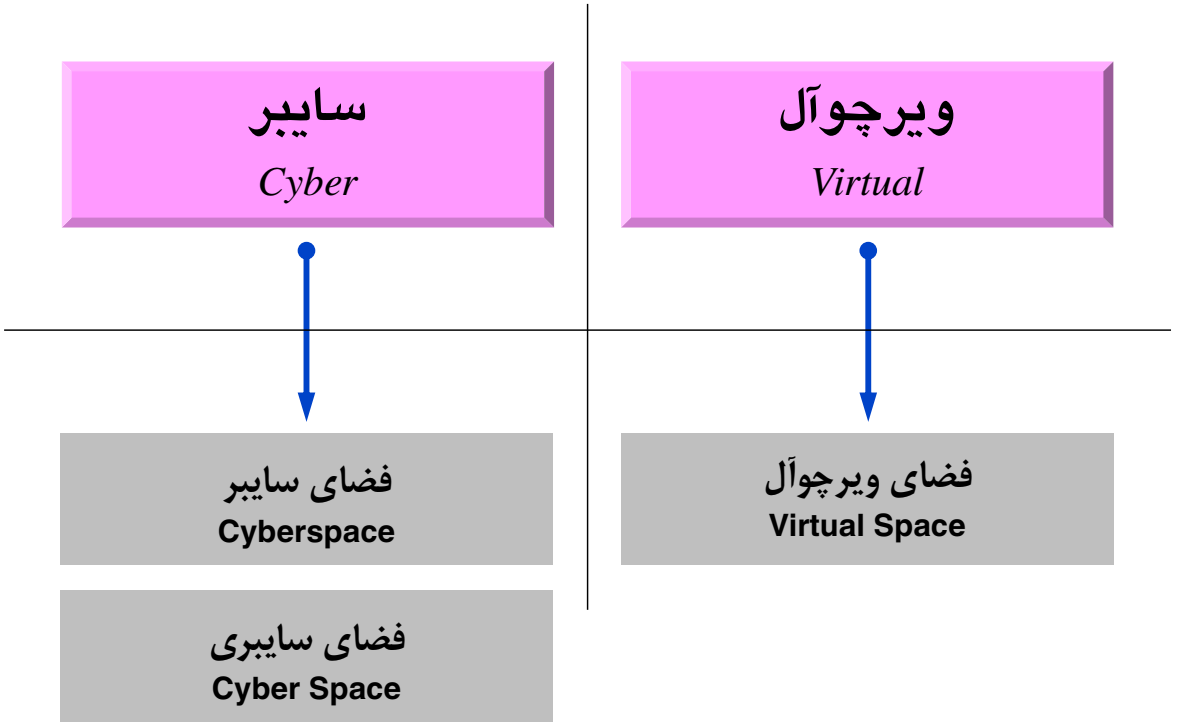

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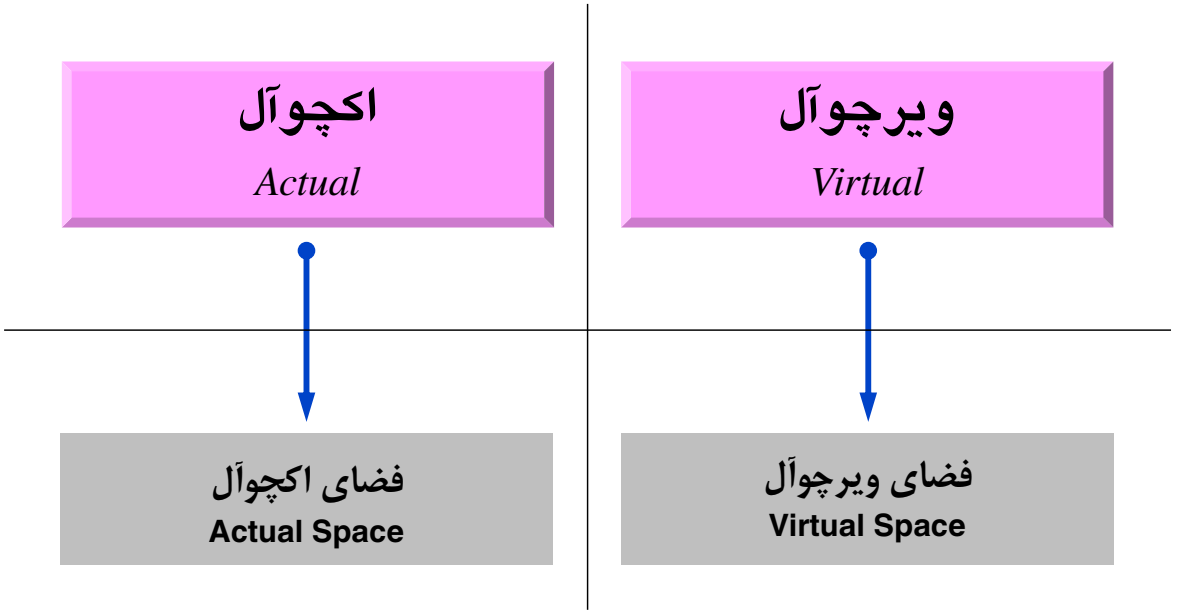

نسبت‌شناسی مفاهیم

سایبر *Cyber*	ویرچوآل *Virtual*	مجازی
فیزیکال *Physical*	اکچوآل *Actual*	واقعی

مدل‌سازی فضای سایبر

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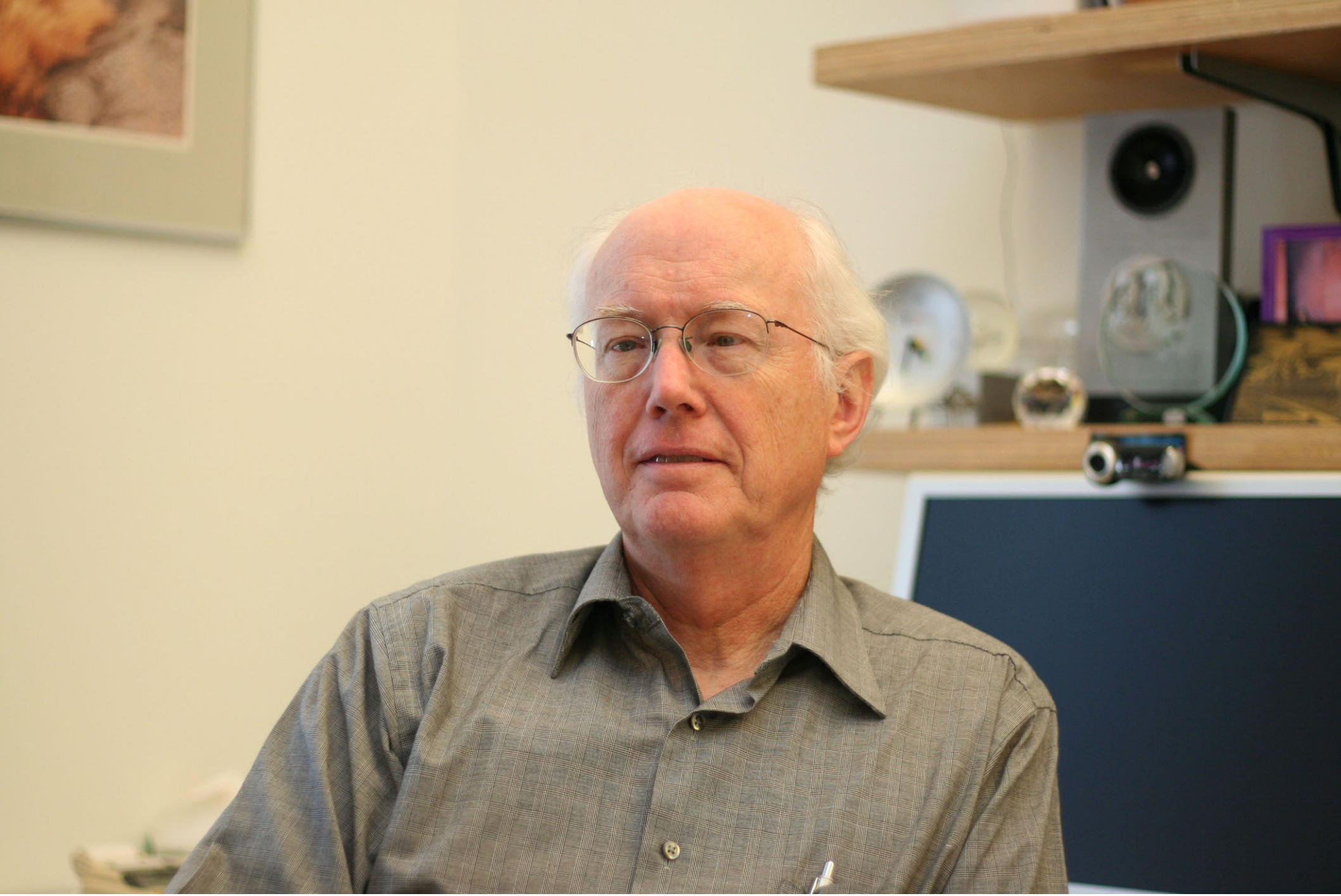
مدل‌های فضای سایبر

مدل چهارلایه‌ی فضای سایبر کلارک

CLARK'S 4-LAYER MODEL OF CYBERSPACE

Ref: Clark, David. "Characterizing cyberspace: past, present and future." MIT CSAIL, Version 1 (2010): 2016-2028.



David Dana Clark (1944-)

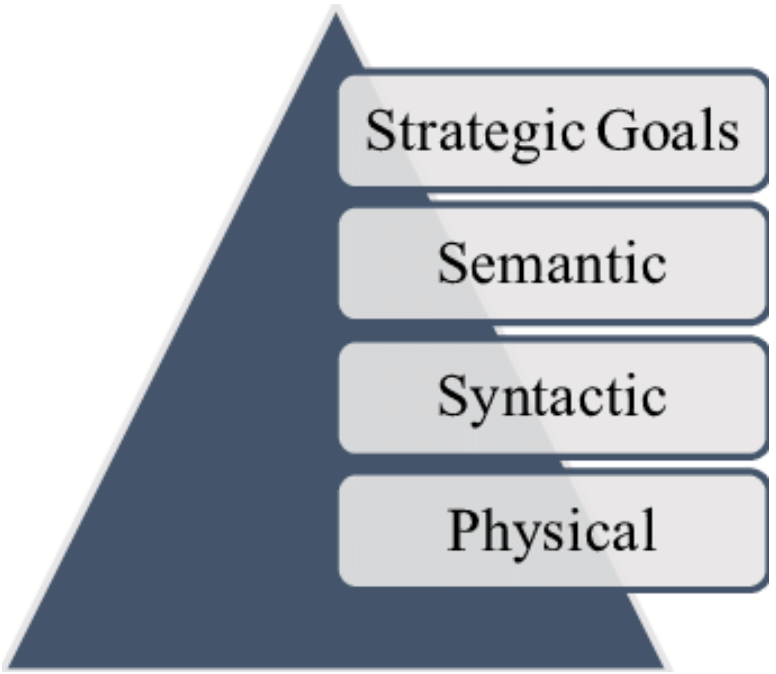
مدل چهارلایه‌ی فضای سایبر شلدون

SHELDON'S 4-LAYER MODEL OF CYBERSPACE

Ref: Sheldon, John B. "Deciphering Cyberpower: Strategic Purpose in Peace and War". Strategic Studies Quarterly 5, no. 2 (Summer 2011): 95-112.

مدل چهارلایه‌ی فضای سایبر گومز

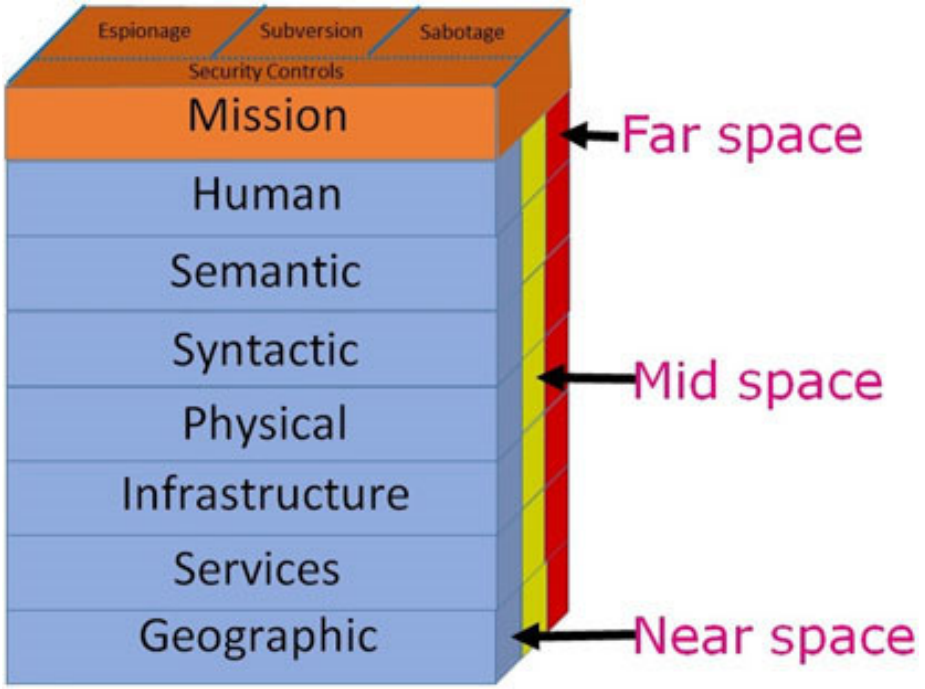
GOMEZ'S 4-LAYER MODEL OF CYBERSPACE



Ref: Gomez, Miguel Alberto. (2017). Victory in Cyberspace. IAFOR Journal of Politics, Economics & Law. 4. 10.22492/ijpel.4.1.04.

مدل هشت‌لایه‌ی فضای سایبر ونابلس

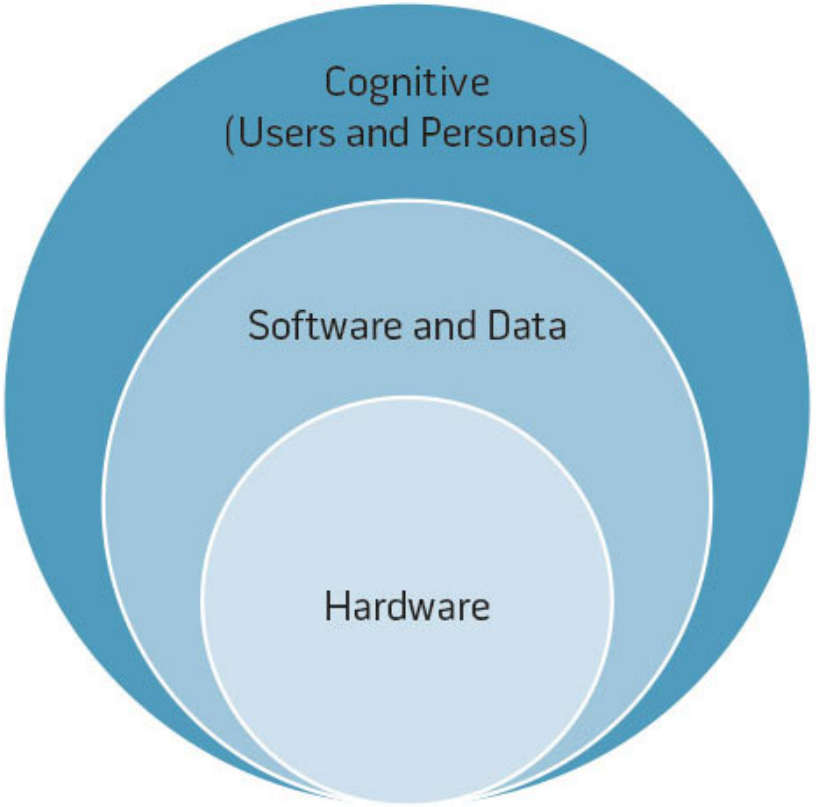
VENABLES'S 8-LAYER MODEL OF CYBERSPACE



Ref: Venables A (2021) Modelling Cyberspace to Determine Cybersecurity Training Requirements. Front. Educ. 6:768037. doi: 10.3389/feduc.2021.768037

مدل سه‌لایه‌ی فضای سایبر روسی

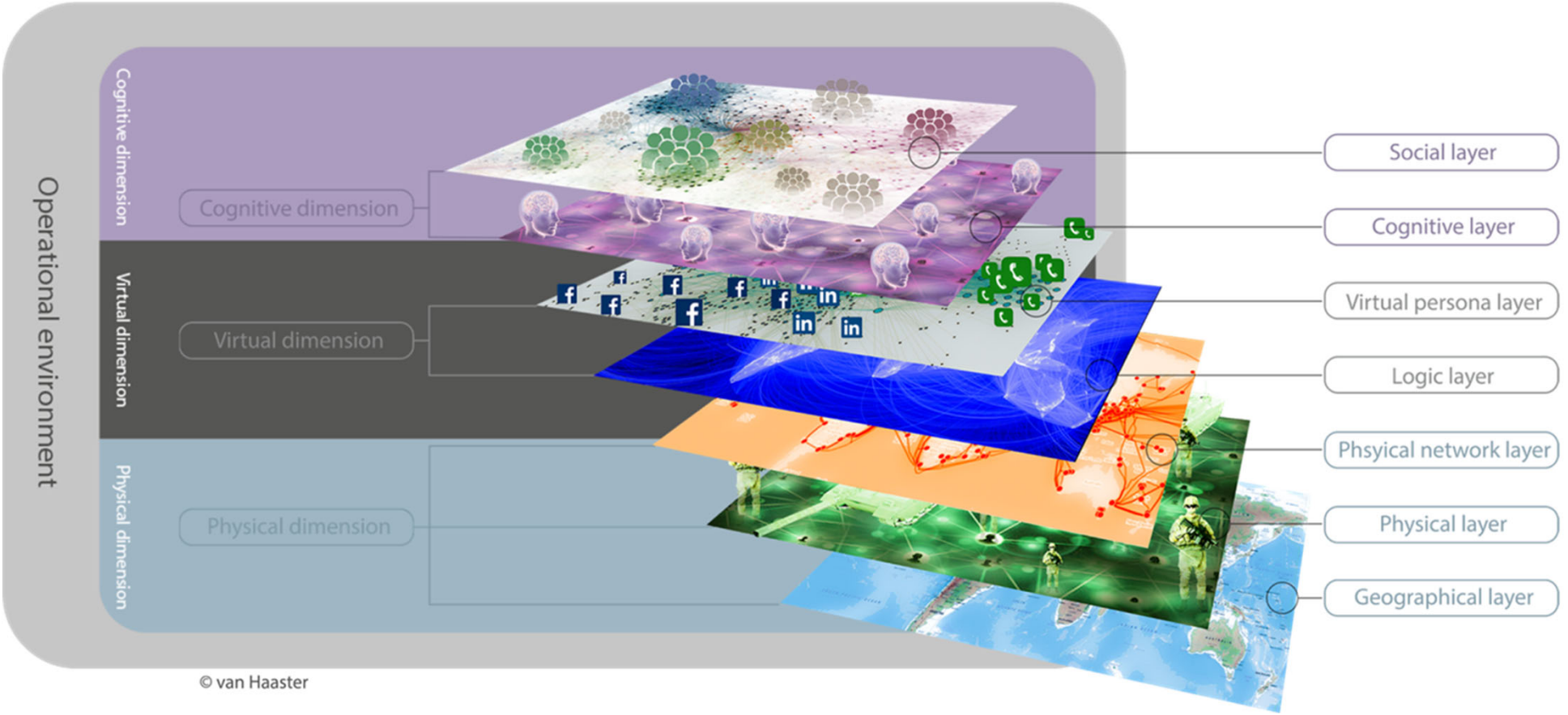
Russian 3-Layer Model of Cyberspace



Ref: http://www.intelros.ru/readroom/jfq/75-2014/24840-the-limits-of-cyberspace-deterrence.html

مدل هفت‌لایه‌ی آمریکا

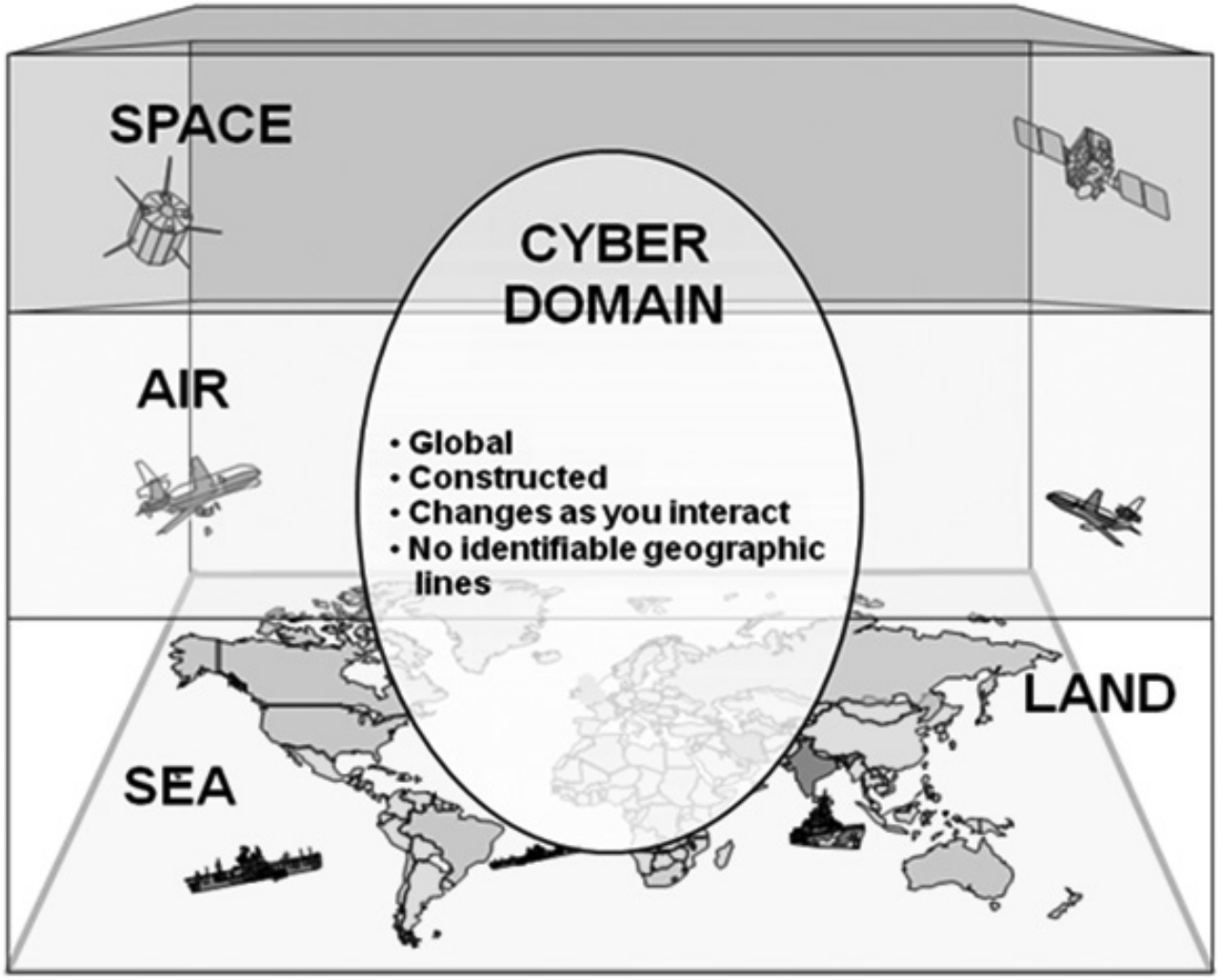
US 7-Layer Model of Cyberspace



Ref: https://faculteitmilitairewetenschappen.nl/cms/view/e4749768-c81b-431a-aa6e-4f73f9226d56/cyber-security-cyber-operations

نسبت دامنه‌ی سایبر با دامنه‌های زمین، دریا، هوا و فضا

مطابق با دکترین ارتش آمریکا



Ref: Waddell et al. Cyberspace operations: What senior leaders need to know about cyberspace. US ARMY WAR COLL CARLISLE BARRACKS PA CENTER, 2011.

General Cyberspace: Cyberspace and Cyber-enabled Spaces

Huansheng Ning, *Senior Member, IEEE,* Xiaozhen Ye, Mohammed Amine Bouras, Dawei Wei, and Mahmoud Daneshmand, *Member, IEEE*

***Abstract*—Cyberspace is the digital world created based on traditional physical, social, and thinking spaces (PST) but in turn makes a great difference on PST. The cyberization and the emergence of cyber-enabled spaces can be viewed as the bridge between cyberspace and PST, which reshaped the current definition of cyberspace and contributed to a novel concept "General Cyberspace (GC)". Generally, GC is a unified description of conventional cyberspace (also shortly cyberspace in this paper) and cyber-enabled PST. It essentially emerges from cyberspace based on ubiquitous connections between things and the deep convergence of spaces. This paper proposes the definition of GC and investigates it from its three main aspects: existence, interactions, and applications/services, respectively in terms of philosophy, science, and technology outlook.**

***Index Terms*—General cyberspace, cyber-enabled, cyber philosophy, cyber science, cyber-enabled technology, existence, interaction**

I. Introduction

Currently, as the fast development of information and computer technology, the term "cyberspace" is no doubt to become an increasingly attractive aspect of our daily life, work, and study. Originally, the term "cyberspace" appeared firstly in the artworks made by Susanne Ussing and Carsten Hoff to represent the idea of "sensory spaces", a physical room that can sense and adapt to human beings. In 1980s, the term was coined by Willian Gibson in his science fictions, "Burning Chrome" [1] and "Neuromancer" [2], in which it was described as "a graphic representation of data abstracted from banks of every computer in human system". Since that, its concept was prominently identified as the synonym of the digital world created by computers and received an enormous attention. So far, the term "cyberspace" has been widely used in various academic and technology studies by scholars, researchers, professionals, hobbyists, and hackers in relation to computer technologies and the globalization of network.

Cyberspace is a completely unprecedented space in human knowledge but still exists parallel with PST. Generally speaking, the concept of space in "cyberspace" tends to be abstract and mathematical without the duality of volume. Therefore, the cyberspace in the conventional sense is merely a virtual, digital world created based on various infrastructures such as computers, networks, data and information, hardware and software, etc., which we call conventional cyberspace or cyberspace in short. A large number of studies have been done to explore this sense of cyberspace from various perspectives (e.g. [3]–[12]). The success and popularity of relevant theories and technologies are pushing towards the conclusion that cyberspace is no longer confined to merely digital world but extends beyond it to involve various aspects of physical, social and even thinking space. In this case, an evolution of "cyber-enabled" (also cyberization, referring to "the process of formation of the new cyberspace and reformation of present PST towards cyber-enabled spaces" [13], [14]) is paving the way to a completely new environment where cyber-related elements permeate all spaces and all aspects of our life, which we call general cyberspace (GC). Some new words have been proposed as synonyms of general cyberspace in the diversity of relevant literature to envision the future world, such as smart world [15]–[20], hyperworld/hyperspace [21], and cyber-physical-social-thinking hyperspace (CPST) [19], [22], [23]. Furthermore, some related works have also been conducted with respect to the evolution process [18], [20], [21], characteristics [19], [24], related research areas or projects [20], [24], and future expectation of GC. However, none of these works made a precise definition of GC and little attention has been devoted to aspects of philosophy, science, and technology of GC.

With the deep permeation of cyberization to the real world, the aspects of cyber philosophy, cyber science, cyber technology, and their relations are increasingly emphasized in order to strive for a comprehensive understanding of cyberspace and cyber-enabled spaces as well as sorts of phenomena caused by cyberization. For example, in [25], the authors proposed the concept of "CyberSciTech" as an inter-discipline, trans-discipline, and multi-discipline integration of cyber science and cyber technology to present new perspectives on cyberization as well as emerging cyber-enabled spaces [26], [27]. They pointed out that cyber science is actually technology-driven knowledge collection about GC, which provides ways to understand and study complex phenomena in GC. Correspondingly, the term "Cybermatics" [13], [14], [28]–[30] was proposed as a scientific and systematic discipline to study cyber entities as well as its attributes, properties, behaviors, and practice in GC. However, their works have merely focused on related research topics and areas but lacked the discus-

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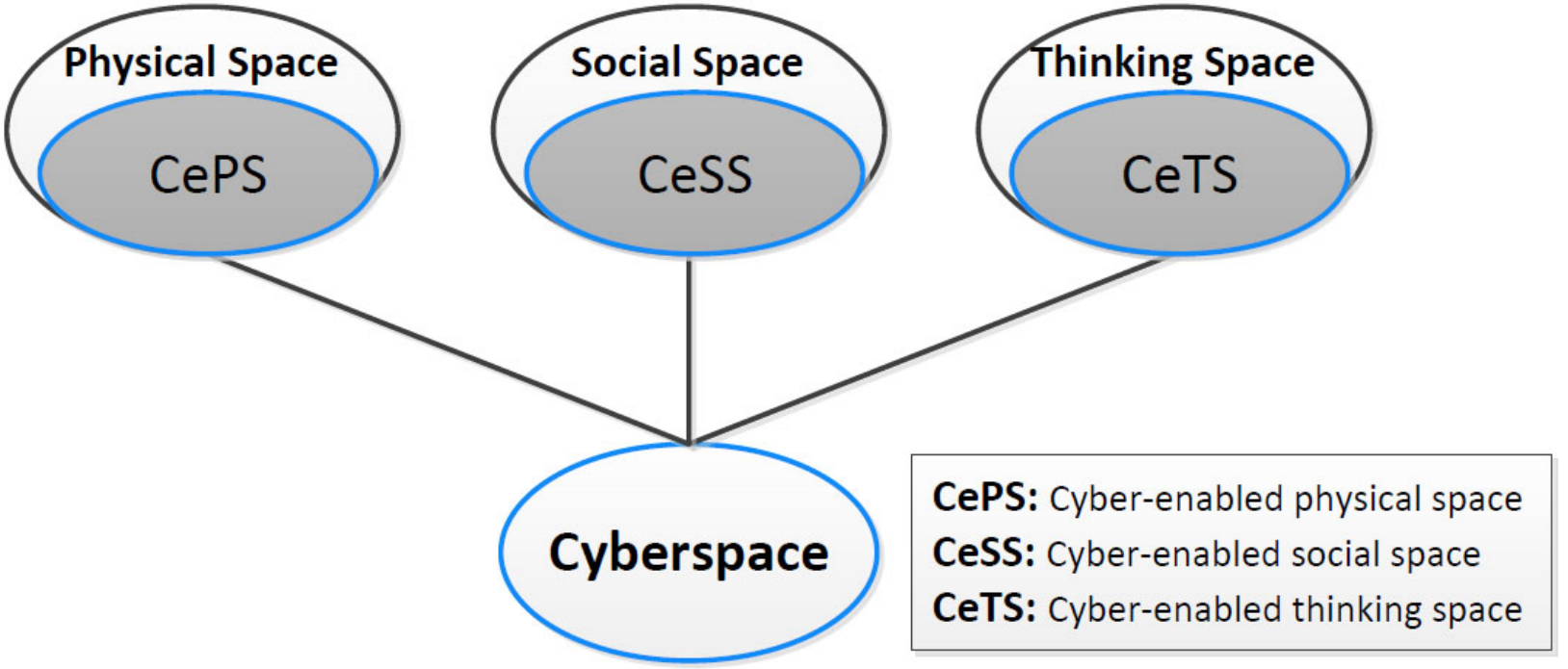
M. Daneshmand is with the Department of Business Intelligence and Analytics and the Department of Computer Science, Stevens Institute of Technology, Hoboken, NJ 07030 USA

فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

فضای سایبر عمومی و فضاهای سنتی

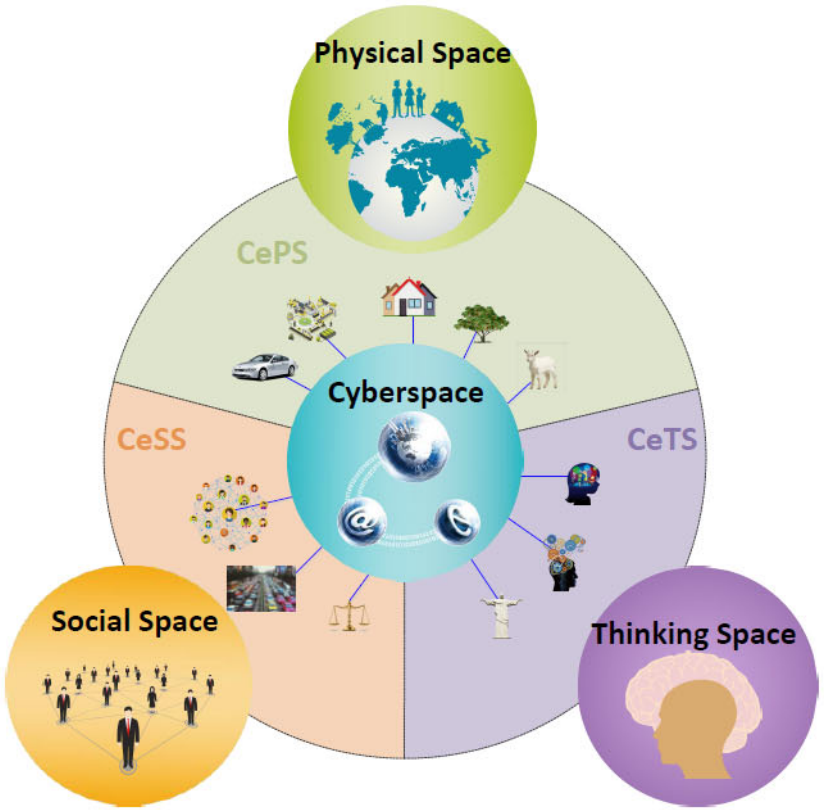
General Cyberspace and Traditional Spaces



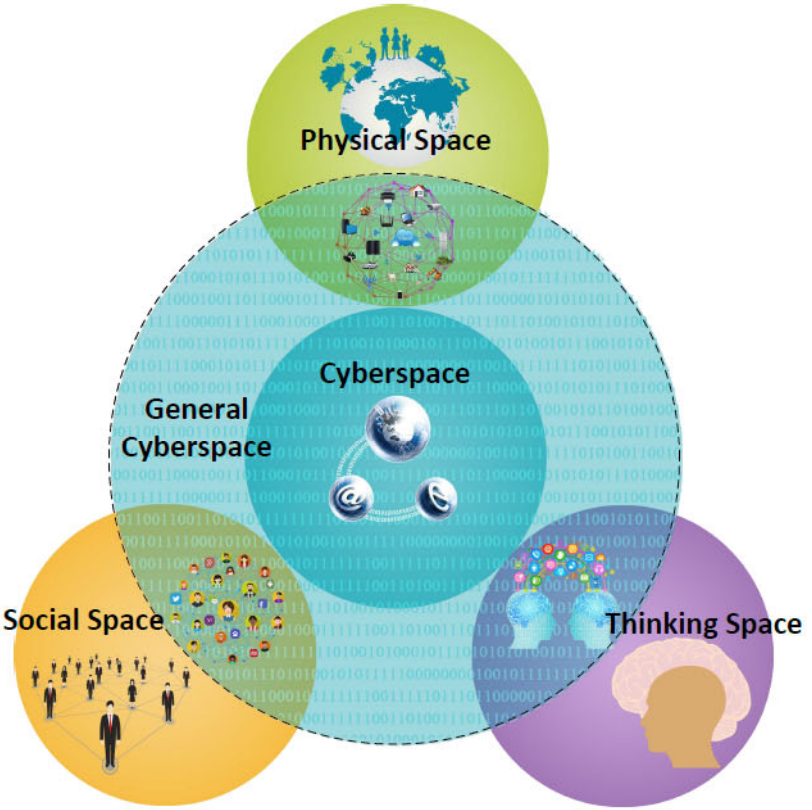
Ref: Ning et al. "General cyberspace: Cyberspace and cyber-enabled spaces." IEEE Internet of Things Journal 5, no. 3 (2018): 1843-1856.

فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

اتصالات همه‌جا حاضر مبتنی بر فضای سایبر عمومی | همگرایی فضاها مبتنی بر فضای سایبر عمومی



(a) Ubiquitous connections based GC



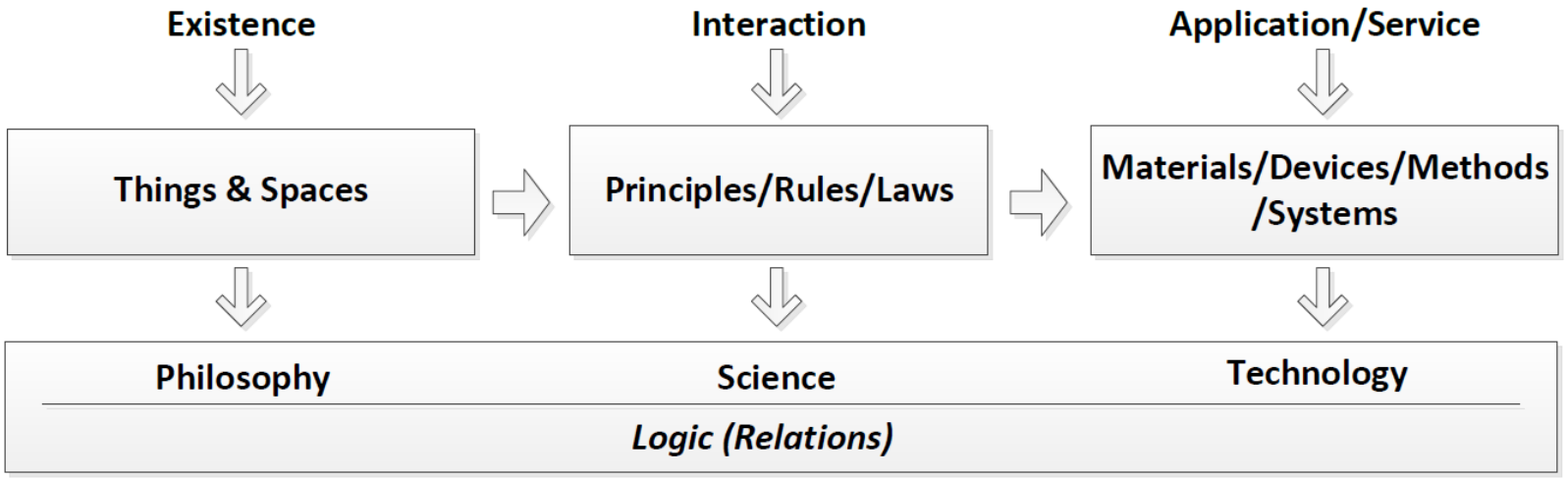
(b) Spaces convergence based GC

Ref: Ning et al. "General cyberspace: Cyberspace and cyber-enabled spaces." IEEE Internet of Things Journal 5, no. 3 (2018): 1843-1856.

فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

طیف دانش فضای سایبر عمومی

KNOWLEDGE SPECTRUM OF GENERAL CYBERSPACE



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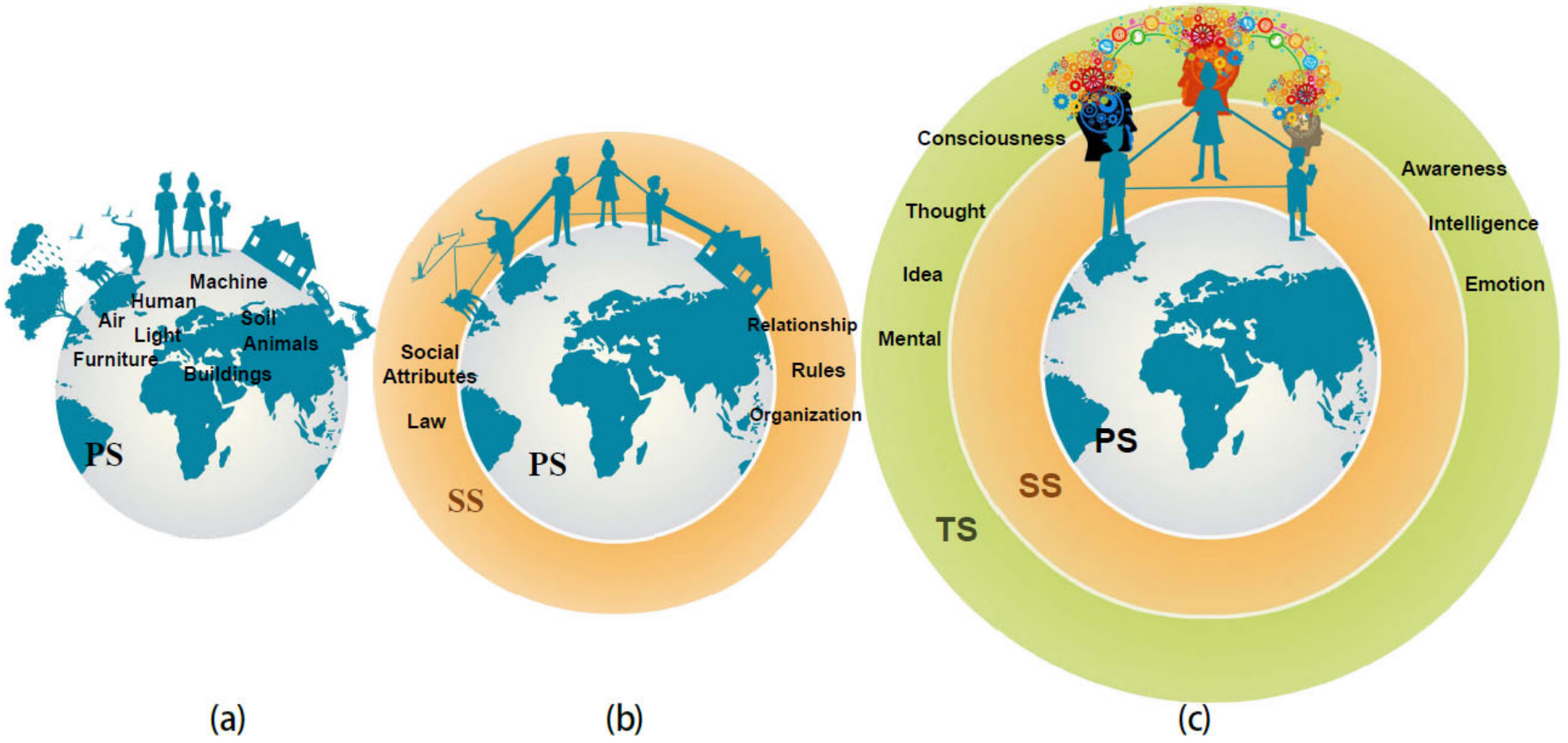
فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

وجود سنتی

TRADITIONAL EXISTENCE



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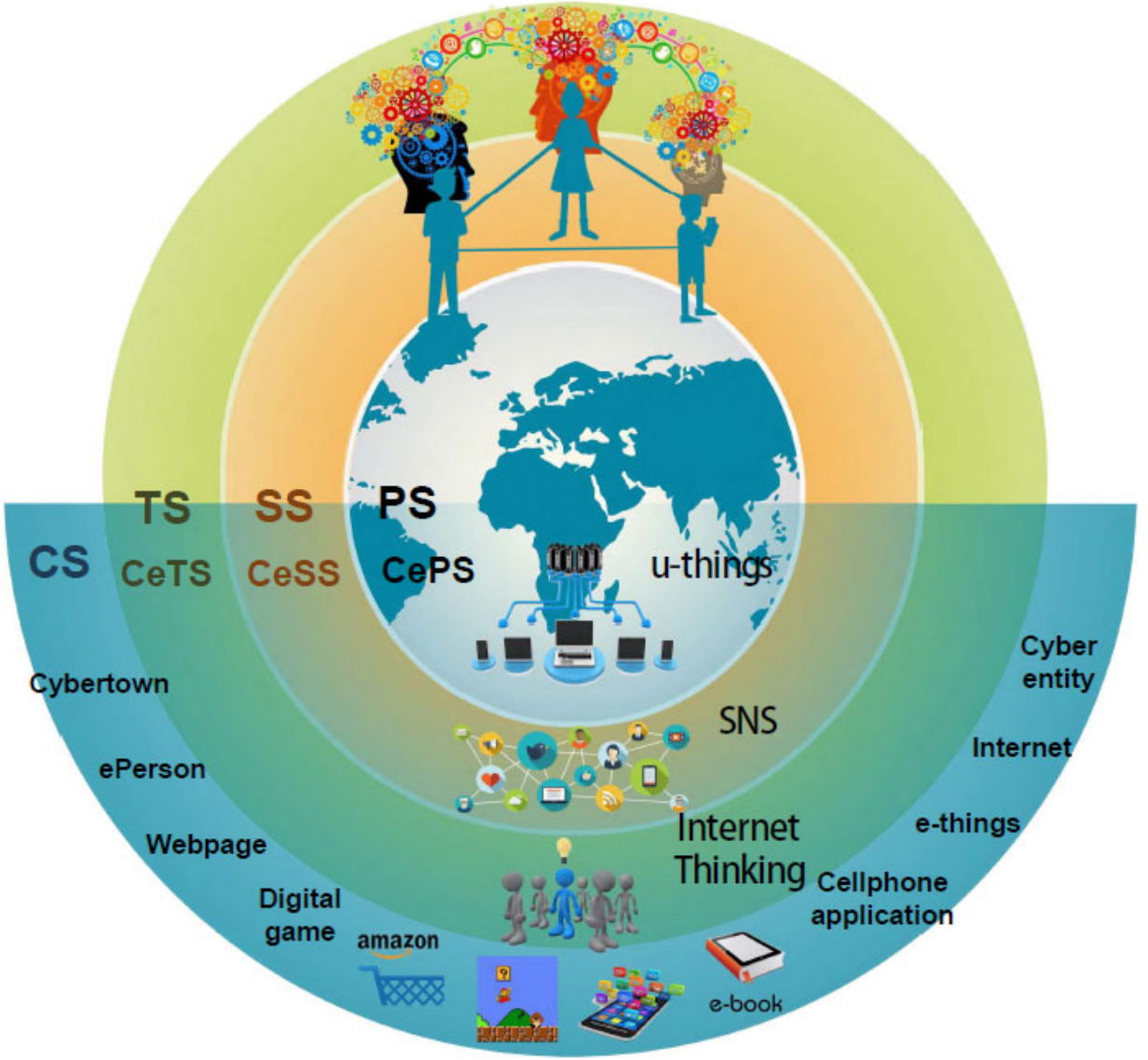
فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

وجود فعال‌شده با سایبر

CYBER-ENABLED EXISTENCE

SUMMARY OF ABBREVIATIONS

PST	physical, social, and thinking spaces
GC	general cyberspace
CeXS	cyber-enabled spaces
CePS	cyber-enabled physical space
CeSS	cyber-enabled social space
CeTS	cyber-enabled thinking space
IoT	Internet of Things
IoP	Internet of People
SIoT	Social Internet of Things
IoTk	Internet of Thinking
CPS	cyber-physical system
CPSS	cyber-physical-social system
CPST	cyber-physical-social-thinking hyperspace
PS	physical space
SS	social space
TS	thinking space
CS	cyberspace
U2IoT	unit IoT and ubiquitous IoT
Cyber-I	cyber individual
SNS	social network services
ICT	information and computation technology



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فضای سایبر عمومی: فضای سایبر و فضاهای فعال‌شده با سایبر

وجود سنتی در چهار فضا و وجود فعال‌شده با سایبر

A SHORT OVERVIEW OF TRADITIONAL EXISTENCE IN FOUR SPACES AND CYBER-ENABLED EXISTENCE

Existence		Description	Examples
Physical Existence	Traditional	Physical space and things existing in physical space. Most of them are along with some characteristics that can be described by multi-disciplines such as physics, chemistry, biology, etc.	Tables, animals, plants, furniture, cloth, house, machine, electric, air, soil, water, sun, light, etc.
	Cyber-enabled	Traditional physical existence associated with cyberspace.	Robots, smart phones, smart cars, smart houses, wearable devices, etc.
Social Existence	Traditional	Social space and things existing in social space. They usually result from the collection and interaction of human beings and other non-human creatures.	Communities, families, food chain, relationships, rights and obligations, national laws, etc.
	Cyber-enabled	Traditional social existence associated with cyberspace.	Social network services/social media, etc.
Thinking Existence	Traditional	Thinking space and thinking related things existing in thinking space. They are usually in relation to the brain activities of human beings.	Thoughts, ideas, awareness, intelligence, consciousness, emotions, religion, etc.
	Cyber-enabled	Traditional thinking existence associated with cyberspace.	Internet thinking, big data thinking, etc.
Pure Cyber Existence		Cyberspace and anything existing virtually and digitally in cyberspace.	Webpages, software, Internet, cellphone applications, digital games, e-things, ePerson/digital persona, etc.

Ref: Ning et al. "General cyberspace: Cyberspace and cyber-enabled spaces." IEEE Internet of Things Journal 5, no. 3 (2018): 1843-1856.

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Cybermatics: A Holistic Field for Systematic Study of Cyber-Enabled New Worlds

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ABSTRACT Following the two trends of computerization and informatization, another emerging trend is cyberization in which numerous and various cyber entities in cyberspace will exist in cyber-enabled worlds, including the cyber world and cyber-conjugated physical, social, and mental worlds. Computer science and information science, as holistic fields, have, respectively, played important roles in computerization and informatization. Similarly, it is necessary for there to be a corresponding field for cyberization. Cybermatics is proposed as such a holistic field for the systematic study of cyber entities in cyberspace and cyber world, and their properties, functions, and conjugations with entities in conventional spaces/worlds. This paper sets out to explain the necessity and rationale for, and significance of, the proposed field of Cybermatics, what it is and what it encompasses, and how it is related to other fields and areas.

INDEX TERMS Cyber, Cybermatics, cyberization, cyberspace, cyber entity, cyber world, cyber-enabled, cyber-conjugated, cyber-physical, cyber-social, cyber-mental, science, computer, data, information, network, communication, ubiquitous, system.

I. INTRODUCTION

Over the 200 years since the Industrial Revolution, the human ability to compute and communicate has been extended to machines, initially by mechanical means, but latterly by computers and communication devices such as telephones and wireless devices. Over the last two decades, both these capabilities have been further extended to ordinary things that are part of everyday life, such as consumer goods, vehicles, mechanical systems, houses, clothes, furniture, farms, organizations, cities and so on, as first envisioned and called ubiquitous computing by Mark Weiser around 1990 [1], and later named as pervasive computing by IBM in 1999 [2].

In addition to these computation and communication capabilities, these machines, devices and ordinary things are also all able to be interconnected by networks, especially the Internet and Web. In addition, these non-human things are also feasibly capable of sensation, processing information, interaction, cognition, and even thinking and taking autonomic actions. As a result, we are stepping into a completely new world environment of pervasive computation, communication, interaction, sensation, information and intelligence embedded in numerous ordinary things, including plants and even the human body as well as the brain, towards a hyper world [3] with hyper-connections [4]. We first envisioned this development in 1995, and also depicted a smart world [5] with smart u-things [6] and ubiquitous intelligence [7] in 2005. This new world environment will extend to such a range of things and apply to such a variety of contexts that it will bring about revolutionary change in almost every facet of human life and society.

In essence, the profound change brought about by this new world environment will be due to the ubiquity

سایبرماتیک: حوزه‌ای کل‌گرایانه برای مطالعه‌ی سیستماتیک دنیاهای جدید فعال‌شده با سایبر

سه عصر/روند محاسبه و مشخصه‌های آنها

CYBERMATICS: A HOLISTIC FIELD FOR SYSTEMATIC STUDY OF CYBER-ENABLED NEW WORLDS

Mark Weiser's Three Relations in Three Computing Eras	Humans and Computers  ***m-to-1*** ***MC***	 ***1-to-1*** ***PC***	 ***1-to-m*** ***UC***
Comp Element	Mainframes	Personal Computers	Things + Clouds
Existing Form	Large/Stationary	Small/Portable	Invisible/Ubiquitous
Main Purpose	Computation	Information	Cyberization
Proc. Content	Numbers/Data	Media/Stream Data	Context/Big Data
Central Goal	Fast/Precise	Rich/On-demand	Aware/Autonomic
Basic Behavior	Passive	Interactive	Active
Field of Study	Computer Science	Information Science (Informatics)	Cyber Science - **Cybermatics** -

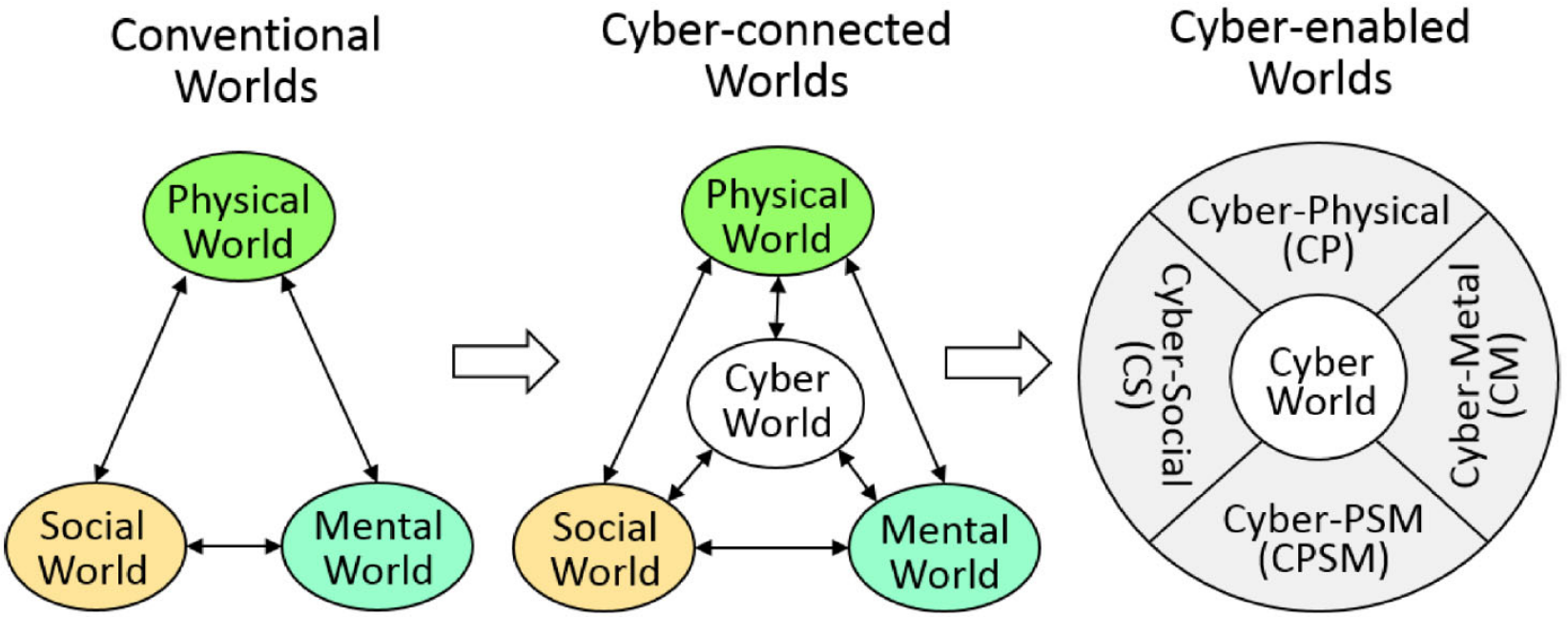
The three computing eras/trends and their characteristics.

Ref: Ma, Jianhua, et al. "Cybermatics: A holistic field for systematic study of cyber-enabled new worlds." IEEE Access 3 (2015): 2270-2280.

سایبرماتیک: حوزه‌ای کل‌گرایانه برای مطالعه‌ی سیستماتیک دنیاهای جدید فعال‌شده با سایبر

دنیاهای معمول، دنیاهای متصل‌شده با سایبر، دنیاهای فعال‌شده با سایبر

CYBERMATICS: A HOLISTIC FIELD FOR SYSTEMATIC STUDY OF CYBER-ENABLED NEW WORLDS



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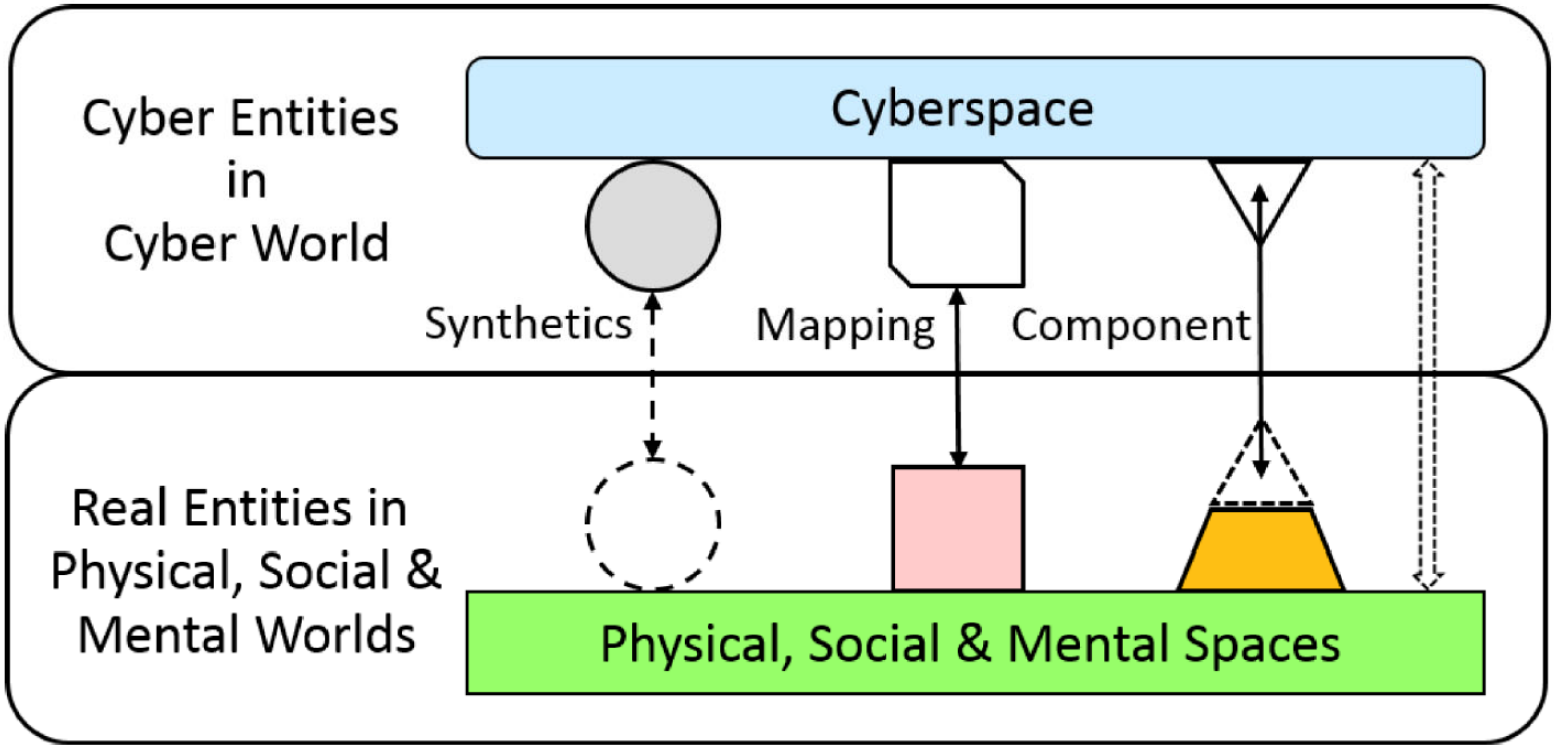
سایبرماتیک: حوزه‌ای کل‌گرایانه برای مطالعه‌ی سیستماتیک دنیاهای جدید فعال‌شده با سایبر

موجودیت‌ها و روابط آنها در دنیاهای سایبر، فیزیکی، اجتماعی و ذهنی

ENTITIES AND THEIR RELATIONS IN CYBER, PHYSICAL, SOCIAL AND MENTAL WORLDS

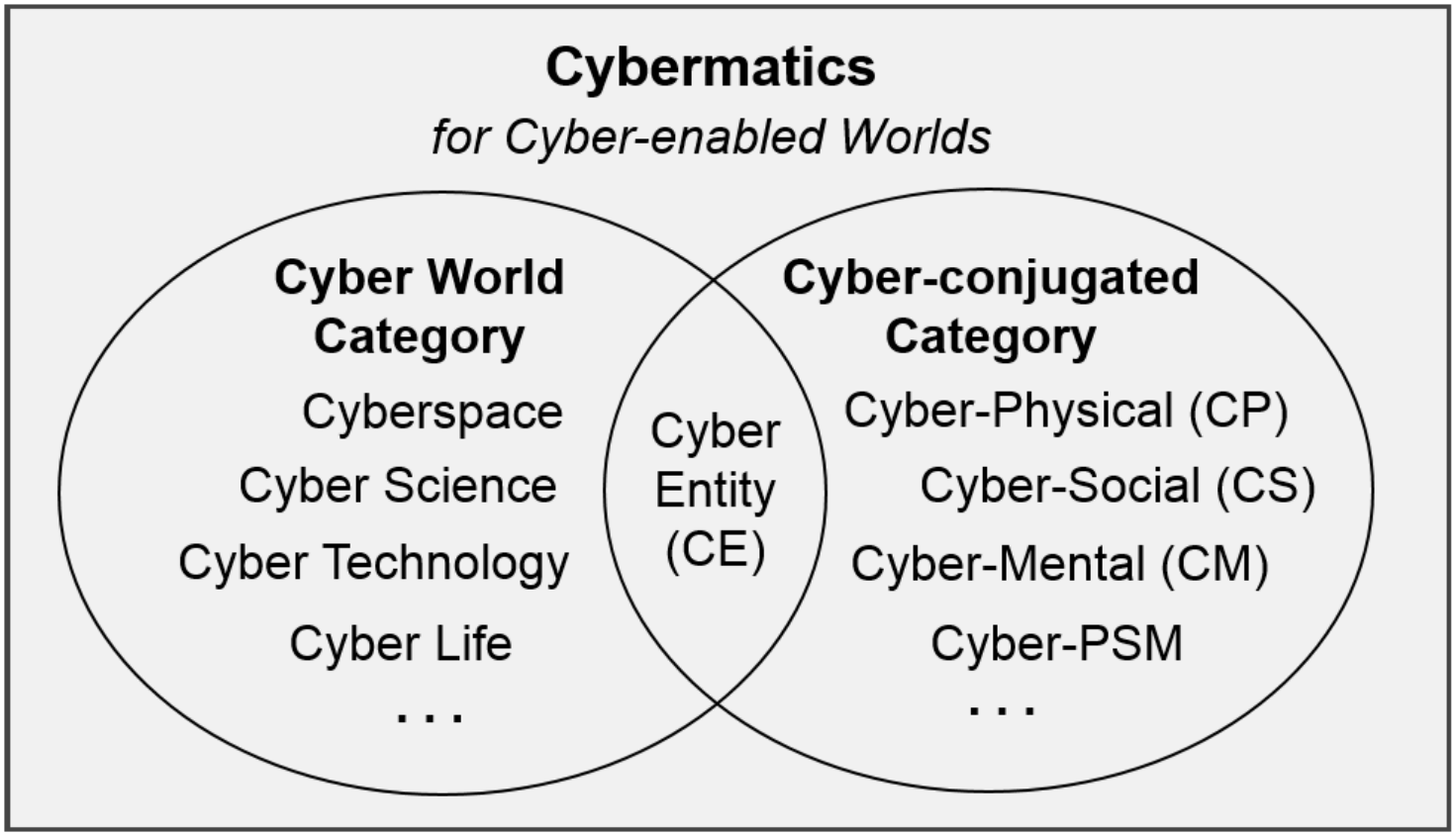


Ref: Ma, Jianhua, et al. "Cybermatics: A holistic field for systematic study of cyber-enabled new worlds." IEEE Access 3 (2015): 2270-2280.

سایبرماتیک: حوزه‌ای کل‌گرایانه برای مطالعه‌ی سیستماتیک دنیاهای جدید فعال‌شده با سایبر

رده‌های عمومی سایبرماتیک برای دنیاهای فعال‌شده با سایبر

THE GENERAL CATEGORIES OF CYBERMATICS FOR CYBER-ENABLED WORLDS



Ref: Ma, Jianhua, et al. "Cybermatics: A holistic field for systematic study of cyber-enabled new worlds." IEEE Access 3 (2015): 2270-2280.

مدل‌سازی فضای سایبر

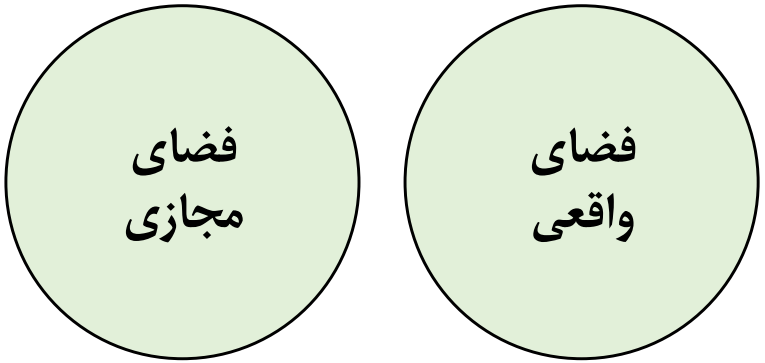
۳

رویکرد دوفضایی در مقابل رویکرد امتدادی

روی‌کردهای اصلی در مدل‌سازی فضای سایبر

روی‌کرد امتدادی

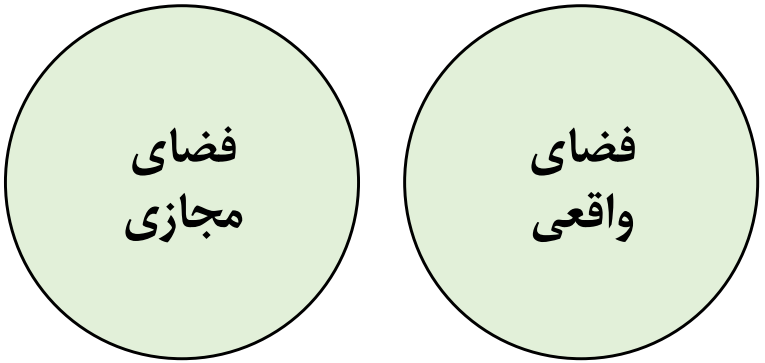
روی‌کرد دوفضایی



روی‌کردهای اصلی در مدل‌سازی فضای سایبر

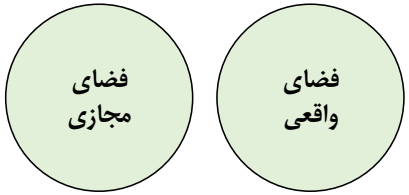
روی‌کرد دوفضایی

روی‌کرد دوفضایی

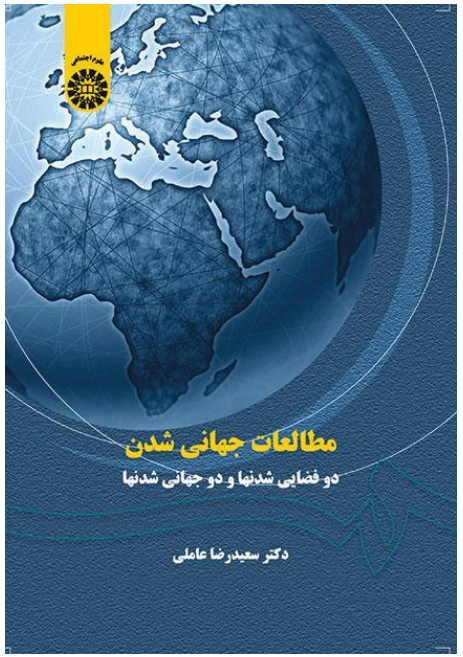


رویکرد دوفضایی

پارادایم دوجهانی‌شدن‌ها

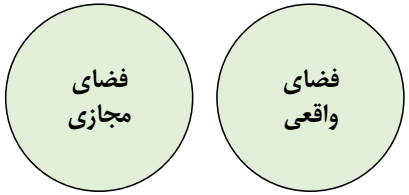


پارادایم دوجهانی‌شدنها، نگاهی است که نخست بر تمایز بین جهان مدرنیته و جهان جهانی‌شده تأکید می‌کند و در گام بعد به تبیین و متمایز کردن دو جهان موازی و درعین‌حال مرتبط و درهم‌تنیده می‌پردازد و به جهانی‌شدنهای متکثر در درون این دو جهان توجه می‌کند. با این نگاه، مهم‌ترین تغییر جهان معاصر که بنیان تغییرات آیندهٔ جهان را می‌سازد، رقابتی شدن جهان واقعی و جهان مجازی است. ظهور جهان جدید یعنی **جهان مجازی**[1] بسیاری از روندها، نگرشها و ظرفیتهای امروزی و آیندهٔ جهان را تحت تأثیر خود قرار خواهد داد. این جهان در واقع به موازات و گاه مسلط بر **جهان واقعی** ترسیم می‌شود و عینیت واقعی می‌یابد. این دو جهان از یک رابطهٔ **انعکاسی هندسی**[2] برخوردارند و دادوستدهای بی‌شماری بین این دو جهان جریان دارد.

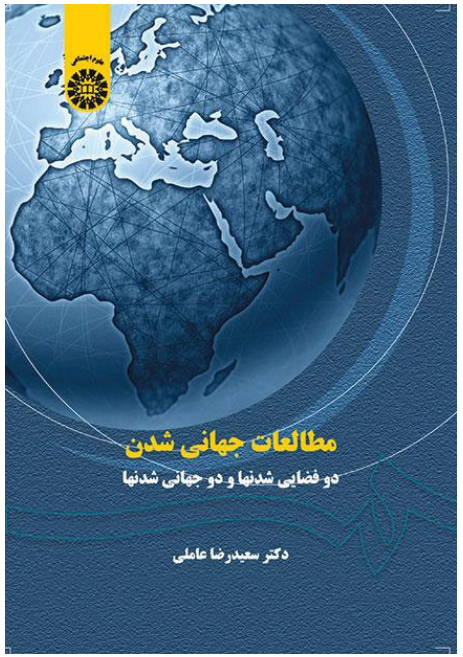


رویکرد دوفضایی

امکان‌ناپذیری فرض دوگانگی فضاها به‌لحاظ هستی‌شناسی

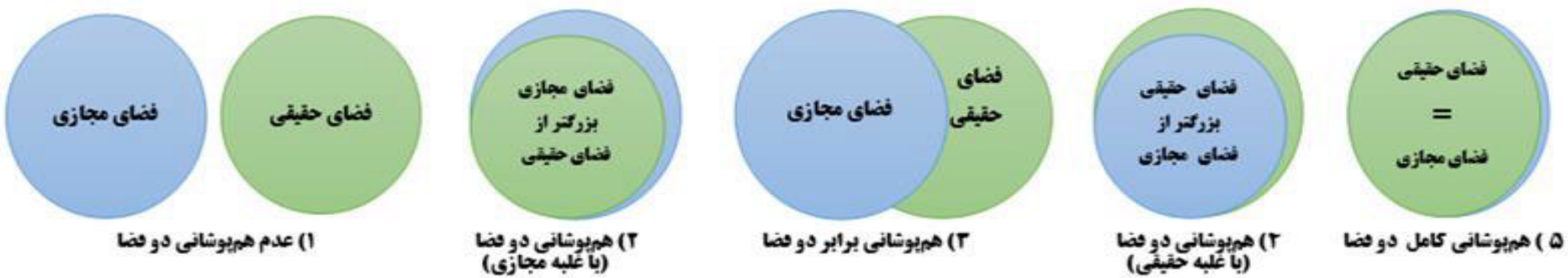


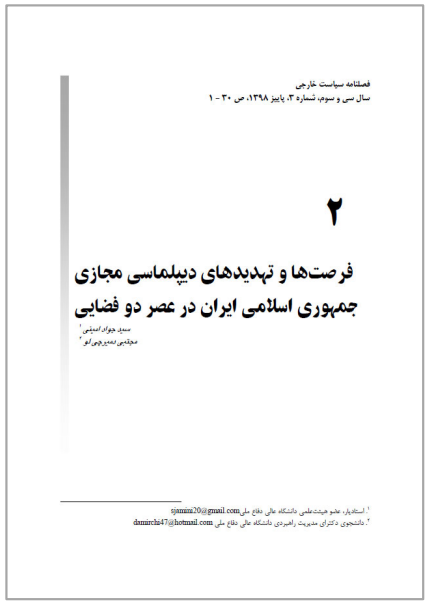
اگرچه این دو جهان در کرهٔ زمین قرار دارند و **فرض دوییت** به لحاظ **هستی‌شناختی** امکان‌پذیر نیست، ولی با رویکرد استعاری این دو جهان کاملاً قابل فرض و به لحاظ عملکرد و ظرفیت قابل تفکیک است. در واقع نظام ارتباطی و ذات شیئی جهان فیزیکی و ذات عددی و اطلاعاتی جهان مجازی، عامل مهمی است که این دو جهان را از هم متمایز می‌کند. فیزیک‌گرایی و جهان فیزیکی طبیعتی محلی و محدود دارد و تغییرات در جهان فیزیک موضوع تغییرات شیئی و محکوم به **اصطکاک و فرسایش** است. جهان مجازی از ظرفیت جهانی نامحدود و درعین‌حال از ذاتی پلاستیکی و قابل تغییر برخوردار است. در جهان فیزیکی، ما از یک **واقعیت‌گرایی** متمایل به فیزیک جهان و روابط چهره‌به‌چهره برخورداریم. در فرایندهای جهان واقعی نیز، روندها بر **کار فیزیکی و روندهای فیزیکی** متکی‌اند. از سوی دیگر همهٔ اتفاقات در ظرف فیزیکی و واقعیتهای محسوس جهان اتفاق می‌افتد.



رویکرد دوفضایی

نسبت میان فضای مجازی و فضای واقعی: حالت‌های متصور دوفضایی




فصلنامه سیاست خارجی
سال سی و سوم، شماره ۳، پاییز ۱۳۹۸، ص ۳۰ - ۱

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فرصت‌ها و تهدیدهای دیپلماسی مجازی جمهوری اسلامی ایران در عصر دو فضایی

سید جواد امینی[۱]
مجتبی دمیرچی‌لو[۲]

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[۲] دانشجوی دکترای مدیریت راهبردی دانشگاه عالی دفاع ملی dmirchi47@hotmail.com

روی‌کردهای اصلی در مدل‌سازی فضای سایبر

روی‌کرد امتدادی

روی‌کرد امتدادی

مدل‌سازی فضای سایبر

۴

مدل پیشنهادی

مدل پیشنهادی مطالعه‌ی فضای سایبر

مدل پیشنهادی مطالعه‌ی فضای سایبر

دنیا
World

انسان
Human

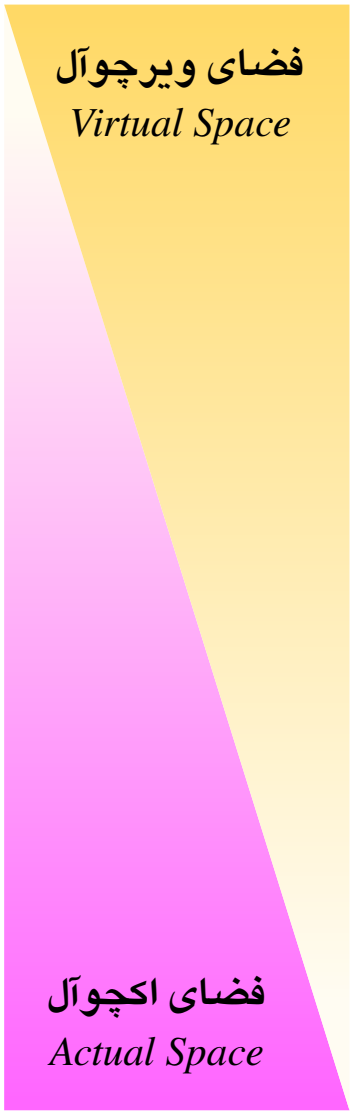
کاربرد
Application

زیرساخت
Infrastructure

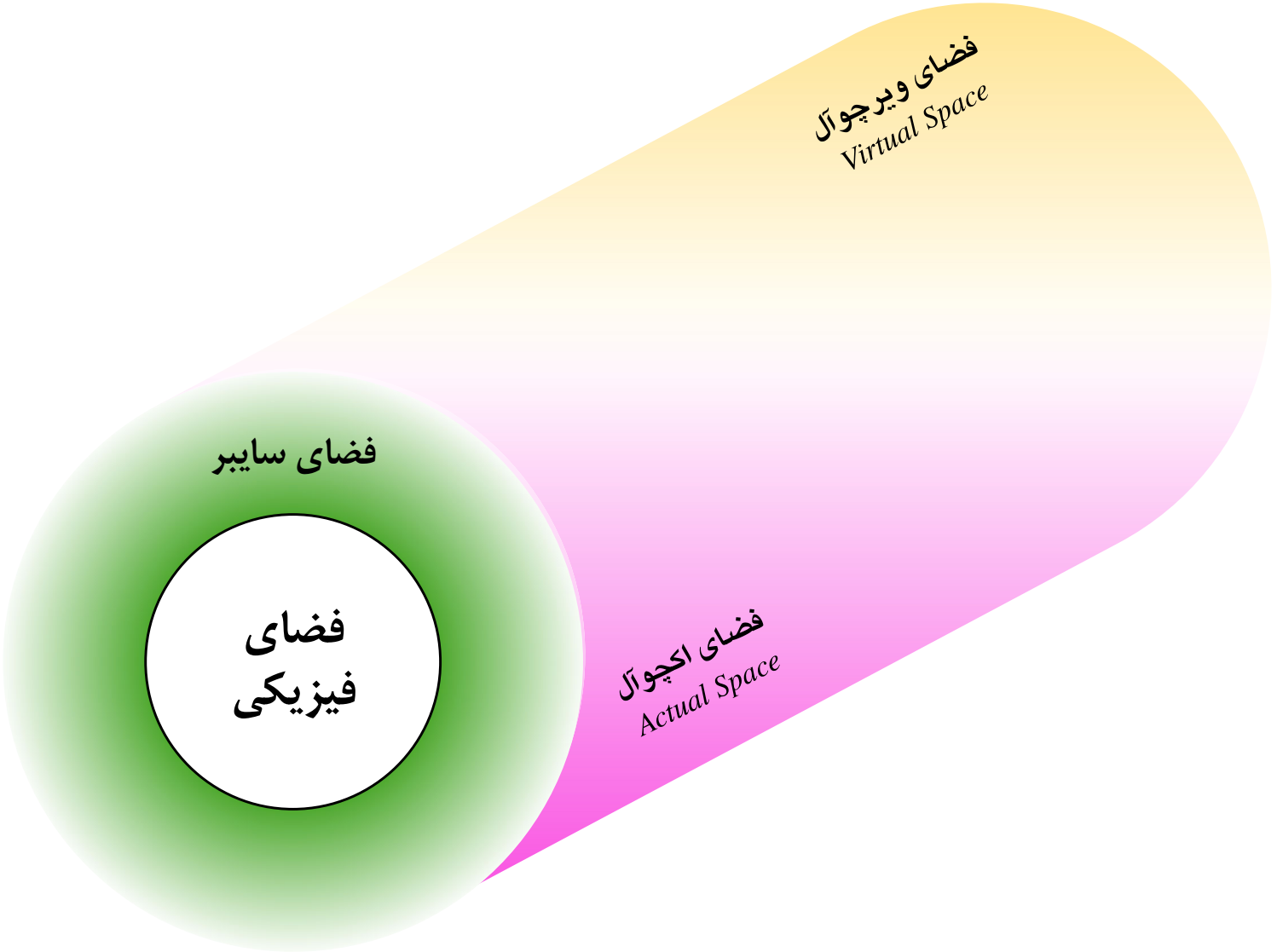
- **اطلاعات** *Information*
- **کنترل** *Control*
- **ارتباطات** *Communication*
- **محاسبات** *Computation*

نسبت فضای ویرچوآل با فضای اکچوآل

طیف تدریجی بین دو فضا



مدل امتدادی فضای سایبر



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منابع و مراجع

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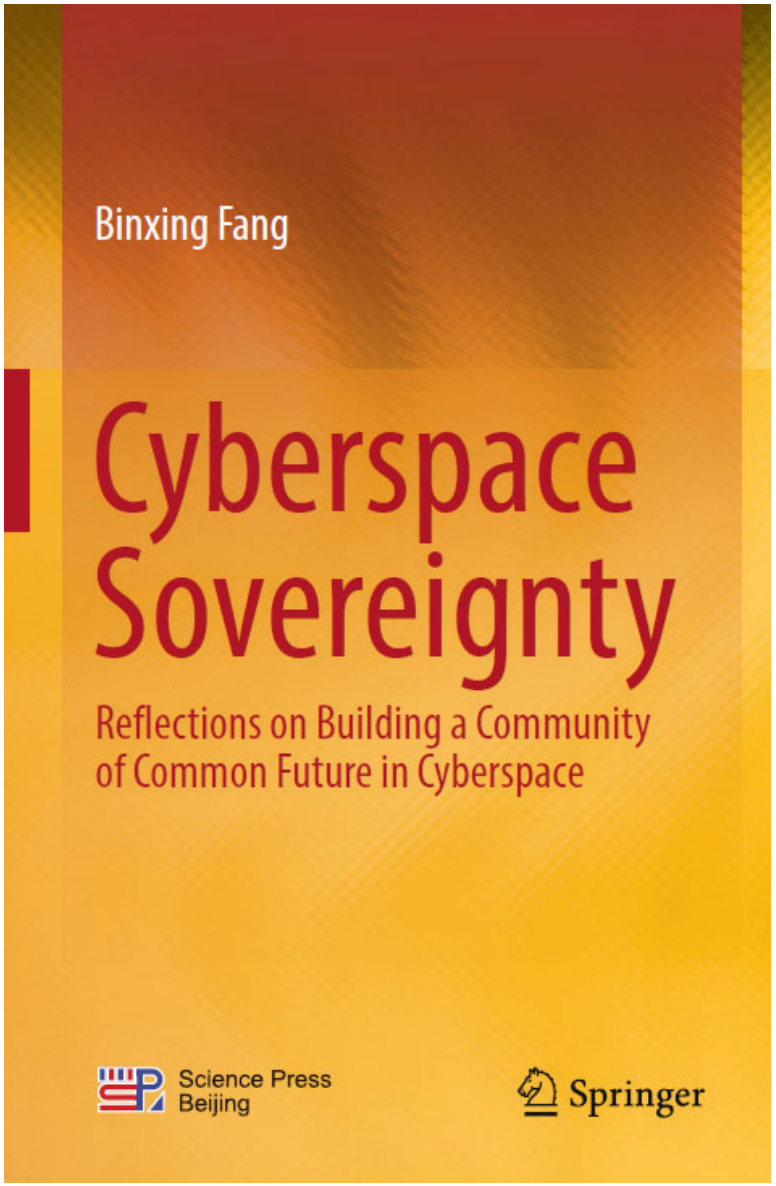
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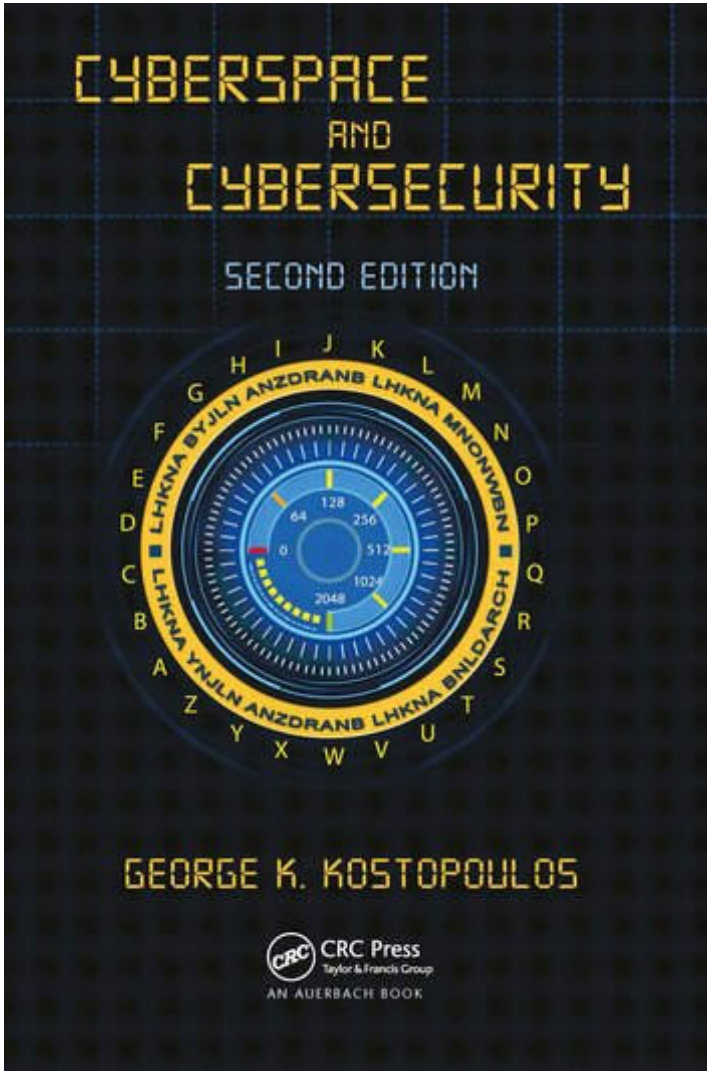
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SECOND EDITION
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CRC Press
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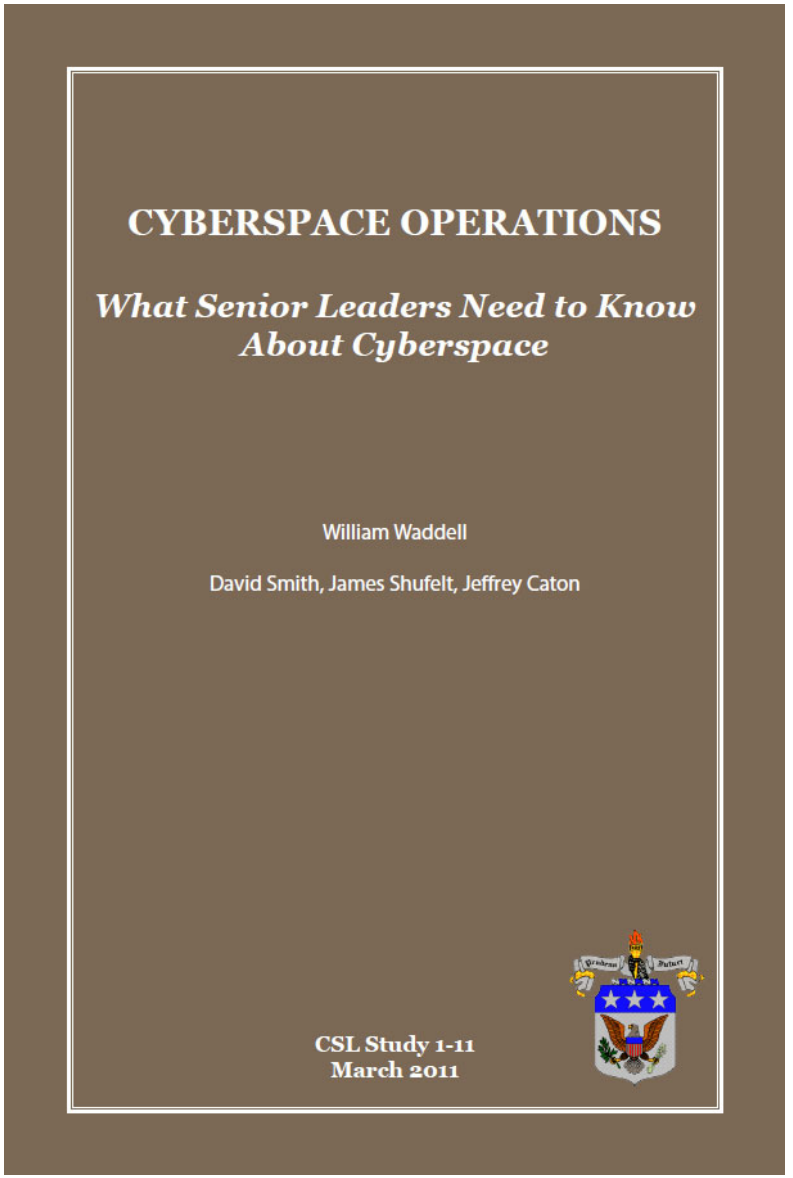
AN AUERBACH BOOK

کتاب مرجع

کتاب مرجع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What Senior Leaders Need to Know About Cyberspace
William Waddell
David Smith, James Shufelt, Jeffrey Caton
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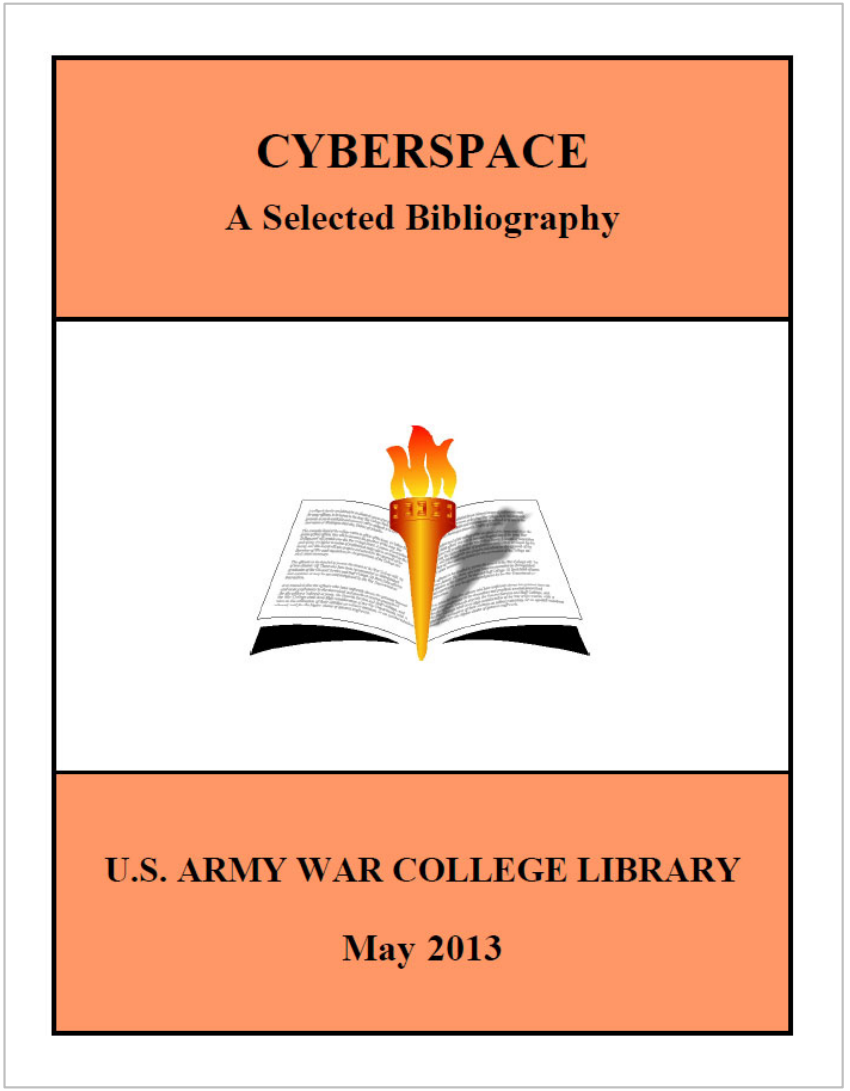
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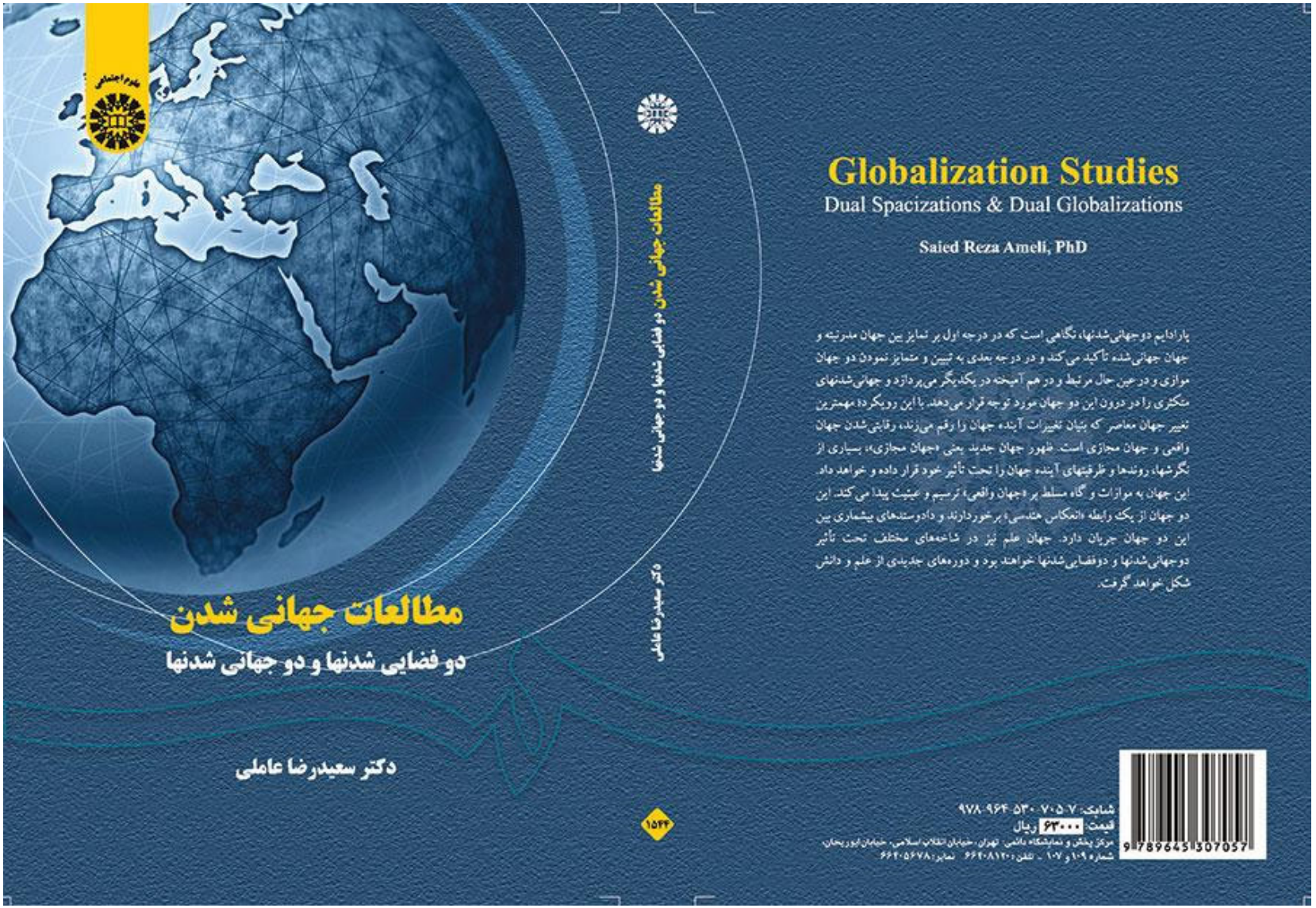

مقاله مرجع

Characterizing cyberspace: past, present and future

David Clark
MIT CSAIL

Version 1.2 of March 12, 2010

This work is funded by the Office of Naval Research under award number N00014091059 and N000140810898. Any opinions, findings, and conclusions or recommendations expressed in this email are those of the author (s) and do not necessarily reflect the views of the Office of Naval Research.

Introduction

In general terms, most practitioners share a working concept of cyberspace—it is the collection of computing devices connected by networks in which electronic information is stored and utilized, and communication takes place[1]. Another way to understand the nature of cyberspace is to articulate its purpose, which I will describe as the processing, manipulation and exploitation of information, the facilitation and augmentation of communication among people, and the interaction of people and information. Both information and people are central to the power of cyberspace. If we seek a better understanding of what cyberspace might be, one approach is to identify its salient characteristics: a catalog of its characteristics may be more useful than a list of competing definitions.

A four layer model

In this note, I will attempt to capture the character of cyberspace using a model with four layers. From the top down, the important layers are:

- The people who participate in the cyber-experience—who communicate, work with information, make decisions and carry out plans, and who themselves transform the nature of cyberspace by working with its component services and capabilities.
- The information that is stored, transmitted, and transformed in cyberspace.
- The logical building blocks that make up the services and support the platform nature of cyberspace.
- The physical foundations that support the logical elements.

It is not the computer that creates the phenomenon we call cyberspace. It is the interconnection that makes cyberspace—an interconnection that affects all the layers in our model. Today, we associate the phenomenon with the Internet, with its particular approach to interconnection, but there could be many alternative cyberspaces, defined (and created) by different approaches to interconnection. Indeed, in his book *The Victorian Internet*[2], Tom Standage argues that the mode of interconnection created by the

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[1] The term was coined by a science fiction writer, William Gibson, and popularized in his book Neuromancer (1984).
[2] Standage, Tom. *The Victorian Internet*. Berkley Trade (October 15, 1999)

مقاله مرجع

Deciphering Cyberpower

Strategic Purpose in Peace and War

John B. Sheldon

WHAT IS THE strategic purpose of cyberpower? All too many works on cyberspace and cyberpower are focused on the technical, tactical, and operational aspects of operating in the cyber domain. These are undoubtedly important topics, but very few address the strategic purpose of cyberpower for the ends of policy. Understanding its strategic purpose is important if policy makers, senior commanders, and strategists are to make informed judgments about its use. Cyberpower does indeed have strategic purpose relevant to achieving policy objectives. This strategic purpose revolves around *the ability in peace and war to manipulate perceptions of the strategic environment to one's advantage while at the same time degrading the ability of an adversary to comprehend that same environment.*

While it is proper to pay attention to the technological, tactical, and operational implications, challenges, and opportunities of cyberspace, this article concerns itself with its use—"the ability to use cyberspace to create advantages and influence events in all the operational environments and across the instruments of power"—for achieving the policy objectives of the nation.[1] Transforming the effects of cyberpower into policy objectives is the art and science of strategy, defined as "managing context for *continuing advantage according to policy*" (emphasis in original).[2] The definition provides the overall strategic impetus for the use of cyberpower. To fully understand the power of cyber, one must acknowledge the character of cyberpower and cyberspace. The linkage between strategic context, strategy, and

The author wishes to thank Derek Reveron, Naval War College; Col Harold J. Arata, USAF, and his exemplary team at the Center for Cyberspace Research; Drs. Harold R. Winton, Richard Muller, James W. Forsyth Jr., Stephen Wright, and Stephen D. Chiabotti at the School of Advanced Air and Space Studies; and Lt Col William E. Young, USAF, currently at Air War College.

John B. Sheldon, PhD, is professor of space and cyberspace strategic studies at the School of Advanced Air and Space Studies and deputy director of the AF Space and Cyber Strategy Center, Maxwell AFB, AL. He also teaches cyber strategy at the AF Institute of Technology's Cyber 200 and Cyber 300 courses at Wright-Patterson AFB, OH. Prior to his current duties, he served in Her Britannic Majesty's Diplomatic Service.

مقاله مرجع

General Cyberspace: Cyberspace and Cyber-enabled Spaces

Huansheng Ning, *Senior Member, IEEE,* Xiaozhen Ye, Mohammed Amine Bouras, Dawei Wei, and Mahmoud Daneshmand, *Member, IEEE*

***Abstract*—Cyberspace is the digital world created based on traditional physical, social, and thinking spaces (PST) but in turn makes a great difference on PST. The cyberization and the emergence of cyber-enabled spaces can be viewed as the bridge between cyberspace and PST, which reshaped the current definition of cyberspace and contributed to a novel concept "General Cyberspace (GC)". Generally, GC is a unified description of conventional cyberspace (also shortly cyberspace in this paper) and cyber-enabled PST. It essentially emerges from cyberspace based on ubiquitous connections between things and the deep convergence of spaces. This paper proposes the definition of GC and investigates it from its three main aspects: existence, interactions, and applications/services, respectively in terms of philosophy, science, and technology outlook.**

***Index Terms*—General cyberspace, cyber-enabled, cyber philosophy, cyber science, cyber-enabled technology, existence, interaction**

I. Introduction

Currently, as the fast development of information and computer technology, the term "cyberspace" is no doubt to become an increasingly attractive aspect of our daily life, work, and study. Originally, the term "cyberspace" appeared firstly in the artworks made by Susanne Ussing and Carsten Hoff to represent the idea of "sensory spaces", a physical room that can sense and adapt to human beings. In 1980s, the term was coined by Willian Gibson in his science fictions, "Burning Chrome" [1] and "Neuromancer" [2], in which it was described as "a graphic representation of data abstracted from banks of every computer in human system". Since that, its concept was prominently identified as the synonym of the digital world created by computers and received an enormous attention. So far, the term "cyberspace" has been widely used in various academic and technology studies by scholars, researchers, professionals, hobbyists, and hackers in relation to computer technologies and the globalization of network.

Cyberspace is a completely unprecedented space in human knowledge but still exists parallel with PST. Generally speaking, the concept of space in "cyberspace" tends to be abstract and mathematical without the duality of volume. Therefore, the cyberspace in the conventional sense is merely a virtual, digital world created based on various infrastructures such as computers, networks, data and information, hardware and software, etc., which we call conventional cyberspace or cyberspace in short. A large number of studies have been done to explore this sense of cyberspace from various perspectives (e.g. [3]–[12]). The success and popularity of relevant theories and technologies are pushing towards the conclusion that cyberspace is no longer confined to merely digital world but extends beyond it to involve various aspects of physical, social and even thinking space. In this case, an evolution of "cyber-enabled" (also cyberization, referring to "the process of formation of the new cyberspace and reformation of present PST towards cyber-enabled spaces" [13], [14]) is paving the way to a completely new environment where cyber-related elements permeate all spaces and all aspects of our life, which we call general cyberspace (GC). Some new words have been proposed as synonyms of general cyberspace in the diversity of relevant literature to envision the future world, such as smart world [15]–[20], hyperworld/hyperspace [21], and cyber-physical-social-thinking hyperspace (CPST) [19], [22], [23]. Furthermore, some related works have also been conducted with respect to the evolution process [18], [20], [21], characteristics [19], [24], related research areas or projects [20], [24], and future expectation of GC. However, none of these works made a precise definition of GC and little attention has been devoted to aspects of philosophy, science, and technology of GC.

With the deep permeation of cyberization to the real world, the aspects of cyber philosophy, cyber science, cyber technology, and their relations are increasingly emphasized in order to strive for a comprehensive understanding of cyberspace and cyber-enabled spaces as well as sorts of phenomena caused by cyberization. For example, in [25], the authors proposed the concept of "CyberSciTech" as an inter-discipline, trans-discipline, and multi-discipline integration of cyber science and cyber technology to present new perspectives on cyberization as well as emerging cyber-enabled spaces [26], [27]. They pointed out that cyber science is actually technology-driven knowledge collection about GC, which provides ways to understand and study complex phenomena in GC. Correspondingly, the term "Cybermatics" [13], [14], [28]–[30] was proposed as a scientific and systematic discipline to study cyber entities as well as its attributes, properties, behaviors, and practice in GC. However, their works have merely focused on related research topics and areas but lacked the discus-

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مقاله مرجع

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SPECIAL SECTION ON BIG DATA SERVICES AND COMPUTATIONAL INTELLIGENCE FOR INDUSTRIAL SYSTEMS

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Cybermatics: A Holistic Field for Systematic Study of Cyber-Enabled New Worlds

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This work was supported by the Grants-in-Aid for Scientific Research through the Japan Society for the Promotion of Science under Grant 25330270 and Grant 26330350, in part by the Fundamental Research Funds for the Central Universities under Grant 06105031, and in part by the National Natural Science Foundation of China under Grant 61471035.

ABSTRACT Following the two trends of computerization and informatization, another emerging trend is cyberization in which numerous and various cyber entities in cyberspace will exist in cyber-enabled worlds, including the cyber world and cyber-conjugated physical, social, and mental worlds. Computer science and information science, as holistic fields, have, respectively, played important roles in computerization and informatization. Similarly, it is necessary for there to be a corresponding field for cyberization. Cybermatics is proposed as such a holistic field for the systematic study of cyber entities in cyberspace and cyber world, and their properties, functions, and conjugations with entities in conventional spaces/worlds. This paper sets out to explain the necessity and rationale for, and significance of, the proposed field of Cybermatics, what it is and what it encompasses, and how it is related to other fields and areas.

INDEX TERMS Cyber, Cybermatics, cyberization, cyberspace, cyber entity, cyber world, cyber-enabled, cyber-conjugated, cyber-physical, cyber-social, cyber-mental, science, computer, data, information, network, communication, ubiquitous, system.

I. INTRODUCTION

Over the 200 years since the Industrial Revolution, the human ability to compute and communicate has been extended to machines, initially by mechanical means, but latterly by computers and communication devices such as telephones and wireless devices. Over the last two decades, both these capabilities have been further extended to ordinary things that are part of everyday life, such as consumer goods, vehicles, mechanical systems, houses, clothes, furniture, farms, organizations, cities and so on, as first envisioned and called ubiquitous computing by Mark Weiser around 1990 [1], and later named as pervasive computing by IBM in 1999 [2].

In addition to these computation and communication capabilities, these machines, devices and ordinary things are also all able to be interconnected by networks, especially the Internet and Web. In addition, these non-human things are also feasibly capable of sensation, processing information, interaction, cognition, and even thinking and taking autonomic actions. As a result, we are stepping into a completely new world environment of pervasive computation, communication, interaction, sensation, information and intelligence embedded in numerous ordinary things, including plants and even the human body as well as the brain, towards a hyper world [3] with hyper-connections [4]. We first envisioned this development in 1995, and also depicted a smart world [5] with smart u-things [6] and ubiquitous intelligence [7] in 2005. This new world environment will extend to such a range of things and apply to such a variety of contexts that it will bring about revolutionary change in almost every facet of human life and society.

In essence, the profound change brought about by this new world environment will be due to the ubiquity

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The Fundamental Conceptual Trinity of Cyberspace

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Abstract: This article is based on the premise that the increasing human interaction in cyberspace elevates it to the level of a strategic domain and, as such, raises theoretical and practical challenges for International Relations. It is founded on an epistemological reflection on the fundamental assumptions of the paradigms that permeate International Relations. The main objective is to conceptualise cyberspace as the strategic domain in the 21st century, as well as to develop an analytical framework that will both provide evidence and investigate the resilience of the foundations of current International Relations, these being specifically, the following precepts: i) sovereignty based on territoriality, ii) state monopoly of power, and iii) accountability between international actors. With this in mind, the approach refers to defence documentation and scientific sources in order to reach a definition that will characterise cyberspace, considering its technical, scientific and strategic aspects. At the same time, the bibliographic work underpins the development of the analytical tool known as the Fundamental Conceptual Trinity of Cyberspace, based on the characteristics of the cyberspace domain: i) deterritoriality, ii) multiplicity of actors, and iii) uncertainty.

Keywords: cyberspace; cybernetics; territory; accountability; International Relations.

Introduction

This research is about the inherent aspects of cyberspace: deterritoriality, multiplicity of actors and uncertainty. These characteristics elicit reflection about the basic elements relative to the state: territory, concentration of power and accountability. The analytical tool "Fundamental Conceptual Trinity of Cyberspace[1]" (FCT) was developed with the aim of improving the understanding of those aspects and how they may affect the theoretical bases of International Relations (IR) and Political Science. It relates to an analytical-reflexive effort that is limited both by the complexity of the theme and by the spatial limitations of this publication. The work aims to contribute to the recent, albeit already broad

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Modelling Cyberspace to Determine Cybersecurity Training Requirements

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Cyberspace is a constantly evolving and expanding environment that is being used for an ever-increasing range of purposes. As such, it attracts numerous threat actors seeking to identify and exploit its vulnerabilities. In order to be able to fully mitigate the risk of compromise, it is necessary to first understand the nature and composition of cyberspace and how it is used. This chapter seeks to address this issue by presenting a method to model cyberspace in three dimensions with humans included as an integral part. Expanding beyond describing cyberspace purely in terms of technology and its uses, it explores geographic, political, and temporal aspects to reflect its dynamic nature. The first component of the model examines the varied attributes of cyberspace ranging from the landscape in which its components are located to how they are used. The second dimension investigates the path of data in all its forms from its source to destination, emphasising that cyberspace is fundamentally a communications medium and is not borderless. Thirdly, it focuses on the security dimension and the motivations of those with malicious intent, demonstrating the multidisciplinary and essentially human nature of cybersecurity in countering their activities.

Keywords: cyberspace, cybersecurity, cyber operations, threat modelling, cybersecurity training, cyber situational awareness

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INTRODUCTION

The role of cybersecurity is well understood and has become the basis for a thriving and successful industry. Supporting this profession is a mature and fully developed education and training organisation providing the range of skillsets needed to supply suitably qualified personnel. However, the complexity of the discipline is such that individuals tend not to be aware of all aspects of the subject. This can lead to cybersecurity practitioners concentrating on just those niche areas in which they have been trained resulting in a very narrow view of the profession. The challenge of end-to-end security encompassing all aspects of cyberspace is rarely considered and for good reason. As an artificial environment that is constantly expanding with new uses being found and novel technologies continually introduced, achieving total security is a formidable undertaking. Indeed, it may be considered so large and complex as to be disregarded as impracticable. This chapter seeks to address this issue by presenting a novel way of representing cyberspace to enable all aspects to be examined. Drawing on previous research, it introduces a three-dimensional model of the environment optimised to better understand how its properties, attributes, and risks can be understood at any place and time. In doing so, it demonstrates that cyberspace does not exhibit universal characteristics but that its structure and characteristics may differ at the source and destination of any data exchange. By achieving a greater appreciation of the properties of that part of cyberspace relevant to a particular use case, the training required to provide comprehensive cybersecurity can be better understood.

مقاله مرجع

Representing a Human-Centric Cyberspace

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Abstract. There is a lack of consensus when using the term "cyberspace" [1]. Computers and network devices are prominent in definitions of cyberspace; less common is the essential and inclusion of human users. However, the human user is both implicitly integral to and actively part of the cyberspace.

Cyberspace is often conceptualized as three layers of interconnected networks: social, information and geospatial (physical) [2]. These represent an indirect human element within cyberspace. This is characteristic of related fields, such as cybersecurity, where human-centered research has been lagging behind technological aspects. A model that incorporates the human user in cyberspace is needed to direct future research and improve security and usability (navigation).

A new human-centric model of cyberspace is proposed (the HCCM), with the user as a physical and integral entity, together with recognition of the cognitive representation of cyberspace. It focuses on boundaries and transformation points between objects and spaces and offers a platform for future human-centric research in cybersecurity.

Keywords: Cybersecurity · Cyber security · Human user · Human Factors · Human-machine interaction

1 Introduction

Metaphors and analogies, such as "wild west" and "space", have been central to attempts to understand the global online computer network and its meaning for society and culture broadly [3]. The term "cyberspace" was first used by William Gibson in his book, Neuromancer [4], where he defined it as a "a consensual hallucination". Since then, although the term "cyberspace" is commonly used, there is a lack of consensus about its meaning and what it encapsulates [1] [5]. It is difficult to represent and model cyberspace, due to its associations across physical (e.g. computer hardware) and non-physical domains (e.g., 'information' or 'online' space).

Although computers and network devices are prominent in current common definitions, less common is the inclusion of human users. Cyberspace has been described

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On the Mathematical Definition of Cyberspace

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Abstract

We give a mathematical definition of cyberspace including basic specifications of its different formalities. To this end, we set an appropriate framework for determining adequate theoretical background, allowing rigorous, supple, univalent and adaptive description of what exactly we mean by saying "cyberspace".At the basis of this framework is the concept of the e −category $\boldsymbol{W_e}$. An e −categorycan be viewed as an infinite e −*graph* $(\mathbb{V}, \mathbb{E})$withvector weights, in such a way that the e −nodes in $\mathbb{V}$ are the e −objects, while the$e$ −edges or e −arcs in $\mathbb{E}$ are the e − morphisms. Given this notion, we investigate the possibility of allocating vector weights to objects and morphisms of any e −category $\boldsymbol{W_e}$. We also introduce a suitable metrizable topology on e − graphs and e − categories. The most significant benefits coming from the consideration of such a metric $\boldsymbol{d_{W_e}}$ in the set $\boldsymbol{ob(W_e)}$of objects of an e −categorycan be derived fromthe definitions of *cyber-evolution* and *cyber-domain*. Bearing all this in mind, we define the *local* e— *dynamics*, as a mapping $c\boldsymbol{\psi}: [0,1] \to \left(|\boldsymbol{ob(W_e)}|, \boldsymbol{d_{W_e}}\right)$; its image is an$e$—*arrangement*. The points of an e—*arrangement* are the *instantaneous local* e − *node manifestations*. An e − arrangement together with all of its instant e—morphisms is an e −*regularization*. The elements of the completion $|\boldsymbol{ob(W_e)}|$ of the set $\boldsymbol{ob(W_e)}$ of objects of an e − categoryare the *cyber-elements*, while the topological space $\left(|\boldsymbol{ob(W_e)}|, \boldsymbol{d_{W_e}}\right)$ is called a *cyber-domain*. A continuous local e −dynamics is said to be a *cyber-evolutionary path* or simply *cyber-evolution* of the

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