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Research Article

Establishing an International Engagement Model of Digital Identity Based on Blockchain

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Blockchain technology has been changing the trust system through machine endorsement and mathematical algorithms, laying a technical foundation for network identity from centralized to decentralized management. The decentralized identity with core features, such as "no need for a management center and self-managed identities" have become a key direction for the evolution of a new generation of digital identity based on blockchain. Internationally, the United States, the EU, and other countries have promoted the technological exploration and application innovation of the decentralized identity, aiming to seize the international discourse power in the digital space. This paper establishes an evaluation model of international engagement in the decentralized identity field and takes the United States as a case to analyze the current development status and international engagement of the decentralized identity from multiple dimensions. Furthermore, it proposes some suggestions for other countries to improve the international engagement in the decentralized identity field.

1. Introduction

In recent years, with the rapid development of blockchain technology, many governments have begun to pay attention to this technology and related applications. Blockchain technology changes the trust system with mathematical algorithms, laying a technical foundation for network identity from centralized distribution to decentralized management. With the development of the traditional Internet to the value Internet, the new generation of digital identity based on blockchain, as an emerging technology integrating blockchain, encryption algorithm, authentication, and other Internet technologies, has gradually become an inevitable choice for the evolution of network identity.

To seize the new opportunities of digitalization, the United States has proposed a "decentralized identifier" firstly and the EU has proposed a forward-looking strategic layout "European self-identity framework." Many governments aim to break through the core technology of the new generation of digital identity based on blockchain in advance and firmly control the international discourse power of

digital space. Therefore, any country's international engagement of new-generation network identification objectively and accurately can inflect one's country's capability and development status on this area. Any country, which is eager to make a great improvement in the decentralized identity field, can get some advice by analysing with this international engagement model.

2. Evolution of Digital Identity

With the rapid development of the Internet, more and more people come into the Internet world for searching information online, communicating with each other online, or trading online. It means cybersecurity, data security, and efficiency are playing extremely key roles, which facilitate the development of digital identity is from centralized to decentralized.

2.1. Technology Evolution. From the beginning, the digital identity solution is a centralized identity model, in which an organization creates, controls, and manages each user's

digital identity. Such as, if a user wants to use Yahoo, he/she has to type in personal information and register in a new account on Yahoo's website. In the second phase, aiming to improve the data security and user experience, the digital identity solution changes into a federated identity model. There is a new role called Identity Provider (IDP), controlling users' identities. Users are able to log in to too many Internet applications and services by registering one or a few IDPs. Such as, in China, users can use their personal WeChat account (an instant messaging application, like messenger or Twitter), as an IDP, to realize one-click login services on various Internet applications [1].

Nowadays, with the concept of "decentralized identity," the digital identity solution is in an entirely new model, called the decentralized identity model. The decentralized digital identity model greatly reduces the user's dependence on the account, reduces the control of the user data for centralized agencies, and makes the identity information to the greatest extent. When the user interacts with information, the two parties need to "maintain" the connection relationship. Once one of them is dropped, the connection is connected immediately. Point-to-point interaction on one side to fundamentally eliminates the demand for centralized accounts [2]. In addition, the user uploads the public key to verify the identity to the blockchain. The interchange of the public key through encryption and private P2P connection channels to ensure verification security. This decentralized digital identity model is more like a business card in the real-world wallet. The business cards that have been digitized and the digital signature encryption guarantee will not be leaked multiple times in the network. Under this model, users can own and control their digital identities by themselves instead of a centralized organization or an IDP. All digital identity information interacts through private and public keys on the blockchain [3].

2.2. Governments' Action.

Decentralized identity (DID) has been paid extensive attention from governments around the world, and the ecosystem of DID has grown up gradually by top-down governmental guidance. The national strategy, government funding, cross-border public services, and pilot projects are accelerating the development of DID.

Since 2011, the U.S. government has implemented *the National Strategy for Trusted Identity in Cyberspace* (NSTIC) to improve the national capability on such as cybersecurity, data security, and personal information protection and has begun to provide financial support to target enterprises and organizations. In 2016, the U.S. Department of Homeland Security (DHS) awarded those enterprises, researching and developing on the blockchain-based digital identity technology, and notably, the Science and Technology Bureau at DHS funded a DID working group established in the World Wide Web Consortium (W3C). In 2017, DHS has begun to provide financial support, and accumulated $4 million in funding, to small and medium-sized enterprises in DID field [4]. Since 2018, the governments of Canada, South Korea, the European Union, and many other countries have begun to deploy and plan the technology. In Canada, a federal province's government of British Columbia led a digital identity certification committee,

aiming to establish a new digital identity ecosystem and conducted a pilot application project-related decentralized identity in 2018. In South Korea, a large consortium of companies has cooperated with local governments to carry out the pilot application of decentralized identity on drivers' license services in 2020 [5]. In the EU, Blockchain Partnership Programme (EBP) developed the European Sovereign Identity Institution (ESSIF) based on the European Blockchain Services Infrastructure (EBSI) to provide cross-border public services for all EU citizens all over the EU in 2020. In addition, during the G20 summit, the concepts of self-sovereign identity and decentralized identity have been set as a key discussing topic over many participating countries in 2021 [6].

3. Establishment on an Evaluation Model of International Engagement

The international discourse power is a country's right to formulate international standards and rules. The international discourse power of a certain technology is a country's ability to influence the development of technology, and the right to lead the international standards and rules on this technological field. Establishing a qualitative analysis model for the international engagement of network identification is an efficient way to analyze the current development status of any country's decentralized identity from multiple dimensions and propose clear advice to promote the international engagement in the network identification field.

3.1. Definition of International Discourse Power.

The international discourse power means that nations and countries integrate national concepts corresponding to national identities into the international environment through various discourse channels and obtain the ability to build international common sense through the recognition of the international community [7]. The international discourse power includes not only the right to define events, and the right to formulate various international standards and rules, but also the right to evaluate and judge the merits of the argument.

Based on the research of the existing discourse model (as shown in Figure 1) [8] and some Internet governance participation index models [9], and combined with the characteristics and development laws of decentralized identity, this study establishes an international engagement model of decentralized identity and its evaluation dimensions.

3.2. The Model of International Engagement on Decentralized Identity.

The international engagement model of decentralized identity consists of four evaluation dimensions: national strategy, research level, community participation, and application development (As shown in Figure 2).

Firstly, as a comprehensive and basic environment for developing a certain technology in the whole country, the "national strategy" reflects a country's overall strategic priority to develop the ecosystem of decentralized identity and the international influence in this field.
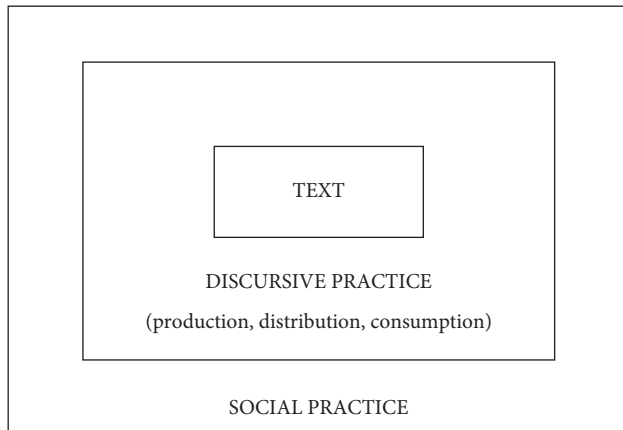
FIGURE 1: Fairclough's 3 dimension of critical discourse analysis. Created by norman fairclough, via ResaerchGate (https://www.researchgate.net/publication/281506450_Critical_Discourse_Analysis).
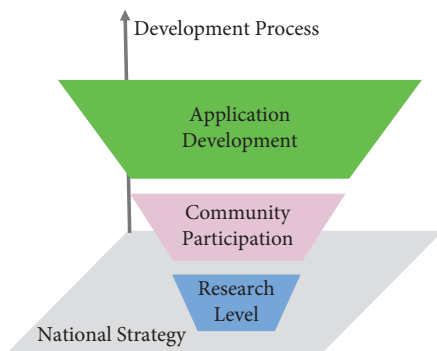

FIGURE 2: The model of international engagement on decentralized identity (DID).

Secondly, as a key development environment in the early stage of technological development, the "research level" reflects a country's academic and technical capabilities for participating in the field of DID. This dimension reflects the country's potential ability to a country's international engagement at the level of rule-making.

Thirdly, "community participation" reflects a country's control over core platforms, key positions, and major issues in the field of DID. This dimension directly displays the effect of participation and the international discourse power.

Fourthly, "application development" reflects the innovative development of a country's internal enterprises in the field of DID. This dimension displays the influence of the bottom-up international engagement from the perspective of industry development, which is an important symbol of the industry's maturity.

Besides, not only each evaluation dimension has a 2–3 evaluation basis, but also each evaluation basis can be evaluated by several assessment methods separately (see Figure 3).

3.2.1. National Strategy. Specifically, the evaluation basis for "national strategy" includes government policies and financial supports. In detail, government policies can be

evaluated through the authority, foresight, and feasibility of policies. The financial support can be evaluated through the amount of special government funds invested in enterprises and the effect of public-private partnerships.

3.2.2. Research Level. The evaluation basis for "research level" includes academic capabilities and technical standards. In detail, the academic ability can be evaluated by the number of think tanks, the ability to publish authoritative papers, and the influence of those papers. The technical standards can be evaluated by the number of outputting technical specifications, agreements, standards, and patents.

3.2.3. Community Participation. The evaluation basis for "community participation" includes the number of related communities and key positions. In detail, the number of communities can be assessed by the number of various communities led by experts or business representatives from the country. The key positions can be evaluated by the number of core participating experts in this field and the activeness of key leaders.

3.2.4. Application Development. The evaluation basis for "application development" includes the number of enterprises, the amount of investment in R&D, and the horizontal and vertical coverage of the DID industry. In detail, the number of enterprises can be determined by the number of enterprises engaged in this field, and the number of active enterprises participating in standards-making and well-known open-source projects. The investment in R&D can be evaluated by the amount of startups' innovative finance in this field. In addition, the industry chain and user scale can be evaluated by the vertical development of the supply chain and the horizontal coverage of the DID industry [10].

4. A Case Study on the Evaluation Model of International Engagement

In order to verify this model of international engagement, this study will choose a typical country, as an example, to evaluate the international engagement of DID with the model. After a number of data collections and research studies according to this model, the United States, as a developed country, has an absolute leading position in the international engagement of DID. Any country that would like to improve their international engagement of DID has to experience a process of catching up with the United States. Therefore, the following study will analyze how the United States gain a leading position in the DID field.

4.1. National Strategy. The United States attaches great importance to the construction of a trusted digital identity system, the development of DID has been highly concern by the US government from national strategies to special government funds. It is not difficult to find that the American government regards the DID as a very important innovation, the government set a top-level country-side

FIGURE 3: The detailed evaluation of the model of international engagement on DID.

strategy on digital identity and encourages technical enterprises to innovate in the DID industry under the government authority's leading and funding.

In terms of government policy, the US government announced the implementation of the *National Strategy or Trusted Identities in Cyberspace* (NSTIC) in April 2011. It plans to spend 10 years establishing a user-centric trusted identity ecosystem, through the government's promotion and industry's efforts, aiming to provide a public and compatible identity service that is able to protect user privacy and satisfy data security. This strategy is directed by the NSTIC National Program Office (NPO), an agency under the U.S. Department of Commerce, and led by the U.S. National Institute of Standards and Technology (NIST). Specifically, the strategy has three main initiatives. The first is to establish a government working group such as the Identity Ecosystem Steering Group (IDESG) to be responsible for the formulation of the identity ecosystem framework. The second is to carry out government guidance projects nationwide and to fund pilot application projects, aiming to promote the development and application of related digital identity technologies. The third is to promote the process of digital identity integration between the federal governments by developing a cloud credential exchange platform [11].

On the financial supports side, since 2018, the U.S. Department of Homeland Security (DHS) has signed phased project contracts with eight leading enterprises in the W3C DID working group (WG), such as Danube, Digital Bazaar, and some American and European technology companies to provide long-term financial supports, with an aggregate value of approximately $3.77 million (US dollars). It aims to support the participation of American companies in the international standardization of DID technology and to encourage DID-related solutions to be used in innovations and applications of the American people's livelihood and government affairs. Until October 2021, 8 companies have reported their results to the U.S. government, designed application scenarios from the two dimensions of "digital personal credentials" and "digital transactional credentials" and completed some interoperability tests [12].

4.2. Research Level. The research level of the United States ranks No.1 in the world, and its overall academic capabilities provide a strong initiative and a basic research environment for the development of the DID field. In addition, the output capacity of technical standards in this field is also far ahead of other countries in the world.

In terms of academic capabilities, the total number of the American think tanks and the authority of top think tanks in the world are the first in the world [13]. In 2020, the United States is still the country that has the largest number of think tanks in the world with 2,203 think tanks. And, the United States has 5 of the TOP 10 think tanks in the world, thus, the US has a greater authority in terms of think tanks (see Figure 4). Furthermore, the number of papers published in the DID field and the impact factor of those papers are ranked first in the world. In detail, in the SCI/SSCI database,

RANK	COUNTRY	NUMBER OF THINK TANKS
1	United States	2203
2	China	1413
3	India	612
4	United Kingdom	515
5	South Korea	412

2020 TOP THINK TANKS WORLDWIDE (US and non-US)

Table 3

1. Carnegie Endowment for International Peace (United States)

2. Bruegel (Belgium)

3. Fundação Getúlio Vargas (FGV) (Brazil)

4. Center for Strategic and International Studies (CSIS) (United States)

5. French Institute of International Relations (IFRI) (France)

6. Chatham House (United Kingdom)

7. RAND Corporation (United States)

8. Japan Institute of International Affairs (JIIA) (Japan)

9. Peterson Institute for International Economics (PIIE) (United States)

10. Wilson Center, FKA Woodrow Wilson International Center for Scholars (United

FIGURE 4: Countries with the largest number of think tanks and 2020 top 10 think tanks worldwide (Us and non-us). Statistics by McGann, James G., "2020 Global Go to Think Tank Index Report" (2021), via TTCSP global go to think tank index reports (https://www.bruegel.org/wp-content/uploads/2021/03/2020-Global-Go-To-Think-Tank-Index-Report-Bruegel.pdf).

through the search keyword "Decentralized Identity," a total of 837 documents were retrieved in the past 10 years, of which 193 were published by the United States, accounting for 23%, topped on the list. By calculating the H-index (high citations), the US gains 26 points on the H-index, which is much higher than that of other TOP 10 countries. In addition, of the TOP 4 authoritative academic institutions that publish DID-related papers in the US, 80% of them are well-known American universities, including MIT, the University of Tennessee, Purdue University, and the University of Texas at Antonio.

On the technical standards' side, known from the IncoPat global patent database, there are a total of 66 standards or specifications in the DID field (produced by international standards organizations respectively such as W3C, DIF, IETF, and OpenID), of which the main writers from the United States account for 95% approximately. The total number of patent applications in the DID field is 853, of which 411 patents have been published in the United States, accounting for 49.36%, ranking first in the world [14].

4.3. Community Participation. The United States has a very high degree of participation and influence in the process of community participation in the DID field. Therefore, it can be seen that the United States has a key advantage in the international engagement in this field.

In terms of the number of DID-related communities, according to incomplete statistics, among the 15 international communities (including TOIP, MyData Global, ID2020, RWOT, IIW, EBP, WEF, OpenID, OASIS, HyperLeger, INATBA, Kantara Initiative, W3C, DIF, and IETF) with outstanding DID-related contributions, nearly
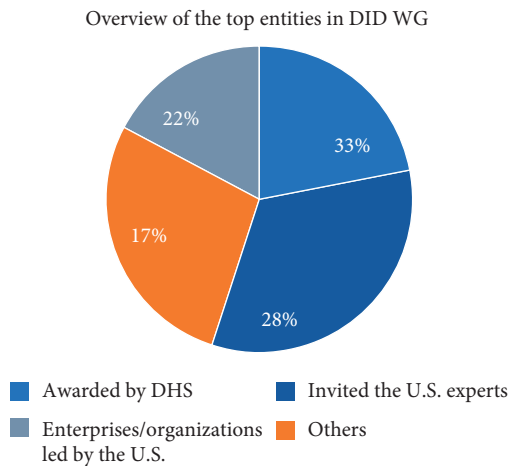
Overview of the top entities in DID WG

FIGURE 5: The overview of top entities in the W3C DID WG.

70% of the international communities, governance platforms, foundations are headquartered in the United States [15]. It is worth mentioning that the Decentralized Identity Foundation (DIF), which controls the writing permission of global application solutions (DID methods), was also led by the United States [16].

On the side of key positions, as the W3C is a high-yield authority in the field of DID standards-making, the activeness of leading experts' contribution in the W3C DID WG standard-making has been tailed through analysing each WG meeting. The results showed that 70% of the TOP 20 experts who were comparably active, and regarded as key leaders, in DID v1.0 standard-making is from the US. And early 60% of American experts or business representatives participated in the standard-formulating work in total [17].

4.4. Application Development. Judging from the perspectives of the number of enterprises, the amount of investment in R&D, and the horizontal and vertical coverage of the DID industry, the United States has been at the forefront of the world in the application and development of DID.

As for the number of enterprises engaged in this field, the data from the Crunchbase database is known that a total of 25 companies were retrieved through the keyword "Decentralized Identity," of which 8 were American companies, accounting for 32%, and a total of 218 companies were retrieved through the keyword "Digital Identity," of which 66 were American companies, accounting for 30%, both ranking first in the world [18]. Among the leading enterprises participating in the W3C DID WG standard-formulating, 33% are funded by the DHS of the United States, and 22% of the remaining participating entities are US companies or organizations led by the US (see Figure 5).

On the side of the investment on R&D, the data gained from the CBinsights database, a total of 218 companies were retrieved worldwide through the keyword "Digital Identity," with an amount of 2 billion US dollars financed by the startups' engaged in DID field, of which 66 were US companies, accounting for 38%, and a total financing amount of 1.47 billion US dollars, accounting for 22.2%, placed the first [19].

In terms of the horizontal and vertical industry coverage, the US government promotes the multi-industry innovative application practice of DID through a series of government-enterprise cooperation. Among them, the field of personal credentials has covered multiple application scenarios such as immigration, licenses, and vaccine certification, also, the field of transactional credentials has covered 5 major industries, such as steel, agriculture, oil and gas industry, and e-commerce [20]. The United States has achieved a complete layout of the entire DID industry chain, including a series of full-process designs and testing from personal credential wallets to decentralized authentication capabilities [21].

5. Conclusion

Generally speaking, since DID is a highly fundamental and key technology, the US government encourages enterprises to carry out targeted innovation and development through government-enterprise cooperation. The purpose is to stimulate the activity of international standard formulation and enhance the participation of the international community through the application innovation of enterprises. At the same time, the enterprise side explores actively the development of the entire DID industry chain and explores the application of DID in various industries and areas. Overall, the United States has formed a forward-looking strategic layout of "government in the front, enterprises in the back," which provides all-around support for the United States' international engagement in the DID field.

As for some developing countries, such as India or China, they may not pay significate attention to the changes brought about by the new generation of network identification, and lack the overall strategic layout, funds, and government special support as well, even not have great efforts to improve the degree of research levels, community participation, and application development on DID. Thus, the international engagement of the developing countries in the DID field is not as strong as the United States. To gain more advantages of international engagement in the DID field, other countries should try to focus on the four dimensions in the model, improving their national strategy, research level, community participation, and application development on the DID technology.

Data Availability

The data used to support the findings of this study have been deposited in the repository, you can check from the following links: 1. https://inspire.wipo.int/incopat-global-patent-database; 2. https://identity.foundation/; 3. https://www.w3.org/; 4. https://www.cbinsights.com/;5. https://decentralized-id.com/government/usa/dhs/.

Conflicts of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgments

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