MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
V.N. Karazin Kharkiv National University
Faculty of Mathematics and Informatics
Department of Theoretical and Applied Informatics

Master's Qualification Thesis

On the topic Semantic web in the Internet of Things, analysis of methods for solving existing problems and prospects for development

Executed by: 2nd-year student, group MCS-64
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___________**Hou Yabo**___________
(surname and initials)
Supervisor _______Yurii Parfeniuk ___
(surname and initials)
Reviewer Dmytro Chumachenko
____
(surname and initials)

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1. INTRODUCTION

1.1. Abstract

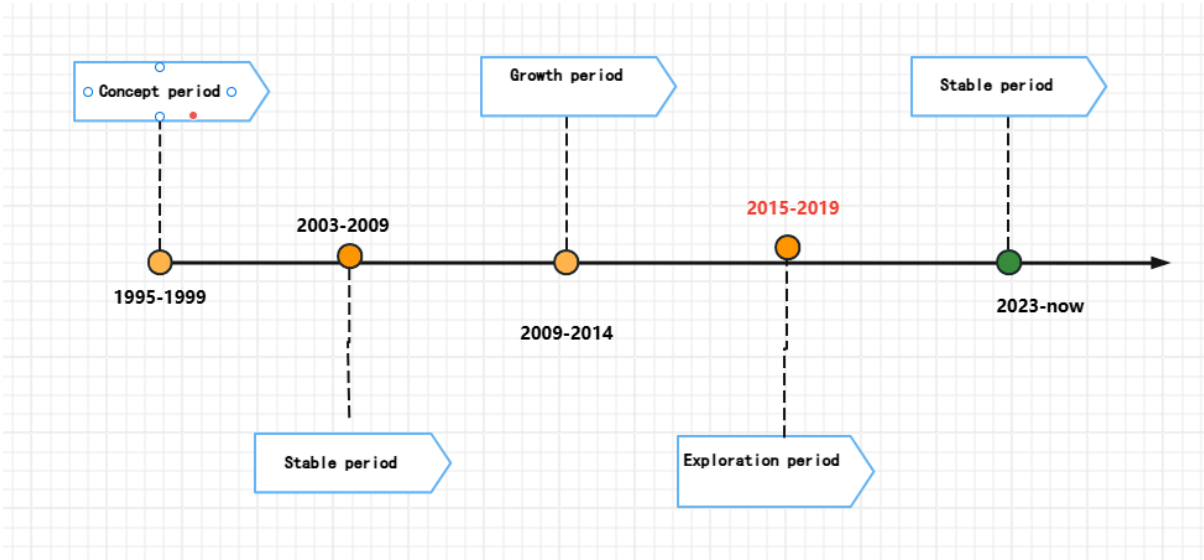
The Semantic Web and the Internet of Things have developed rapidly this year and have been rapidly applied to our lives. It is expected that by 2050, 60% -90% of people worldwide will use smart devices, and the penetration rate of smart devices will be even higher in developed countries.[1] We have so much data because of the rapid development and high quality of the Semantic Web and the Internet of Things. But in the rapid development and high quality of smart devices, we also have to face various challenges,even as difficulty, such as how to define the metadata, how to storage of metadata and manage them , as well as subsequent data analysis and processing, data queries, especially data interoperability and sharing. This issue is a historic bottleneck challenge encountered in the development of the Internet of Things and the Semantic Web. To solve this bottleneck obstacle problem, this thesis will analyze the current problems and discuss how to solve them from the perspectives of the Semantic Web and the Internet of Things. It will also discuss the challenges faced in the future and the applications of the Semantic Web in the Internet of Things, providing guidance for the future development of the Semantic Web and the Internet of Things, as well as potential problems that may arise.

[1]https://www.fromgeek.com/telecom/487459.html

1.2. Background

The Internet of Things is gradually being popularized and applied in our lives. As far as the current development status of the Internet of Things is concerned, it has been applied to our lives and improved our convenience. However, the development of the Internet of Things has also encountered some difficulties that urgently need to be solved. Such as the Internet of Things relies on our hardware sensors and data collection devices. At the same time, when our hardware devices collect these raw data, we define and store them. In the future, when we need these data, how can we quickly and correctly obtain the corresponding data. But now the metadata definition and storage standards of the Internet of Things vary greatly among different industries, especially when the amount of data accumulates over time, this problem becomes particularly prominent, and these raw data are largely disorganized. In the process of communication, various devices will become more difficult, especially when various industries of the Internet of Things need to achieve ecological integration, and the interaction between various systems will become even more difficult.

Up to now, the development of the Internet of Things has mainly gone through the following stages and is still constantly improving and developing.



Around 1999, several professors and graduate students from the Auto ID Laboratory at the Massachusetts Institute of Technology in the United States first proposed the concept of the Internet of Things, marking the formal birth of the Internet of Things in everyone's field of vision. The concept involved in this idea was actually addressed to some extent in Bill Gates' 1995 book 'The Road to the Future'.

From 2003 to 2009, the Internet of Things entered its infancy. During this period, the International Organization for Standardization (ISO) established the Internet of Things Research Group in 2013 and began to specify the basic standards and scope of the Internet of Things, providing a solid theoretical foundation for the later development of the Internet of Things. During this period, the core technologies of the Internet of Things began to develop rapidly, especially the rapid rise and widespread promotion and application of technologies such as RFID and sensors in the Internet of Things.

From 2009 to 2014, the Internet of Things entered a growth period. In these years, the mobile Internet entered a mature period, providing basic support for the network services of the Internet of Things. The Internet of Things equipment began to gradually access the network, making the Internet of Things develop rapidly.

From 2018 to 2022, the Internet of Things entered its exploration period. The IaaS market is gradually maturing, and public cloud providers are gradually joining IoT platforms and providing stable device infrastructure services, using cloud platforms to provide data services for basic devices.

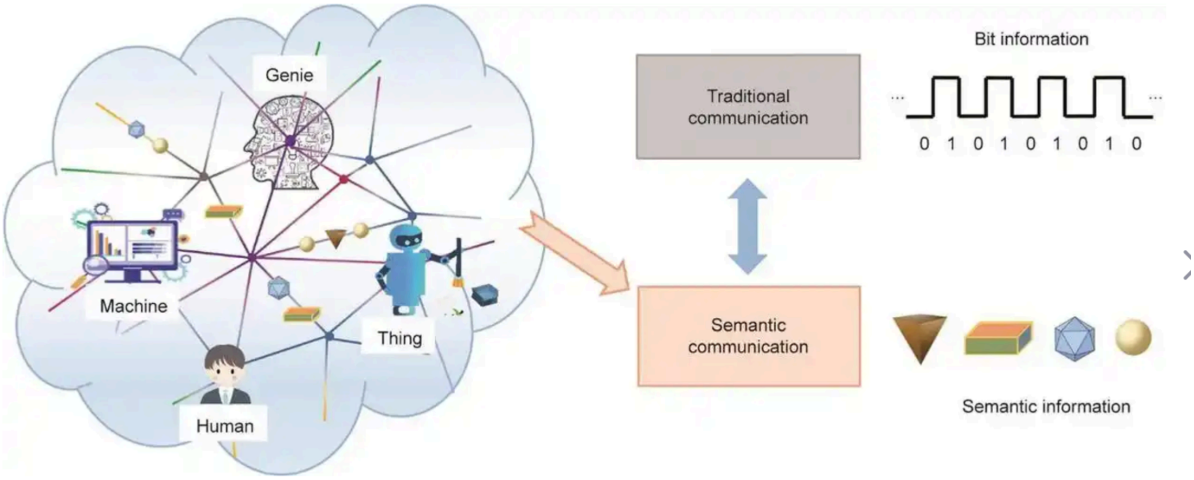
From 2022 to present, the Internet of Things has entered a stable period, during which its hardware devices and software services have been fully utilized, continuously achieving interconnectivity between things.

The Semantic Web is mainly an intelligent network that can make judgments based on semantics, especially with the development of artificial intelligence in recent years, which has made the concept of the Semantic Web a reality. The development has gone through the following stages:

In 1968, J R. Quillian first proposed a model of natural understanding language that could be used for human associative memory, which was also a preliminary semantic web model. However, at that time, network technology was not yet developed, and this theory was not widely promoted and applied.

With the rapid development of the Internet, Tim Berners Lee of the World Wide Web Consortium (W3C) formally proposed the concept of the semantic web in 1998, aiming to define all documents on the World Wide Web as semantic "metadata" that can be understood by computers, thus making the entire Internet a platform for information exchange.

Since the 21st century, the rapid development of Internet technology, especially the emergence of search engines and artificial intelligence, has rapidly promoted the development of the semantic web.

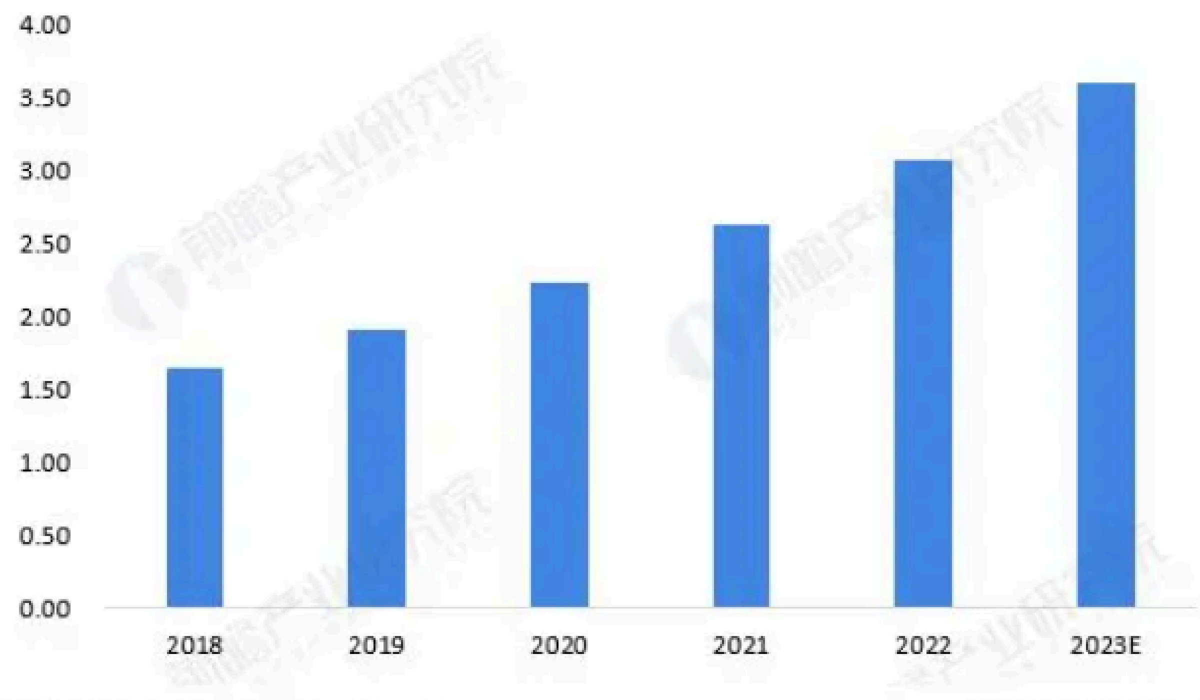

Genie
Machine
Thing
Human
Traditional communication
Semantic communication
Bit information
0 1 0 1 0 1 0 1 0
Semantic information

1.3. Research Meaning

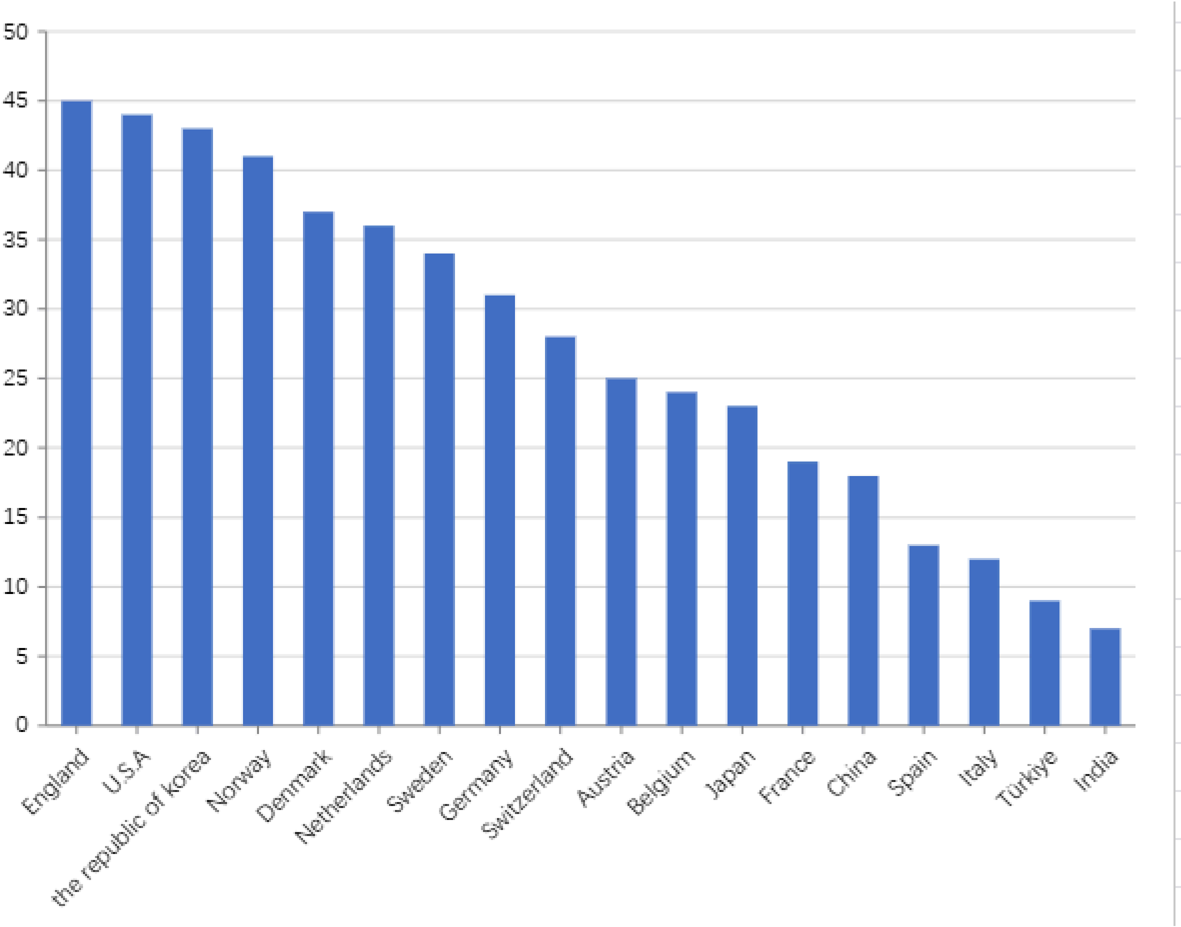
The development trend of the Internet of Things is currently at its peak , and its penetration rate in the market is also very objective. According to the White Paper on the World Internet of Things Digital Economy released at the 2024 World Internet of Things Conference [2], the number of global IoT connections will be exceed 25 billion by 2024 year. It is expected that by 2030, the number of IoT devices worldwide will clock up 29 billion, and it reflecting the rapid development and widespread application of IoT technology. By 2050, the number of IoT devices worldwide will be ubiquitous in every corner of our lives. From the perspective of the popularity of the Internet of Things, exploring and researching the Internet of Things is very important and meaningful.The following chart shows the number of IoT devices (in billions) and the penetration rate of smart devices in recent years. It is not difficult to see that the number of smart devices used has increased by about 100% this year, with more developed countries having higher penetration rates of smart devices.

[2]http://www.wiotc.org/cn/reports/WPIIDE/

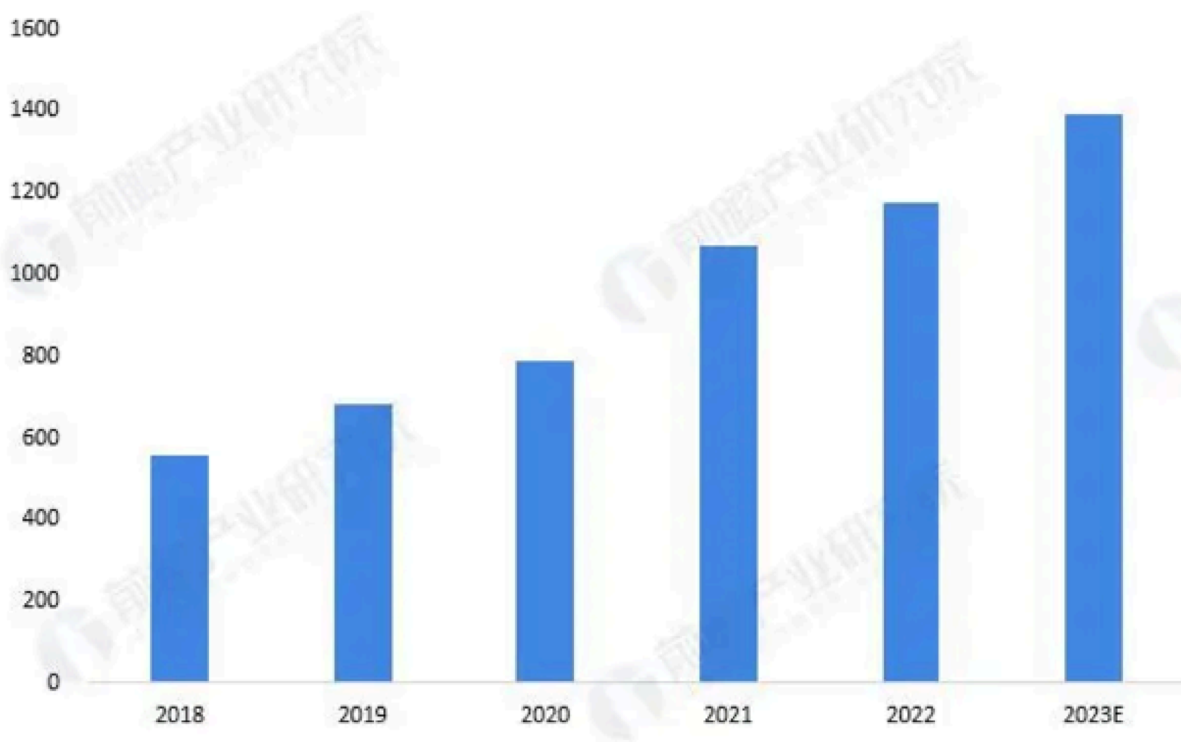
Number of smart devices used (billion)



Percentage of use of smart devices by country



Global smart Home Industry sales revenue, 2018-2023 (unit: USD 100 million)



The semantic web defines the storage, processing, and data processing of the collected data, as well as the use of simple and easy to understand formats or languages for data processing to be exposed to the outside world. This will make information exchange between devices, even across industries will become more convenient.

The Semantic Web can help us provide intelligent search engines, organize data integration, analyze sentences, provide relevant recommendation systems, and assist us in making decisions and adopting appropriate strategies to make our lives more convenient. It can quickly understand and analyze the content of the text we want to express, internally implement logical processing, help us analyze our problems, and make our lives more convenient. For example, if we want to travel and play in a certain place, our in car system can collect our voice commands, help us analyze the best path to the destination, and recommend whether the current road will be congested based on the current number of search users, as well as recommend another road to help us better recommend better roads.

2. MAIN CONCEPTS

This chapter will analyze the current development status from the perspectives of the Semantic Web and the Internet of Things. The main points of discussion about how to read the metadata,how to define storage, data interoperability, currently development status, as well as data security and application scenarios of the Internet of Things. At the same time, solutions and ideas will be provided for the above problems. The following context will gradually elaborate on the above issues.

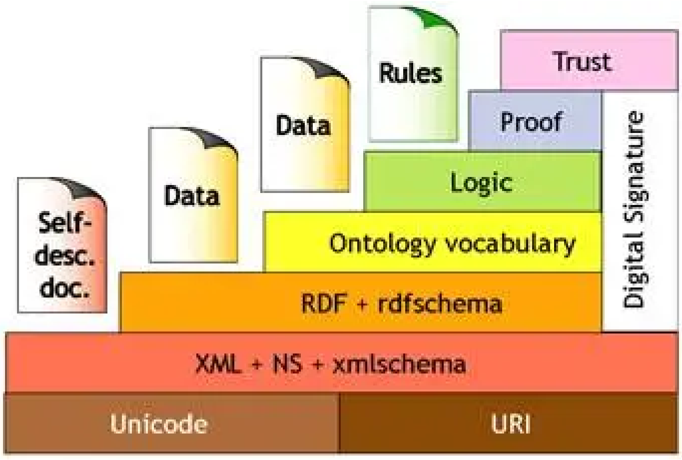
2.1. Issues related to massive data collection, storage, and processing

In real-life scenarios, our hardware devices collect more and more data. How to remove some invalid data without storage or processing will reduce the storage of useless data and greatly improve service accuracy.

In addition, we will face various situations and complex data. Each system may have been developed by different vendors, and their protocols and exposed interfaces are also different. We are faced with dirty data and invalid data. How to clean, organize, and reprocess this data into the dataset we want will also make system integration difficult, especially when multiple systems interact, The problem of defining raw data will become increasingly prominent, and if this issue is not resolved, it will seriously hinder the development of the Internet of Things.

In addition, when we use different models to define the data we need to store, the extraction of this data becomes disorganized and difficult to maintain. If we adhere to the norms of the Semantic Web, to some extent, we can reduce these unnecessary troubles. Next, we will introduce the technical specifications, standards, and tools used in semantic web technology:

Since its proposal by Tim Berners Lee in 1998, the Semantic Web has been around for over 20 years. However, its rapid development was only achieved in 2020, especially with the emergence of chatgp, which has led to the application of intelligent semantic web. Although the Semantic Web has made great progress, its problems have become particularly prominent due to its short development time.we can see the picture which introduces the structure about the Semantic Web,It is obvious that data storage and definition lay a solid foundation for the Semantic Web. Next, we will discuss the standardization of data storage issues from the perspective of the architecture of the Semantic Web



Picture structure about the Semantic Web

1. Use a unified character set:

All metadata is identified using Unicode and URI. Among them, Unicode is a recognized character set, in which all characters are represented by two bytes, and a total of 65536 characters can be represented, basically including commonly used characters in all languages in the world. The data format can be Unicode, and its biggest feature is that it supports combinations of all major popular languages in the world and can perform resource retrieval simultaneously. URI (Uniform Resource Identifier), also known as Uniform Resource Locator, is used to uniquely identify a specific and indivisible concept or resource on the network. In the semantic web architecture, this layer is the foundation of the entire semantic web, where Unicode is responsible for encoding resources and URI is responsible for identifying resources.

2. Markup layer language

We can adopt the specification requirements of XML+NS+XML schema to define the content and structure of data, and separate various information content, structures, and relationships on the network using standard language and syntax.

Among them, XML is a streamlined standard universal markup language that is mainly responsible for defining data structures, while supporting users to mark and define their own data structures and express data structures according to their customized needs. In the following example, we can see that each layer identifies a definition of a data structure, and we only need to follow the corresponding syntax to complete the definition of the data structure.The following example uses the syntax of XML to define data.

```
<migration urlid="http://www.microsoft.com/migration/1.0/migxmlext/migtestapp">
    <component type="Application">
        <displayName>Some Application</displayName>
        <environment context="System">
            <variable name="myVar1">
                <text>value</text>
            </variable>
            <variable name="myAppExePath">
                <script>MigXMLHelper.GetStringContent("Registry","HKLM\Software\MyApp\Installer [EXEPATH]")</script>
            </variable>
        </environment>
        <role role="Settings">
            <detects>
                <detect>
                    <condition>MigXMLHelper.DoesObjectExist("Registry","HKLM\Software\MyApp [win32_version]")</condition>
                </detect>
                <detect>
                    <condition>MigXMLHelper.DoesFileVersionMatch("%MyAppExePath%","ProductVersion","8.*")</condition>
                    <condition>MigXMLHelper.DoesFileVersionMatch("%MyAppExePath%","ProductVersion","9.*")</condition>
                </detect>
            </detects>
            <rules context="User">
                <destinationCleanup>
                    <objectSet>
                        <pattern type="Registry">HKCU\Software\MyApp\Toolbar\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp\ListView\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp [ShowTips]</pattern>
                    </objectSet>
                </destinationCleanup>
                <include>
                    <objectSet>
                        <pattern type="Registry">HKCU\Software\MyApp\Toolbar\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp\ListView\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp [ShowTips]</pattern>
                    </objectSet>
                </include>
                <exclude>
                    <objectSet>
                        <pattern type="Registry">HKCU\Software\MyApp [Display]</pattern>
                    </objectSet>
                </exclude>
ation › component › role › rules
```

NS (Name Space) stands for namespace, determined by URI index. Its main function is to locate and find resource locations. Usually, we name it based on different business and data backgrounds. Its characteristic is uniqueness, so when using it, we try to use different identification characters to describe different things.

```
<migration urlid="http://www.microsoft.com/migration/1.0/migxmlext/migtestapp">
    <component type="Application">
        <displayName>Some Application</displayName>
        <environment context="System">
            <variable name="myVar1">
                <text>value</text>
            </variable>
            <variable name="myAppExePath">
                <script>MigXMLHelper.GetStringContent("Registry","HKLM\Software\MyApp\Installer [EXEPATH]")</script>
            </variable>
        </environment>
        <role role="Settings">
            <detects>
                <detect>
                    <condition>MigXMLHelper.DoesObjectExist("Registry","HKLM\Software\MyApp [win32_version]")</condition>
                </detect>
                <detect>
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                </detect>
            </detects>
            <rules context="User">
                <destinationCleanup>
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                        <pattern type="Registry">HKCU\Software\MyApp\Toolbar\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp\ListView\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp [ShowTips]</pattern>
                    </objectSet>
                </destinationCleanup>
                <include>
                    <objectSet>
                        <pattern type="Registry">HKCU\Software\MyApp\Toolbar\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp\ListView\* [*]</pattern>
                        <pattern type="Registry">HKCU\Software\MyApp [ShowTips]</pattern>
                    </objectSet>
                </include>
                <exclude>
                    <objectSet>
                        <pattern type="Registry">HKCU\Software\MyApp [Display]</pattern>
                    </objectSet>
```

The underlying technology implementation of XML Schema still adopts XML syntax constraints, supports common data types, and can better serve effective XML documents and provide data validation mechanisms. It includes the flexible definition structure of XML, data determinacy composed of URI indexes and NS, as well as the various data types and validation mechanisms provided by XML Schema, making it an important component of the Semantic Web architecture. This layer is responsible for representing the content and structure of data grammatically, separating the definition, storage, and presentation of network information, data structure, and content using standard language.

Above, we have introduced the data storage specifications and definitions of the Semantic Web. It is not difficult to see that if all systems adopt this constraint specification, the subsequent data extraction, processing, and conversion will be fully guaranteed, which will provide stable support for future business expansion.

2.2. Cross domain service integration and interoperability issues

Nowadays, data in the Internet of Things often comes from different devices and systems, and the amount of data has gradually increased. However, the current Internet of Things and its ecosystem are not mature enough, and there may be communication and interaction problems between devices that are not connected. Especially, current research focuses more on the development of IoT applications in a specific field, and less on the integration, sharing, and interoperability of IoT services across domains. The dynamic and ubiquitous requirements of IoT services pose new challenges to the construction of service platforms. For example, the computer and camera in our home may not be produced by the same brand. Therefore, if we want our computer and camera to communicate and interconnect, there may be incomprehensible commands or even incorrect commands being executed.

Therefore, in the development of the Internet of Things, we can take the following measures to ensure smooth interaction between various systems:

RDF: This protocol is mainly used for defining, querying, and accessing data. The main definition is to use a unified standard data model to describe and identify resources across multiple systems, and to use indivisible attributes and values to describe these resources. At the same time, the basic types and quantities of data are defined. Using such limitations will make the underlying data for communication between various systems and services simple and shareable. There will be no incomprehensible sentences or grammar.

RDFS (RDF Schema): A vocabulary language used to define RDF resource properties and classes, which can be used to create classes and properties with a business hierarchy and define their relationships between businesses. This makes resources not singular, but have business relationships. When there is a large amount of data, each resource no longer exists independently but is interconnected, which is what we understand as the Semantic Web. For example, we can set a basic class for the computer and a basic class for the mouse. These two resources can exist separately, but they have a logical relationship.

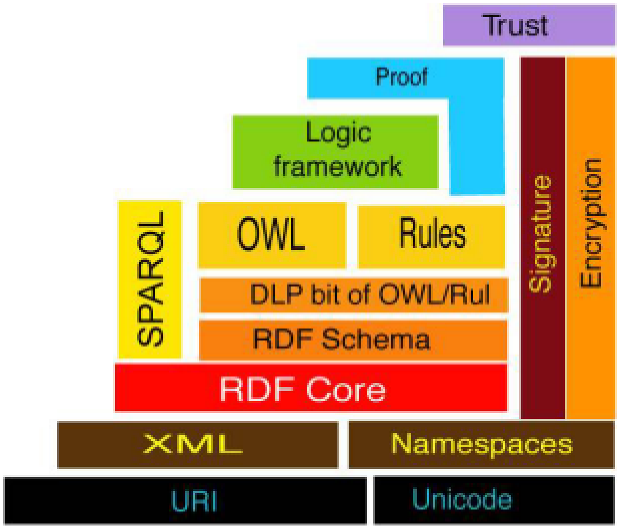
OWL (Web Ontology Language): mainly used to define and describe the logical relationships between complex classes and attributes on the semantic web, as well as the logical constraints between them. It is mainly used to build and partition different business domains and domain branches. OWL provides a detailed description of ontology and some RDFS principles. For example, in medicine, OWL can have different branches such as gastroenterology and hepatology, and play unique roles in different branches while also handling their logical relationships.

SPARQL: A query language mainly used for querying RDF data, similar to business query SQL for relational data, used to process RDF graph data. For example, in medicine, when we need to locate the cause of a patient, if we have relevant or similar cases, we can quickly query previous related cases and provide relevant experience and help.

Logic: It is mainly used to ensure that the data model and inference rules are correctly determined. By using predefined logical rules (such as RIF/SWRL) and reasoning through data models (RDFs and OWL), data based on these models can have stronger logical, expressive, and intelligent processing capabilities.

Proof: It is mainly used to ensure the authenticity of the data source and the credibility of the content, thereby avoiding the spread of erroneous information. This aspect mainly addresses the original authenticity of the underlying data, rather than data that has been tampered with arbitrarily.

Trust: undertakes the responsibility of ensuring data reliability and security. Mainly from the application level, data encryption, logical verification, etc. are carried out to ensure the reliability, accuracy, and trustworthiness of data, thus ensuring that users can obtain accurate and reliable data services at the application level



Adhering to the above specifications can reduce system interaction and integration costs, as well as reduce data heterogeneity issues. In the future, semantic web technology will further improve the ability of data integration and integration, enabling seamless integration and sharing of massive device and sensor data in the Internet of Things.

2.3. The development of intelligent semantic web is not mature enough

The concept of the Semantic Web was first proposed by Tim Berners Lee of the World Wide Web Consortium in 1998. Its purpose is to facilitate information sharing among scientific researchers, facilitate barrier free information exchange, and integrate all information on the World Wide Web into a more intelligent platform. It aims to achieve an intelligent network that can not only understand words and concepts, but also their logical relationships, and make decisions, enabling barrier free communication between humans and computers. To this end, the World Wide Web Consortium (W3C) released the Semantic Web Guidelines in 2001, officially establishing standardized standards for semantic web technology. Since then, W3C has released new semantic web recommendation specifications every year, continuously improving and expanding the functionality and application scope of the semantic web. These specifications and standards encompass the architecture and models of the semantic web. The architecture consists of seven layers, which are in sequence: "Character Set" layer, Root Markup Language layer, "Resource Description Framework" layer, "Ontology Vocabulary" layer, and Logic, Proof, Trust, Logic layer. We have also discussed the issue of models describing specific resources through resource attributes and their corresponding values in chapters 3.1 and 3.2. Currently, these architectures and models have been applied.

Although the Semantic Web is currently developing rapidly and has gradually begun to be applied in our lives, the current technology is not particularly mature. For example, the problems we encounter may have never been foreseen. When new problems arise, our models may not have collected relevant data in the past, which can lead to our inability to handle the current problem. For example, when we issue instructions to our devices, the instructions may be vague, unclear, or even incomprehensible errors, which can result in algorithms being unable to provide corresponding responses. This is mainly reflected in the immaturity of resource definition and logical relationship processing, which leads to the inability to find and distinguish the relationships between resources. Therefore, the current semantic web still needs to continuously collect a large amount of resource information and process the logical relationships between resources.

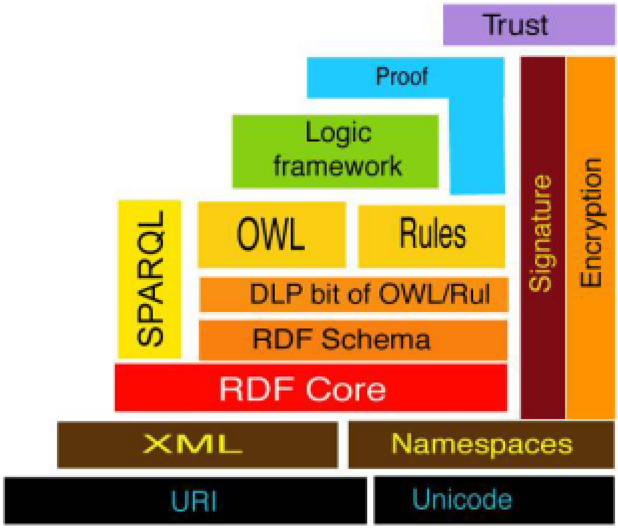
In terms of the current development status and trends of the Internet of Things and the Semantic Web, there is still a lot of room for development in the basic framework of our Internet of Things, and the problem-solving ability of the Semantic Web needs to be further improved. Therefore, we need to establish norms and standards, and gradually improve the framework model according to the standards, in order to ensure the more intelligent development of the semantic web.

With the development of technology, the Internet of Things and the Semantic Web will become more intelligent. Semantic World Wide Web technology will also provide richer semantic information for data in the Internet of Things, helping users to conduct more in-depth data analysis and mining, and discover more valuable information. The Semantic World Wide Web will provide more intelligent data query and retrieval services, meeting the diverse needs of users for IoT data. Through semantic modeling and description of data, the Semantic World Wide Web will provide users with personalized intelligent decision-making and recommendation services, promoting the development of the Internet of Things towards a more intelligent direction.


IoT Services
Digital Ethics
IoT Security
Digital Twin
Digital Business Technology Platform
IoT Business Solutions
IoT Edge Analytics
Hardware Security
Managed IoT Services
Infonomics
Edge AI
IoT-Enabled Applications
Things as Customers
IoT-Enabled Product as a Service
Licensing and Entitlement Management
IoT Platform
Event Stream Processing
Automotive Real-Time Data Analytics
IoT Edge Architecture
LPWA
Internet of Things
Autonomous Vehicles
Low-Cost Development Boards
Commercial UAVs (Drones)
Intelligent Building Automation Systems
IT/OT Alignment
MDM of Product Data
Indoor Positioning
Cloud MOM Services (momPaaS)
Smart Lighting
IoT Integration
Managed Machine-to-Machine Services
Asset Performance Management
expectations
As of July
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time

2.4. Protection of Security and Privacy Issues

Although the current Internet of Things has brought us great convenience, there are also some security issues that need to be taken seriously. Nowadays, IoT hardware devices almost indiscriminately identify and collect our personal data, which may include users' privacy data. Our semantic web also stores data in a standardized manner without encryption or other processing, which may lead to data leakage. At the same time, the Internet is also collecting our personal behavior data, such as our mobile phone number, home address information and so on. If these data are leaked, it will cause our personal privacy to be compromised, bringing great inconvenience and trouble to our personal lives.



We may encounter the following common privacy issues:

1. Express delivery notes, train tickets, bank statements, and other documents contain information such as name, bank card number, and consumption records. Discarding them casually can easily lead to personal information leakage.

2. Various online shopping, virtual communities, social network accounts, etc. may leave personal information, which can lead to the leakage of our phone numbers, receiving harassing calls and text messages, and so on.

3. Merchants are required to fill in detailed contact information and home address for various promotional activities, membership card applications, such as "survey questionnaires", shopping lottery activities, or applying for free mailing materials and membership card activities.
4. Recruitment websites leak personal information, and the personal information in resumes is readily available, which may be resold by illegal individuals at extremely low prices.
5. Registration for various exams, participation in online school classes, etc., often requires registering personal information. Some typing and photocopying shops take advantage of convenience by archiving and keeping customer information.
6. Misuse of ID card copies, including bank account opening, mobile network access, even membership card application, and supermarket point redemption, all require ID cards.
7. Browser browsing history: When searching for certain information in the browser, we often receive relevant information recommendations.

In the rapid development of the Internet of Things and the Semantic Web, our information is often leaked on the Internet, which has brought great trouble to our lives. Therefore, information protection is urgent. The following measures can be taken to prevent information leakage:
1. Strengthen privacy protection awareness: Understand the meaning and importance of privacy rights, learn relevant laws and regulations, and enhance self-protection awareness.
2. Handle personal information with caution: Properly safeguard items and information related to personal privacy, such as ID cards, bank cards, mobile phones, etc; Do not disclose personal sensitive information to others at will.

3. Improve the enterprise data management system: strengthen internal management of the enterprise and provide network security education to employees; Improve data security system to prevent data leakage and abuse.

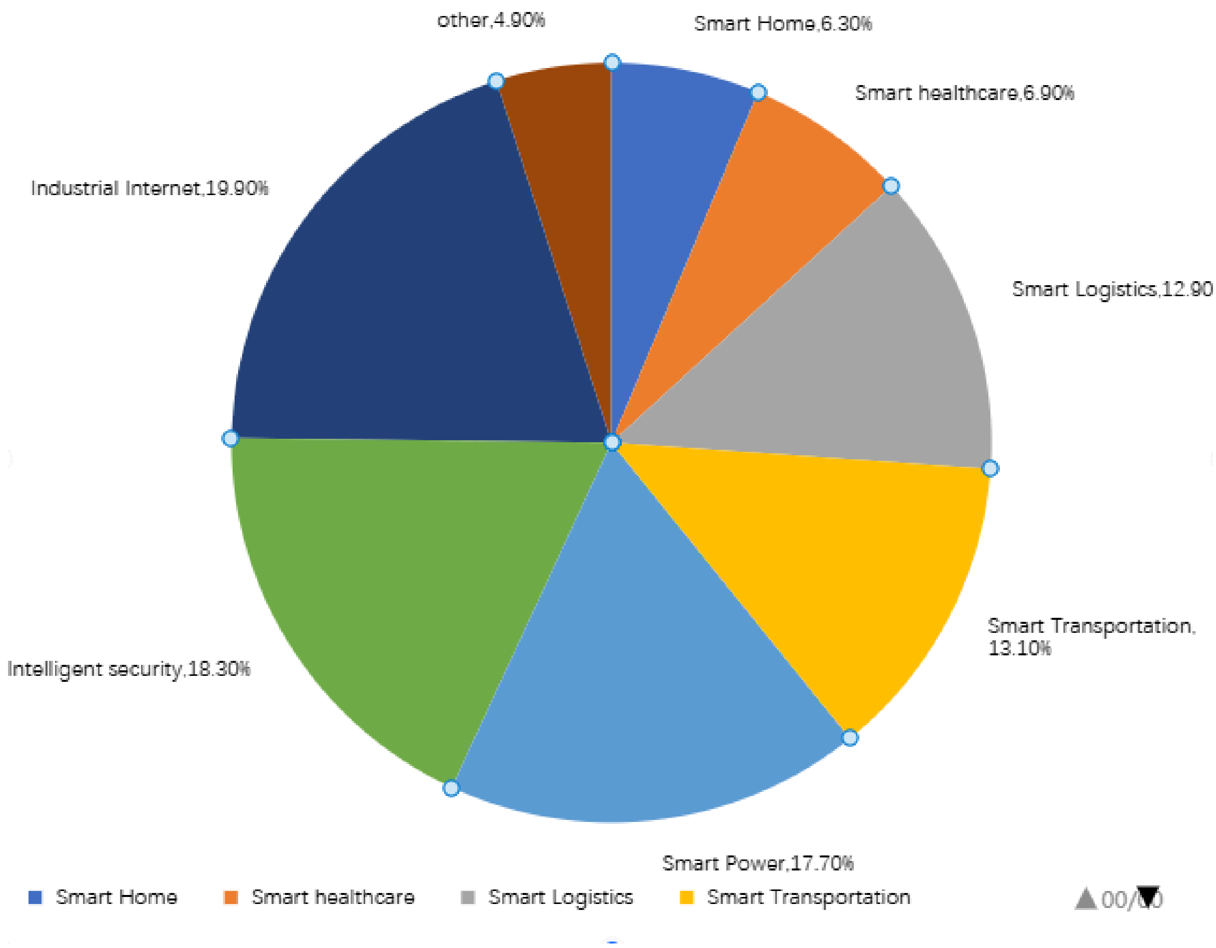
4. Strengthen network security protection: Starting from the protocol and trust of the semantic web, use secure network connections to avoid sensitive operations in public wireless networks; Regularly update and check the privacy settings of network devices; Use encrypted communication tools to ensure that communication content is not monitored, intercepted, or made public.

5. Data storage encryption: When unifying resource positioning, ensure that user core privacy data is stored in ciphertext instead of plaintext. This way, even if the data is stolen due to server attacks, the data obtained by hackers may be ciphertext, and even if the data is leaked, it may still be useless data.

2.5. Application and Development Prospects

With the rapid development of the Internet of Things and the continuous advancement of semantic web technology, the application prospects of semantic web in the Internet of Things are broad: in the future, there will be a qualitative leap in the Internet of Things and semantic web, especially in smart homes, smart cities, smart transportation, smart healthcare, smart industry and other fields.

It is expected that by around 2050, the Internet of Things will be ubiquitous in every corner of our lives, and we are about to enter a new era. The development of the Internet of Things and the Semantic Web. This chapter will discuss the future development and application prospects of the Internet of Things and the Semantic Web.



2.5.1. Smart Home

In the future, we can install temperature sensors in our rooms. These hardware devices can recognize our perceived temperature and make temperature adjustments based on our body temperature and physical condition, so that we can always live in a comfortable environment. In addition, we can remotely operate home devices on our mobile phones. For example, ten minutes before entering the house, we can use the device to pre heat our water heater and turn on the air conditioning to cool down. This will greatly save us unnecessary waiting time and allow us to have more time to do what we want, thereby improving our quality of life.

In this process, our hardware devices can recognize data at home and define and analyze it. In the future, when we are about to go home, we can even automatically turn on the devices at home and adjust them to the appropriate state without remote control.

In the future, we can remotely manage our rooms through our mobile phones, and even our rooms will be automatically managed

2.5.2. Smart City

Most of the streets now have cameras, but they only have shooting functions. However, with the development of the Internet of Things and the Semantic Web, they not only have shooting functions, but also can more intelligently analyze the environment, traffic flow, and even remind pedestrians to pay attention to safety. Our city will become more intelligent.

It is expected that by 2030, the penetration rate of the Internet of Vehicles will reach over 80%. As we continue to drive, the number of vehicles around us can be sensed through hardware devices, such as whether there are vehicles passing by, vehicle speed, emergency braking, lane changing, etc. At the same time, vehicles collect this information and take corresponding avoidance measures, such as slowing down, accelerating, etc. Provide safety measures for our personal safety. At the same time, we will also reduce the waiting time for traffic lights, and our city's transportation capacity will be significantly improved.

We define the data of various industries in the city by building a semantic web of smart cities, and integrate various data through query technology, which can comprehensively cover the public issues of urban life and be applied. At this time, our city will achieve greater intelligence.

2.5.3. Smart healthcare

In the current development of healthcare, some surgeries are still in the manual stage and have not fully entered the information age. In the next few decades, with the continuous development of IoT technology, there will be some high-end instruments and equipment to assist us in handling complex surgeries. In addition, these devices can monitor our physical health at all times. Some devices can be developed small enough to even enter our bloodstream, helping some patients clear viruses, enhance immunity, and help restore health, etc.

Each branch of the healthcare industry can be researched independently, and then the various branches can be combined to make healthcare more intelligent. At this point, the roles of the Internet of Things and the Semantic Web are highlighted. For example, we can define specialties such as cardiology and hepatology separately, and data exchange can be achieved through frameworks such as RDF and RDFS. When we extract and communicate business data from various departments, in the future when patients go to the hospital for treatment, doctors can spend less energy analyzing and defining the patient's condition, and the results analyzed by the semantic web will be more accurate

2.5.4. Intelligent Manufacturing Industry

The productivity of traditional manufacturing industry is far from meeting the development of modern society. In the context of Industry 4.0, intelligent manufacturing industry will have great development space, realizing the transition of society from traditional industry to artificial intelligence. For example, in the manufacturing workshop, we only need to describe the equipment we want to manufacture in language, and then display the shape, size, and parameters of the equipment on the screen. When we issue a confirmation command, the equipment can automatically recognize and manufacture the corresponding equipment, which will greatly improve production efficiency and the manufacturing industry. This will make our living conditions better.

For example, in the automotive manufacturing industry, to manufacture a car, we usually need to first create a car model, a parts model, a testing model, adjust the model, and a series of industrial processes. However, the development of the Internet of Things will completely change and increase the complexity of these processes. We only need to express the functions, and the models, part parameters, etc. required for automobile production can be displayed to us in a timely manner. Of course, these parts can also be produced.

3. CONCLUSIONS

The related technologies and devices of the Internet of Things are gradually developing and maturing. Especially with the relatively mature achievements in sensor related technologies, the collected data is also relatively stable. These reliable data provide a basic guarantee for the reliability and accuracy of data analysis. However, the problems faced are becoming increasingly prominent, especially the standardized definition and storage of data, the heterogeneity between devices, and the communication of information between services.

The Semantic Web defines different basic data sources according to a unified and standardized language pattern, associates data with each other, and forms a logical network between data. This way, when we want to obtain corresponding data, we can read, parse, and even intelligently associate it through association relationships. The Semantic Web will have great advantages in the field of intelligent recommendation.

The concept of semantic web has been developing for some time now, and there is already a certain trend of development, but there is still a long way to go in the future. In the future, we need to define various data definitions and correlations, especially cross industry integration. If this problem is overcome, the use of the Semantic Web and the Internet of Things will be further utilized.

In this article, we outline the problems encountered in the current development of the Internet of Things and the Semantic Web, and conduct research and analysis on how to break through this bottleneck problem. We also provide solutions and directions for the current immature technology and potential problems. Especially in terms of data collection and storage, as well as standardization, data interoperability, and cross industry integration business analysis, the issues of data security and privacy protection are discussed. I hope this bottleneck problem can be resolved in the near future. At the same time, this paper also discusses the development trends and possible practical application scenarios of the future Internet of Things and Semantic Web.

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