Grant Agreement No.: 723227
Call: H2020-ICT-2016-2017
Topic: ICT-37-2016
Type of action: CSA

D2.2 – Report on Future Internet Chinese projects for future collaboration

Work package	WP2
Task	Task 2.2: Survey of Future Internet Chinese projects for future collaborations
Due date	April 30, 2018
Submission date	June 30, 2018
Deliverable lead	SPI
Version	2.0
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Abstract	This deliverable provides an overview of a selection of key Chinese projects (or involving Chinese participation) focusing on Future Internet, 5G and IoT, including their objectives and main results. It also provides an analysis of some of the key topics for future projects within the 5G, IoT and ICT domains. The deliverable provides a review of the current IPR system in China, and closes with a review of cooperation status and impact in the EU and other countries.
Keywords	China, Future Internet, 5G, IoT, Standardisation, Projects, IP, Patent management, Cooperation

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	2018.11.04	Selection and consultation of source material	SPI
0.2	2018.01.12	Compilation of information and development of first draft	SPI
0.3	2018.01.26	Internal updates to first draft	SPI
0.4	2018.02.22	Contributions to first draft	InterInnov, INNO
0.5	2018.03.20	Development of second draft	SPI
0.6	2018.03.21	Internal review of second draft	SPI
0.7	2018.04.06	Development of third draft	SPI
0.8	2018.04.26	Review and quality control	Martel
1.0	2018.04.30	Final version; submitted deliverable	SPI, Martel
1.1	2018.6.27	Final updates to deliverable	SPI
2.0	2018.6.30	Final review; submitted deliverable	Martel

Acknowledgement

This deliverable has been written in the context of a Horizon 2020 European research project, which is co-funded by the European Commission, the Chinese government and the Swiss State Secretariat for Education, Research and Innovation. The opinions expressed and arguments employed do not engage the supporting parties.

Project co-funded by the European Commission in the H2020 Programme		
Name of the deliverable:	Report on Future Internet Chinese projects for future collaboration	
Dissemination Level		
PU	Public, fully open, e.g. web	✓
CI	Classified, information as referred to in Commission Decision 2001/844/EC	
CO	Confidential to EXCITING project and Commission Services	

** R: Document, report (excluding the periodic and final reports)*
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc.

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LIST OF ACRONYMS

APAN	Asia Pacific Advanced Network
CERNET	China Education and Research Network
CIETC	Center for International Economic and Technological Cooperation
CNGI	China Next Generation Internet Demonstration Project
FI	Future Internet
FP6/7	Framework Programme 6 / 7
FYP	Five-Year Plan
IoT	Internet of Things
IPv6	Internet Protocol version 6
MIIT	Ministry of Industry and Information Technology
MOST	Ministry of Science and Technology
NGI	Next Generation Internet
NDRC	National Development and Reform Commission

EXECUTIVE SUMMARY

Europe and China are at the forefront of technological advances in areas related to the Future Internet. While both parties share common objectives, the purpose of EXCITING is to further support and enhance the creation of favourable conditions for strengthening the bilateral cooperation of the European and Chinese research and innovation ecosystems, mainly related to the key strategic domains of IoT and 5G.

Therefore, EXCITING aims to study and compare the research and innovation ecosystems for IoT and 5G in China and Europe, in order to identify and document the main variables that determine the evolution of these fields. The ultimate goal is to produce a roadmap showing how research and innovation ecosystems, policy, standardisation, interoperability testing and practical Large Scale Pilots should be addressed during the H2020 timeframe, and elaborate recommendations for optimising collaboration between Europe and China for IoT and 5G.

This document presents deliverable D2.2 "Report on Future Internet Chinese projects for future collaboration". It is articulated into six chapters, briefly described hereafter:

Chapter 1 | Introduction

Chapter 1 summarises the general and specific objectives of deliverable D2.2 "Report on Future Internet Chinese projects for future collaboration", as well as the methodology used to accomplish them. It also contains a brief description of the structure of the document.

Hence, the document intends to provide a thorough understanding of the relevant projects related to Future Internet (FI) and the most active Chinese organisations in the area.

Chapter 2 | Future Internet R&I in China

Chapter 2 reviews the most relevant projects launched by China in the areas of FI, 5G, IoT and standardisation. Each project is contextualised through a brief description of its objectives, key participants, the structure of participation and the project timeline.

In addition to providing an overview of the Chinese landscape in the area of FI, the analysis carried out helps set the focus of the country when developing projects related to FI, to identify some of the key players in the ecosystem, to evaluate the long-term impact achieved and to better comprehend the magnitude of the changes endured by the project in China, in order to optimise and integrate different type of projects.

Chapter 3 | Topics for future projects by 2020

Chapter 3 describes some of the core topics identified by the Chinese government in the field of FI for the upcoming years. Based on the analysis of the 13th Five-Year Plan (2016-2010), Made in China 2025 and the 5G Development Plan (2017-2020); it can be determined that 5G, IoT and ICT in general, will continue to be highly prioritised as strategic domains for the country's development and therefore, policies and investments aimed at promoting them are expected.

Each of these topics is presented through a background and areas for projects, as well as its potential economic and social development.

Other topics of economic and social interest are: Core Electronic Devices, High-end General Chips and Fundamental Software; Extremely large-scale Integrated Circuit Manufacturing Equipment and Technologies, and Advanced CNC machines and Fundamental Manufacturing Equipment.

Chapter 4 | Intellectual property and Patent management

Chapter 4 offers an overview on the situation of Intellectual Property (IP) and Patent Management in China. It introduces an overview of the IPR system, the evolution of the Chinese regulations, the judicial system and the legislative efforts in this regard. It also provides information concerning current trends, as well as insights on future policies.

The Chinese government has put a strong effort in establishing a stricter control over the protection of new ideas. Furthermore, it has also worked towards the enforcement of the patent holder exclusionary rights. However, in spite of the remarkable labour realised by the country in the past years, there is still room for improvement to further reinforce the defence of IPR and therefore, promote innovation.

Chapter 5 | Cooperation and impact in the EU and other countries

Chapter 5 analyses the strategy and mechanisms for cooperation established by China with other countries and regions, particularly the European Union (EU).

Overall, China has shown willingness to collaborate for accomplishing shared objectives, as proved by the active involvement of the country in EU projects in recent years. At the same time, China has gradually progressed towards a bigger openness through the inclusion of international counterparts in its projects.

These bilateral exchanges have had a positive impact in the advancement of FI and offer a well-established ground for future collaboration.

Chapter 6 | Conclusions

Chapter 6 reflects on the conclusions obtained in the present document. In a short period of time, China has placed itself at the forefront of FI. Considered a strategic domain for development, FI has received strong economic and political support from the Chinese government through different plans currently focused in 5G, IoT and standardisation. The latter one showing a significant shift in the way China understands innovation.

The priorities set for the next years continue their support for the abovementioned fields, due to its impact in the whole progress of FI technology. In fact, the dynamic cooperation established by China in these areas only reinforces their key importance in the vision contemplated by the Chinese government for the future of the country.

1. INTRODUCTION

The 21st century has brought a variety of challenges introduced by rapid technology advancements related to the Internet, creating a situation of uncertainty in the international scenario that has triggered a fierce competition among countries to lead the technological run. However, the impossibility to face those challenges individually has also turned cooperation into an essential need.

In this respect, EXCITING aims to depict the Future Internet (FI) ecosystem in China, including 5G and the Internet of Things (IoT), through the analysis of different projects, the regulation of IP and patents, the definition of key topics and the current cooperation between China and other countries, particularly European Union (EU) Member States (MS). This review allows to identify areas where EU-China cooperation is essential and therefore, easier to implement, as well as the most adequate counterparts.

Thus, the present document constitutes the D2.2 "Report on Future Internet Chinese projects for future collaboration" of EXCITING and contains the outcomes of the Task 2.2 – Survey of Future Internet Chinese projects for future collaborations.

1.1. Objectives

The main objective of the report is to provide a review of the relevant projects being developed in China related to FI and the most active organisations investing in the area. To achieve this, the following specific objectives have been defined:

- **O1**. Identify and analyse the most relevant FI (IoT, 5G, and standardisation) research projects in China, providing a brief description of these projects including their objectives, participants, structure of participation, project timeline and relevance to the FI landscape.
- **O2**. Establish the key topics for future projects by 2020.
- **O3.** Analyse the IP and patent management situation in China.
- **O4.** Analyse the status of EU-China cooperation and impact in EU and other countries.

1.2. Methodology

The methodology used to elaborate the report primarily consisted in desk research. Policy documents, project calls and outcomes, regulations, online clippings and other sources were analysed to obtain the information presented in the report. Experts were consulted to provide additional documentation and questioned as needed to provide any required clarifications.

1.3. Structure of the Report

This report is structured into six sections.

- **Introduction:** Present section, it identifies the objectives, methodology and structure of the deliverable.
- **Future Internet Research and Innovation Projects in China:** Provides a review of some of the main FI-related projects developed or being developed in China (or involving Chinese participation.
- **Topics for Future Internet projects by 2020:** Describes some of the key topics to be explored in the framework of R&D projects by 2020.
- **IPR and patent management system:** Provides a review of the progress made and current status of China's IPR and patent management system.
- **Cooperation and impact in the EU and other countries:** Describes the current strategy and cooperation mechanisms in China and involving the EU and other foreign countries.
- **Conclusions:** Provides a summary and reflection on the findings collected in the framework of the report.

2. Future Internet Research and Innovation Projects in China

This section presents a selection of some of the most important projects launched by China (or involving Chinese participation) in the fields of FI, 5G and IoT. The projects listed include a brief description of their objectives, key participants and structure of participation, and an overview of the developed activities and relevance (when these have been made available or are documented). The selection of projects is based on their size, the importance of the partners involved and the relevance and impact of the project in China.

It is important to note that the Science, Technology & Innovation (STI) sector in the country is governed by the National Science and Technology Development Plan, which is a part of the so-called Five-Year Plans (FYP). From 1953, the FYPs constitute the policy framework that set the priorities and guidelines for the social and economic initiatives to be implemented by the government of China in the next five years. The 13th FYP (2016-2020) is the national framework currently in force.

2.1. Future Internet

2.1.1. China Next Generation Internet Demonstration Project (CNGI)

As highlighted in EXCITING deliverable D2.1[1], the China Next Generation Internet Demonstration Project (CNGI) was one of the main boosters of the country's efforts in the Next Generation Internet (NGI) Domain. While it started back in 2003, its importance for China justifies its inclusion in this list.

Objectives

The CNGI is a strategic programme that aimed to help China gain a relevant position in the development of FI through the early adoption of the Internet Protocol Version 6 (IPv6). Specific objectives and activities of the project included:

- Building the next generation of Internet backbones in China.
- Developing key network technology and major applications for NGI.
- Promoting industrialisation and application of NGI equipment and software.
- Participating in international organisations, enabling China to play a role in setting standards.

Key participants and structure of participation

Key participants included China Mobile, China Netcom/CSTNET, China Railcom, China Telecom and China Unicom, as well as an additional academic research network operated by the China Education and Research Network (CERNET). Together, the participants constituted the six nationwide backbone networks responsible for supporting the project.

[1] EXCITING Deliverable D2.1 – Report on Future Internet and ICT research and innovation policies and ecosystem in China. https://euchina-iot5g.eu/wp-content/uploads/D2.1-Report-Future-Internet-Ecosystem-China.pdf

Developed activities and relevance

The CNGI project was officially approved by the State Council in July 2003. In September 2003, the National Development and Reform Commission (NDRC) announced work plans and established the guidelines for the coordination of the project.

As aforementioned, all major Chinese ISPs participated in the CNGI. Together, they built their own IPv6 backbone networks based on IPv6/IPv4 dual stack technologies. Through the CNGI project, the China Education and Research Network (CERNET), as a research-oriented ISP, started to build an IPv6-only network (i.e. CNGI-CERNET2). In 2015, the Ministry of Education approved 25 higher education institutions as the main nodes of the CNGI-CERNET2. CNGI-CERNET2 currently provides IPv6 access service for students and staff in many Chinese universities.

Through the CNGI project, two IPv6 International Exchange Centres were established: (1) CNGI-6IX and (2) CNGI-SHIX. CNGI-6IX was constructed by CERNET at the Tsinghua University (Beijing). The CNGI-SHIX was built by China Telcom (Shanghai). These exchange centres connect IPv6 backbone networks of different Chinese ISPs to each other. They also connect Chinese IPv6 networks with IPv6 ISPs in the USA, Europe, and the Asia Pacific Region.[2]

As of early 2011, and under the CNGI project, there were six backbone networks, 59 GigaPoPs in Chinese IPv6 backbone networks, extending to 22 major cities and with more than 270 access networks being connected to the IPv6 backbone.[2] The third and final phase of the CNGI programme started in 2016 and is expected to connect an additional 1200 academic and research institutes to the CERNET network.[3]

The CNGI project was implemented as a response to the new developments and challenges related to the FI. China's capacity to make valuable progress in IPv6 triggered an international competition to head the development of the NGI and consequently, led China to adopt several strategic decisions that resulted in initiatives such as the CNGI project.

The implementation of an IPv6 infrastructure strengthened the autonomy and innovation capacity of China, ensuring national information security and the move towards a deep transformation of the information technology industry. It also led to cooperation opportunities with other international stakeholders, including the European Union in the field of NGI. For example, the Tsinghua University National Network Centre and France Telecom Beijing Research and Development Centre cooperated to establish the Olympic Information Management Network and service platform based on IPv6.

At the national level, the CNGI project won the National Science and Technology Progress Award in 2007. According to statistics, during the construction of the CNGI, more than 600 applications for domestic patents were submitted, 11 of which were accepted (mostly invention patents). There were also submission of drafts for standards to the International Organization for Standardisation.[4]

[2] Wu, J., Wang, J. and Yang, J. CNGI-CERNET2: an IPv6 Deployment in China. ACM SIGCOMM Computer Communication Review. April 2011. http://www.sigcomm.org/sites/default/files/ccr/papers/2011/April/1971162-1971170.pdf

[3] Asia-Pacific Network Information Centre (APNIC). China's first IPv6-only backbone network to connect a further 1,200 campuses. https://blog.apnic.net/2017/01/31/chinas-first-ipv6-backbone-network-connect-1200-campuses/. Retrieved June 08, 2018.

[4] http://www.cngi.cn/article/content/view?id=271142

2.1.2. Go4IT project (EU-FP6)

Objectives

As the only Next Generation Internet project with Chinese participation in the Sixth Framework Programme (FP6) of European Commission, the FP6-Go4IT Project aimed at providing a low-cost test environment and respective test services, together with free of charge executable test suites, targeting IPv6 focused protocol testing, using standardised TTCN-3 test methods. Specific objectives included:

- Promoting and fostering conformance testing oriented validation approach as well as associated technologies such as TTCN-3.
- Developing the users' community of such an approach.
- Supplying a range of executable and freely accessible test services.
- Supplying the associated range of support services on a free basis.
- Supplying complementary commercial services such as certification, or consulting.
- Setting up the environment required to develop a low cost, open and generic solution.
- Raising awareness on testing and validation methodologies around the globe.

Key participants and structure of participation

As aforementioned, Go4IT was a European Commission funded project and the only NGI related project that involved China within FP6. In addition to China, and EU partners, it also involved organisations from Brazil and Russia. The partners of the project were: inno AG (Coordinator) and Fraunhofer FOKUS – Germany; jTest and INRIA – France; Cetecom – Spain; Ispras – Russia; IPT – Brazil; and BII, CATR, and BUPT – China.

Developed activities and relevance

The Go4IT project aimed to foster community engagement in adopting a test and validation approach. By providing adapted service activities, supported by an open community web portal and appropriate networking with other IPv6 and test related initiatives, the user community was also able to increase.[5]

The Go4IT project allowed to capitalize on large European investments made in infrastructures by giving the tools to all user communities to test IPv6 protocol based solutions, thus increasing their trust and confidence in new generation infrastructures.

During the implementation phase, the team made major breakthroughs in the testing field, taking advantage of the geographical distribution of the project consortium. The geographical component was also relevant because it allowed an increased dissemination of the project activities in the covered countries and gathered users and market needs in these regions.[6]

[5] https://cordis.europa.eu/project/rcn/80143_en.html, (Accessed May 30, 2018)
[6] e-Infrastructure: Computer and Network Infrastructures for Research and Education in Europe. European Commission – Information Society and Media. https://www.lu.lv/materiali/biblioteka/es/pilnieteksti/izglitiba/e-Infrastructure%20-%20Computer%20and%20Network%20Infrastructures%20for%20Research%20and%20Education%20in%20Europe.pdf (Accessed June 04, 2018)

This project showcased partner's efforts in contributing to promote the industrialisation of IPv6 Next Generation Internet worldwide by establishing international cooperative relations between different regions, namely EU countries, China, Russia and Brazil. This also meant that going forward, the latter regions would continue to maintain positive relations and engage in additional international large-scale projects that could benefit the involved regions. The project demonstrated Chinese, EU, Russian and Brazilian organisations' capacity in applying technology into further development phases and providing relevant services. The project mobilised the key necessary resources for successfully achieving the objectives of the project in particular with universities and academics partners, industrial partners, test houses and standardisation bodies.

The team promoted the platform through the participation in multiple events, including 3 interoperability events in Beijing, Cannes and Moscow; an IPv6 summit in Cannes (November 2006); a workshop in Moscow (April 2007) and workshops in São Paulo and Montevideo (October 2007).[7]

2.1.3. MyFIRE (EU-FP7)

FIRE – Future Internet Research and Experimentation – is a crucial initiative launched and financed by the European Commission (EC) that has been growing since its inception in 2010 with the ambition of being Europe's Open Lab for Future Internet research, development and innovation[8].

Objectives

The MyFIRE project was part of the Future Internet Research and Experimentation (FIRE)[9] initiative from the European Commission. The project aimed at optimising FI experimentation (through international collaboration) and setting up and using testbeds by increasing awareness on economic data and exploring best practices related to technical testbeds. Specifically, it also aimed to increase the benefits of experimentation in the area of FI by improving the functionality of experimentation and stimulating increased experimentation. MyFIRE explored three specific topics:

- **Research and technology**: it aimed to identify researchers and industry's real needs for testbed experimental facilities in the future.
- **Standardisation**: it aimed to identify standardised methodologies and approaches for testbeds in order to promote innovation and leverage the research results.
- **Innovation process and social and economic impacts**: it aimed to identify the economic costs, benefits and the results of using the testbeds for validating research results.

In support of these topics, MyFIRE also aimed to:

- Identify the main issues and needs in the testbeds approach.
- Define the testing methodologies used by the different stakeholders worldwide to analyse and document best practices
- Build tools and roadmaps to increase the effectiveness of testing activities.

[7] TTCN3 Asia 2007 www.ttcn-3.org/TTCN3UCAsia2007/Presentations/Session%201/GO4IT%20T3UC%20Beijing%2029-30%20Oct%2007V2.pdf
[8] Future Internet Research and Experimentation, FIRE: www.ict-fire.eu
[9] https://www.ict-fire.eu/fire/

- Disseminate the results and create an international internet research community.

MyFIRE aimed to give special attention to the development of international cooperation with other initiatives similar to FIRE, especially in the four BRIC partner countries (Brazil, Russia, India and China) of the MyFIRE consortium[10,11].

Key participants and structure of participation

The project involved the participation of countries from the European Union and BRICs. The project consisted of eight partners, namely: INNO, ETSI, Fraunhofer, and the University of Edinburg from the EU, IPT from Brazil, ITMO from the Russian Federation, ERNET from India and BII from China.

Developed activities and relevance

The MyFIRE project mainly aimed to contribute to the scientific and technological development of the countries involved in the area of ICT in order to create a significant R&D infrastructure with impact on the different sectors[12]. The project created a supportive environment that enabled key stakeholders to develop a solution to a core topic from start to end. This was also possible thanks to the contributions made by international partners, especially in the BRIC countries, concerning the requirements for building efficient experimental facilities. As a result of the strong collaborations and the stakeholders' expectations, MyFIRE identified the experimental activities most appropriate to develop a sustainable testing methodology able to contribute to European standards development[13]. MyFIRE achieved the multiple objectives it proposed, having achieved the results[14]:

- Developed an efficient set of mechanisms for testbed processes.
- Identified the user communities and their needs to improve research value of the huge investments in FIRE testbeds.
- Increased awareness on economic data and technical related best practices.
- Developed a brand-new approach to address the setup, design, use and optimisation of experimental test facilities.
- Created an environment providing the awareness for the efficient development of experimental facilities in Europe in collaboration with international partners, especially in the BRIC countries

The project provided an opportunity for Chinese organisations to cooperate with Europe, Brazil, India and Russia to develop testing methodologies capable of contributing to the development of European standards. Furthermore, it was an opportunity to engage in fruitful dialogue between the ICT research community and experts from various areas (e.g. sociology, policy making, economy and standardisation).

[10] CORDIS news https://cordis.europa.eu/news/rcn/123647_fr.html (Accessed April 13, 2018)
[11] ERNET India http://www.eis.ernet.in/content/myfire (Accessed April 13, 2018)
[12] "Adding value to Future Internet Experimental Facilities: Challenges, requirements and recommendations" https://www.researchgate.net/publication/281019566_Adding_value_to_Future_Internet_Experimental_Facilities_Challenges_requirements_and_recommendations (Accessed April 13, 2018)
[13] CORDIS news https://cordis.europa.eu/news/rcn/123647_fr.html (Accessed April 13, 2018)
[14] http://cordis.europa.eu/project/rcn/95516_en.html (Accessed April 3, 2018)

2.1.4. The establishment of the Global IPv6 Testing and Certification Centre

Objectives

The goal of the Centre was to establish testing standards for the Next Generation Internet and testing platform, as well as providing authoritative test authentication services. It also aimed to maintain cooperative relations with domestic and overseas stakeholders through this platform and push forward the standardisation of IPv6 worldwide.[15]

Key participants and structure of participation

The project participants included major mobile operators in China and a variety of domestic and overseas organisations in the field of FI. The project consisted of seven partners, namely China Mobile, China Unicom, China Telecom (Group) Co., Ltd, CAICT, CERNET, IETF, and the IPv6 Forum.

Developed activities and relevance

The Global IPv6 Testing and Certification Centre was established in 2008 as the earliest authorised IPv6 certification laboratory for the IPv6 forum. It is also the operator of the IPv6 Ready Logo certification programme.

Since its inception, the Global IPv6 Testing and Certification Centre focused on the establishment of testing standards for the NGI, testing platform building, ensuring the consistency, interoperability, automation and performance of the R&D of the test fields, while providing authoritative test authentication services, including IPv6 Ready, IPv6 Enabled, IPv6 Education, etc.

In order to strengthen the cooperation between production and research, the Global IPv6 Testing and Certification Centre provided Zhongguancun enterprises with quality IPv6 testing services. In 2010, it was allowed to set up Zhongguancun open Laboratory. In 2011, the test centre was awarded the next generation of Internet IPv6 testing and certification service to Beijing Engineering Laboratory through acceptance and evaluation.

In 2012, the Centre organised the 1st IPv6 transition technology international testing conference, and it built up the next generation IPv6 testing certification engineering centre in Beijing. In 2014, the CNGI website was launched and provided IPv6 testing services for Alibaba, Tencent and other 30 companies' websites. In 2015, the Centre provided IPv6 Ready certification for more than 160 enterprises, including Huawei, Cisco, and completed more than 2000 IPv6 education engineering certifications.[16]

The Global IPv6 Testing and Certification Centre organised key events focusing on topics related to IPv6 and SDN. During the Global IPv6 & Next Generation Internet Summit 2015, it was emphasised that IPv6 is the key factor for the development of IoT and was encouraged to accumulate the experiences and usage in IPv6, promoting the transition from IPv4 to IPv6 and enhancing the deployment of IPv6.

The BII – Global IPv6 Testing and Certification Centre maintains a close cooperation with IPv6 Forum, SIP Forum, ETSI, UNH-IOL, and the three major mobile operators in China, namely China Mobile, China Unicom, China Telecom, and many other domestic and overseas organisations. It has been tracking the latest international IPv6 technical standards and testing technologies, and constantly

[15] www.ipv6ready.org.cn/index.php/about/about/id/34
[16] http://www.ipv6ready.org.cn/index.php/about/about/id/36

updating and improving IPv6 test platforms and systems. It is dedicated to providing IPv6 testing and certification services for the NGI, thus promoting the deployment and application of IPv6 worldwide. In November 2017, the BII-Global IPv6 Testing Centre released the "2017 IPv6 Support Report". The report provides an update and analysis of existing support for IPv6 network devices, terminals, applications and websites worldwide. The aforementioned report shows that the industry is ready for full access to IPv6, with support for different network devices, terminal products and various applications.

2.1.5. Construction of Next Generation Internet Standard System

This project is part of the Chinese government plans to promote the adoption of the NGI. It was funded by Next Generation Internet Technology Research and Development, Industrialisation and Scale Commercial Special Project, was launched by the NDRC in 2012.

Objectives

The Construction of Next Generation Internet Standard System was formulated by NDRC, in 2012, in order to improve the deployment of the Next Generation Internet in China and implement research and development, industrialisation and a scale commercial programme. The objectives of the project were structured into three main domains:

Network construction and user scale

- The backbone network and about 10% metropolitan areas' network should support IPv6.
- Implement a large scale public network evolution plan to make the transition from IPv4 to IPv6, and achieve IPv4 and IPv6 web browsing interoperability.
- IPv6 broadband access users should reach a total of more than 8 million.

Business application and terminal

- Approximately 100 influential commercial websites in China should support IPv6.
- Promote the use of IPv6 on the websites of some government agencies, enterprises and institutions; city government websites, new services of telecom operators should all support IPv6, and the newly added terminals and mobile terminals should all support IPv6.

Technological breakthroughs and drive the industry development

- Accelerate the smooth evolution of IPv4 to IPv6 and the research, demonstration and testing of new network architecture and technology, mastering key core technologies.
- Master the core technologies and build a relatively complete standardisation system.
- The energy consumption per unit of network information flow should decrease by more than 8% per year, and the energy consumption per every additional 10,000 RMB[17] (*ca.* €1,292) output value for network equipment manufacturing should decrease by more than 3% per year.[18]

[17] Oanda. 1 yuen (RMB) = 0.13 Euro (April 20, 2018). All conversions are presented according to this exchange rate.
[18] http://www.ndrc.gov.cn/zcfb/zcfbtz/201202/t20120217_462019.html (Accessed April 3, 2018)

Key participants and structure of participation

The project was funded by Next Generation Internet Technology Research and Development, Industrialisation and Scale Commercial Special Project in 2012, which was initiated by the National Development and Reform Commission.[19]

The project was led by the China Academy of Information and Communications Technology (CAICT) and had the following participants: China Telecom Group Corporation, Tsinghua University, Research Institute of Electronic Industry Standards, Ministry of Industry and Informatisation, computer Network Information Centre, Chinese Academy of Sciences, Huawei Technology Co., Ltd., Wuhan Fiberhome Network Co., Ltd., Beijing Tiandi Interconnect Information Technology Co., Ltd., Centre for the Development of the Central editorial Office, Institute of Computing Technology, Chinese Academy of Sciences, Beijing University of posts and Telecommunications, Beijing.

Developed activities and relevance

The project was launched in 2012 by NDRC and finalised by CAICT in January of 2018.

The project completed 62 industry standards, 24 international standards and submitted 107 proposals for international standards. CAICT, as project coordinator, facilitated the construction of the Next Generation Internet Standard System, aiming at the establishment of relevant industry standards, national standards and international standards of Next Generation Internet. [20]

The project was significant in making a smooth transition from IPv4 to IPv6 and accelerating the industrialisation and large-scale commercialisation of IPv6 across China. No international partners were involved.

2.1.6. IPv6 Network and Website Support Evaluation System and Platform Construction

Objectives

The project aimed to construct a comprehensive IPv6 Network and Website Support Evaluation System and Platform. Specifically, it aimed to improve the following aspects: network construction and user scale; service application and terminal; and bring about technological breakthroughs and drive the industry development.[19]

Key participants and structure of participation

The project was funded by Next Generation Internet Technology Research and Development, Industrialisation and Scale Commercial Special Project in 2012 which was initiated by National Development and Reform Commission.

The project was led by China Institute of Information and Communication, with the following participants in the consortium: Tsinghua University, BII Group Holdings Ltd., Huawei Technology Co., Ltd., Computer Network Information Centre of Chinese Academy of Sciences and Institute of High Energy Physics of Chinese Academy of Sciences.

[19] http://www.caict.ac.cn/xwdt/ynxw/201804/t20180426_157882.htm (Accessed April 3, 2018)
[20] http://www.cesi.ac.cn/201801/3561.html (Accessed June 27, 2018)

Developed activities and relevance

The construction of the IPv6 Network and Website Support Evaluation System and Platform facilitated the implementation and application of IPv6 throughout China, by providing a complementary infrastructure for evaluation, testing and information sharing. This project accelerated China's IPv6 implementation and laid the basis for future cooperation between China and other leading countries in the field of future internet. Specifically, the project achieved the following:

- The IPv6 support evaluation system and platform construction were completed, with a total of 15 test specifications having been established, including network, website, equipment and domain name systems.
- Five test tools, including the distributed network performance test system for NGI, website testing system, DNS test system, were developed.
- Four test verification environments were built, such as the transition technology and interoperability of Next Generation Internet Network.
- The test and evaluation services facing three major operators, websites and application demonstrations were completed.
- The Next Generation Internet development information publishing platform was developed.

2.2. 5G

2.2.1. 5G Mobile Communication System Initial Stage Major Project

Objectives

The objective of this project was to obtain the key technologies on 5G mobile communication so that China would become one of the leading forces in the research and technological development of 5G international standards, while meeting the expected requirements of mobile communication application by 2020 that was set by the project. Furthermore, it aimed to increase the number of core intellectual property rights on the basis of 4G and staying ahead in the area of system development.[21]

Key participants and structure of participation

This project was funded by the Ministry of Science and Technology of the People's Republic of China under the National 863 Programme.

Developed activities and relevance

The project included a first and second phase of research activities, with topics of the first phase and second phase having been announced in January of 2014 and January of 2015, respectively. A total of 11 topics were established with a total investment of 300 million RMB (*ca.* €39 million). Within the project, 74 organisations have participated, including many research institute entities registered in China by well-known international telecommunications enterprises. The project also provided support for foreign companies' entities in China, such as Samsung, Nokia and Ericsson.

The main results of the project include the following:

- The requirements and vision of the 5G system, typical application scenarios and KPIs, as well as spectrum requirements analysis were completed, which defined the technical foundation for China to participate in the formulation of 5G standards.
- Innovation was conducted in the research of 5G new wireless network architecture, with important breakthroughs made in the direction of wireless network dense networking, high throughput cooperative network, and wireless access network virtualisation, among others.
- Breakthroughs were made in the key technology of 5G wireless transmission.
- The key technology barrier of millimetre-wave RF chip, which restricts the future development of the Chinese industry was overcome, and the feasibility of applying physical layer security technology in 5G mobile communication system was verified for the first time.
- Pre-deployment of 5G new technology testing and evaluation research was conducted, supporting China's 5G technology research and development.

This project provides evidence of existing international cooperation and can further contribute to future EU-China cooperation in the areas of 5G, especially with participation from the foreign entities in China who have had business experiences in China.

[21] http://www.most.gov.cn/kjbgz/201609/t20160923_127867.htm (Accessed April 3, 2018)

2.2.2. Key Technology and Application of the 4th Generation Mobile Communication system（TD-LTE）

Objectives

The objective of the project was to increase competitiveness among the global technology and industrial competition and build up key infrastructure to facilitate the development of the Internet Plus industry.[22]

Key participants and structure of participation

This project was funded by the Chinese Ministry of Industry and Information Technology (MIIT). It was led by China Mobile Communications Corporation, the Chinese Ministry of Industry and Information Technology and the Institute of Telecommunications. It also included the participation of the Research Institute of Telecommunications Science and Technology, Huawei, ZTE, Zhanxun, Beijing University of Posts and Telecommunications (BUPT), Tsinghua University together with other enterprises, universities, and research units. A total of 14 participants were involved.

Developed activities and relevance

This project supported the accelerated commercialisation and maturity of the 5G industry, which then increased the global market confidence in 5G. A number of the project achievements included:

1. Allowed China's mobile communication industry to rank among the top in the world.
2. Set up a public test and verification platform to promote the overall R&D and industrialisation process of the industrial chain.
3. Overcame the challenges in the application of large-scale networking. A first-class TD-LTE network was constructed to promote its rapid development in the world as well as its application at a large scale.
4. It was the first time to implement the internationalisation of the mobile technology standard across China.
5. Provided a flexible spectrum utilisation;
6. The asymmetric nature of TD-LTE allowed the adjustment of the uplink and downlink resource ratios.
7. The use of coordination abilities, such as Beamforming, helped improved system performance by utilising channel state information to achieve transmit-array gain and further enhance network performance because interference is mitigated between inter-eNodeBs.[23]

This project resulted in significant economic and social benefits. The direct output totalled 1 trillion (€118.8 billion) and 290 billion RMB (*ca.* €37.7 billion) from 2013-2015. In 2015, the TD-LTE system experienced an explosive growth which facilitated the rapid development of the industry and emerging mobile Internet applications. The total economic contribution reached 821 billion RMB (€106.8 billion), representing 9.6% of the overall GDP growth. In China, there are more than 500 million TD-LTE users.

[22] http://www.c114.com.cn/news/16/a990048.html (Accessed April 3, 2018)
[23] http://ydgtix.dev.ftbj.net/skin/revision/image/GTI_TDD_spectrum%20white_paper.pdf (Accessed June 25, 2018)

This has profoundly changed people's life and work styles and has brought historical opportunities for the Internet industry and other emerging industries.

GTI, the first international industrial cooperation platform led by China, was established in order to promote the global development of TD-LTE. GTI now has 127 operators and 130 partners and plays a key role in pushing forward the global application of TD-LTE. By November 2016, TD-LTE had deployed 85 commercial networks in 46 countries, and it was the first worldwide application of TDD technology led by China.

Therefore, the project successfully demonstrated China's capability in developing a 5G commercial network and applying the relevant technologies.

2.2.3. A New Generation of Broadband Wireless Mobile Communication Network (National Science and Technology Major Project)

Objectives

The objective of the project was to make breakthroughs in many key technological areas of the mobile communication network, from algorithms, core technology, standards, the process from product to application, and effectively integrate the innovation and industry value chains. The major goal was to promote 4G standardisation, the industrialisation and the internationalisation.[24]

In 2018, the 5G development will focus on 5G R&D industrialisation, system layout of 5G base station, R&D in pre-commercial product within core network, R&D in terminal chip and terminal prototype 5G scale tests, evaluation of 5G international standard alternative solutions, etc., in order to promote R&D industrialisation and application.[25]

Key participants and structure of participation

The project is funded by MIIT. Participants include technology companies, universities, and research institutes in all provinces/municipal cities across China. The Bureau of Economy and Information Technology in each province/municipal city is responsible for organizing the applications in their region.

Developed activities and relevance

The major achievements of the project until the end of 2017 included:

- Improved industrial R&D capability in China, supporting the development of a complete industrial chain composed by 4G systems, terminals, chips and instrumentation.
- Achievement of 4G industrialisation and commercialisation at the global scale. The total number of 4G subscribers in China reached 734 million and the total number of 4G base stations is 2,498,000. China has built one of the largest 4G networks in the world, considering the total number of subscribers.
- Increased participation in international standards, with China's efforts in developing TD-LTE-Advanced having become one of the 4G international standards.

[24] http://www.most.gov.cn/kjbgz/201701/t20170106_130264.htm (Accessed April 3, 2018)

- Development of extensive 5G R&D, which was possible with the support of the IMT-2020 (5G) promotion group. The 5G concept and technical route was put forward for the first time to complete the study of 5G vision and requirements. Additional 5G technology research and development experiments were launched.[25]

This project was aligned with the main development trends of Information Technology proposed by the Chinese government. The implementation of this project has increased the competitive strength and innovation capacity of China's wireless mobile communications and has promoted the national mobile communication technology and industry to become internationally competitive. It has also facilitated cooperation in 5G development, specifically in standardisation and industrialisation between China and the EU.

2.2.4. 5G Technology Research and Development Test Phase III

Objectives

The objective of the third phase of the 5G Technology Research and Development Test is to continue testing the key processes of the 5G industry to achieve the pre-commercial level by the end of 2018. To achieve the goal, it is necessary to closely adhere to the 3GPP international standard to speed up the development of pre-commercial equipment; to make a full use of the research and development platform of technology testing and accelerate the construction of a complete industrial chain; to synchronously advance the research and development of 3.5 GHz and 4.9 GHz in conjunction with the 5G frequency plan; and to promote the development of business applications, as well as launch series of 5G Application Innovation Competition.[26]

Key participants and structure of participation

The IMT-2020 (5G) promotion group launched this project and is continuously carrying out the various test phases to move it forward. The releasing of the test phase standards during the standard press conference, which was held on January 16, 2018, have seen participation from authorities such as MOST, NDRC and MIIT, as well as mobile operators and tech companies.

Developed activities and relevance

The Test Phase III was launched in January of 2018 and will come to an end by December 2018.

The project will lay the foundations for the commercialisation and standardisation of 5G industry chain across China. International collaboration plays a key role in achieving this goal, which can be seen from the attendees of the standard press conference. Achieving the proposed objectives will also contribute to the global 5G standards and industry development as a whole. It has strengthened China's cooperative relations with international stakeholders and will lead to more cooperation opportunities, particularly on the R&D of 5G technology. From 2016 to 2018, the 5G Technology Research and Development Test was divided into three stages: 5G key technology tests, 5G technology programme validation and 5G system verification.

[25] http://www.miit.gov.cn/newweb/n1146285/n1146352/n3054355/n3057674/n3057678/c5803093/content.html (Accessed April 3, 2018)
[26] http://www.imt-2020.cn/zh/news/detail/101 (Accessed April 3, 2018)

Huawei announced the validation and evaluation of 3GPP R16 standards for phased results under the promotion of IMT-2020(5G). The test is considered one of the key stages of 5G key technology test based on the "New functions for R16 and future and verification" released by IMT-2020 (5G) promotion group.[27]

2.2.5. 5G Scale Network Construction and Application Demonstration Project in 2018

Objectives

This project focused on the implementation of a 5G scale network targeted to municipalities directly under the governance of the Central Government, provincial capitals and major cities in the Pearl River Delta, the Yangtze River Delta and the Beijing-Tianjin-Hebei region. By the end of 2018, the construction of a 5G network is expected to be completed in several advanced cities. In addition, the 5G network should cover at least the complex urban areas and indoor environment with continuous coverage. The demonstration of typical end-to-end application scenarios should also be achieved.

Key participants and structure of participation

The project is funded by the NDRC. All applications will be jointly organised by China Telecom Corporation, China Mobile Communications Group Company and China United Network Communications Group Company. [28]

Developed activities and relevance

This project will be implemented during 2018. It has a special focus on the application of 5G in major Chinese cities, and few international stakeholders are involved. Overall, it contributes to the advancement of 5G infrastructure network and application in China. However, it still presents future cooperation opportunities between EU-China in 5G, particularly for the major cities involved in the development and application of 5G technology.[29]

2.2.6. 5G-PPP and IMT-2020 (5G) Promotion Group agreement on 5G

Objectives

On September 29, 2015, the Infrastructure Association – Public Private Partnership (5G PPP) and the IMT-2020 (5G) Promotion Group signed a Memorandum of Understanding (MoU) for 5G, which established the foundations for cooperation and collaboration between the two organisations. The MoU defined the agreement to share information on basic system concepts for 5G, frequency spectrum to support the global regulatory process and preparation of future global 5G standards by identification of common interest and consensus building.[30]

Key participants and structure of participation

The two participants are the IMT-2020 (5G) Promotion Group and the Infrastructure Association – Public Private Partnership (5G PPP).

[27] http://www.mwrf.net/news/suppliers/2018/23766.html (Accessed June 25, 2018)
[28] http://www.dvbcn.com/2017/11/30-151230.html (Accessed April 3, 2018)
[29] At the time of submission of this deliverable, limited information is available on existing outputs from the project.
[30] https://5g-ppp.eu/imt-2020-5g-promotion-group-and-5g-ppp-announce-memorandum-of-understanding-for-5g/

- **IMT-2020 (5G) Promotion Group**[31]: Is a major platform that promotes 5G technology in China. It has been established by three Chinese ministries in February 2013: Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC) and the Ministry of Science and Technology (MOST). In addition to promoting 5G technology in China, it also aims to facilitate cooperation with international organisations.
- **5G-PPP**[32]: The 5G-PPP is a collaborative programme organised as part of the EC's H2020 programme and fosters industry-driven research. It will run from 2014-2020 and is open to international cooperation and participation. The 5G-PPP has received €500 million from the EC and is expected to leverage five times this value from private investments.

Developed activities and relevance

The 5G-PPP and IMT-2020 (5G) Promotion Group agreement on 5G was signed in 2015, with the collaboration expected to last beyond 2020.

Although not a project, this agreement has established an important foundation for EU-China cooperation in 5G. As mentioned by the Chair of the IMT-2020 (5G) Promotion Group during the signing of the MoU, the two parties are the main drivers of 5G developments in the EU and China. This will allow them to promote comprehensive cooperation in 5G and also to establish the foundation to facilitate a unified 5G standardisation and the development of the 5G industry and applications.[30]

2.2.7. EU-China 5G Collaboration

Objectives

The EU-China 5G Collaboration will be a project funded by the EC and Chinese funds. It will be developed within the framework of the H2020 ICT-22-2018[33] topic with the same name. As defined in the topic description, the challenge of the project will be to demonstrate technologies and system interoperability for a number of core applications of interest in Europe and China. Furthermore, the objective is to conduct 5G trials under two specific scenarios:

- Enhanced Mobile Broadband (eMBB) on the 3.5GHz band, which is a priority band in the two regions for early introduction of very high rate services.
- Internet of Vehicles (IoV) based on LTE-V2X using the 5.9 GHz band for Vehicle-to-Vehicle (V2V) and the 3.5 GHz band for Vehicle-to-Network (V2N).

The project is expected evaluate innovative end-to-end 5G systems built on the outcomes of the previous phases of the 5G R&I activities, optimise the band usage in multiple scenarios with different coverage, and validate the geographic interoperability of the 3.5 and 5.9 GHz bands for the use cases. The two defined scenarios are expected to be implemented in the EU and in China through testbeds.

[31] http://www.imt-2020.cn/en
[32] http://5g-ppp.eu/
[33] EU-China 5G Collaboration (ICT-22-2018)
http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-22-2018.html

Key participants and structure of participation

The project is expected to be implemented through a twinning approach involving organisations participating in China-funded projects. This is expected to facilitate the exchange of knowledge, experience and to support the exploitation of synergies. Specifically, the topic calls for twinning with the National Science and Technology Major Project (NSTMP) "mirror project" launched by China in 2018. Both the EU and Chinese projects are expected to develop joint deliverables, joint test reports, white papers, publications and standard contributions.

Project timeline and expected impact

The projects is expected to have a duration of up to 36 months (according to the call topic). The start date is expected to be in the second half of 2018.

This project is another example of a concrete cooperation opportunity between the EU and China. The specific aspects of the call topic indicate that a very close cooperation is expected, including the development of various joint reports, suggesting an increased coordination effort rather than two independent projects developing similar activities.

With regard to potential impact, in addition to achieving several technological outputs, it is expected that this project contribute to global interoperability demonstrations for 5G networks; achievement of joint contributions to global 5G standard specifications; and new or reinforced cooperation between 5G R&I stakeholders (e.g. industry, telecom operators, SMEs) from the EU and China.

2.3. IoT/Standardisation

2.3.1. National IoT Key Application Demonstration Project 2014-2016 Regional Pilot Work Plan

Objectives

The objective of the project was to put forward the regional pilot work plan and key projects for the demonstration of the IoT applications in different regions across China, and to systematically promote the overall development and application of IoT at the regional level.[34]

Key participants and structure of participation

The project was initiated by National Development and Reform Commission (NDRC) and implemented by the Development and Reform Commission of each province and municipal city across China.

Developed activities and relevance

This project signalled the official start of a comprehensive implementation of IoT applications at a regional level across China. It was a joint national and provincial effort that required close collaboration from the NDRC and the Provincial Development and Reform Commission. The project significantly pushed forward the development of the industrial application of IoT at the regional level to varying degrees. A relatively complete industrial system of IoT was constructed and a link between the upstream and downstream of the industrial chain was formed.

The project was connected with ten previous IoT development programmes, and enhanced the National innovative cities, smart cities, cloud computing model city and the next generation of the Internet demonstration city, as well as the overall coordination of work.

The project showed that China is able to apply IoT applications to provincial/regional scale effectively, and it also presented potential for future cooperation between China and EU in IoT applications at a regional scale.

2.3.2. Intelligent Transportation IoT Demonstration Project: Huishan Intelligent Transportation Demonstration Project

Objectives

The objective of this project was to establish a national demonstration base for Intelligent Transportation IoT, and to explore the introduction of the core IoT technologies into the field of intelligent transportation, starting at Huishan New City as an experiment base.[35]

Key participants and structure of participation

The project was jointly funded and implemented by Huishan District People's Government, Tsinghua University Research Institute in Shenzhen, and the Wuxi Guolian Group.

[34] http://www.gov.cn/zwgk/2013-11/08/content_2524053.htm (Accessed April 3, 2018)
[35] https://m.zol.com.cn/article/2518363.html?via=index (Accessed April 3, 2018)

Developed activities and relevance

This was the first Intelligent Transportation IoT project in China. The 1st Phase of the project started in January 2011, and the demonstration project was eventually applied in the city starting 2016.[36]

The project was responsible for the construction of intelligent transportation in Huishan, including building the advanced public transportation system, city traffic management system, designing the road management system and developing car sensor and protection systems.[37]

The city traffic system integrates six sub-systems: traffic signal control, traffic flow data detection system, off-site law enforcement, video surveillance, information acquisition and guidance, and was responsible for the comprehensive traffic instructions and real-time dispatch in the Huishan area of Wuxi City.

As a regional level project, this project showcased how IoT technology could be applied in civilian contexts through small scale projects and ultimately serve the general public. Thus, it also presented cooperative opportunities (e.g. exchange of good practices, definition of strategies) between China and the EU Member in IoT regional/civil applications, such as intelligent transportation.

2.3.3. National Science and Technology Support Plan under the 12th Five-Year Plan 2010-2014: Urban Infrastructure Safety Monitoring, Control, Internet of Things Technology Research and Application Demonstration Project

Objectives

The objective of this project was to make progress in key technologies in the field of IoT and to ensure the security of important infrastructure in the city[38]. The key technologies addressed include perception, control and construction of IoT systems for the safe monitoring and control of urban infrastructure, which play an important role in supporting the safety and security of major infrastructure.

Key participants and structure of participation

The project was funded by MOST and organised by the Bureau of Science and Technology of Dalian City and jointly undertaken by four scientific research institutions, namely Dalian University of Technology, Harbin Institute of Technology, Southeast University and Tongji University.[39]

Developed activities and relevance

This project was launched in 2011. It was a key project under the 12th National Plan that involved mostly domestic stakeholders (governments and research institutes) and showed that with joint efforts, significant progress in technology and infrastructure network can be made. The project involved large-scale research and demonstration projects in IoT as well as the safety monitoring and control of IoT.

[36] http://tech.hqew.com/news_1225080 (Accessed April 3, 2018
[37] http://www.tranbbs.com/Solution/collection/Solution_83559_2.shtml (Accessed May 30, 2018)
[38] http://www.gov.cn/xinwen/2015-08/11/content_2910940.htm (Accessed April 3, 2018)
[39] http://news.hexun.com/2015-07-02/177208574.html (Accessed April 3, 2018)

Some of the main results of the project included:

- Development of a benchmark monitoring system and laboratory demonstration system for infrastructure safety monitoring and control.
- Research and development of building monitoring data mining, safety evaluation technology and integrated application
- Set up of 16 important infrastructure safety monitoring and control network demonstration projects.
- Establishment of an integrated network of IoT in Dalian, Qingdao, Shanghai, Ningbo, Zhoushan, Nanjing, Beijing, Yunnan and other regional demonstration projects.

2.3.4. 13th Five-Year Plan on the Internet of Things 2016-2020

Objectives

The objective/ expected outcomes of the 13th FYP Plan on the Internet of Things ('Plan') are the following:

- **Technological innovation**: To use a technology innovative system that combines industry, academia and research, to continuously increase the R&D of companies, to make major breakthroughs in IoT infrastructure, sensing technology, operating system and security technology, and to significantly increase the number of core patents received.
- **Standardisation of the industry**: To formulate more than 200 national and industrial standards, and gradually improve the standard system to meet the needs of large-scale application and the industrialisation of IoT. The basic common standards of IoT, the key technical standards and the key application standards should be established. China should also aim to see an improving right to speak in the area of international standards of IoT.
- **Promotion of IoT technology application:** To promote a series of integrated application solutions in fields such as industrial manufacturing and modern agriculture, and in consumption areas such as smart homes and health services. In the field of construction and management of intelligent cities, to foster a cross-domain mechanism that is featured by open access to data and data-sharing, to develop an open-loop application of IoT.
- **Upgraded industry:** To create 10 characteristic industrial agglomeration areas, to develop about 200 backbone enterprises with output value exceeding 1 billion RMB (€130.1 million), as well as a number of SMEs and innovative entities with "expertise, specialisation, characteristics and new features", and to build a group of public service platforms of a broad variety and provide strong support, to build an internationally competitive industrial system.
- **Safety guarantee:** To make major breakthroughs in the research and development of the core security technologies and specialised security products in the IoT and formulate a number of national and industrial standards according to existing needs.[40]

[40] http://blog.csdn.net/WSN_IPv6/article/details/70193738 (Accessed April 3, 2018)

Key participants and structure of participation

The Plan was launched by MIIT and serves as the guiding documents to the development of the IoT industry in 2016-2020 period.

Developed activities and relevance

This IoT plan specifically gives instructions to actively promote the exchange and cooperation of IoT technology, to encourage domestic and international enterprises to strengthen cooperation on R&D of key IoT technologies and products, and to jointly establish an international industrial technology alliance. It encourages companies to set up R&D institutions abroad, participate actively in international standard-setting, and get involved in international competition. These policies target the reinforcement of existing China-EU cooperative projects in IoT and are expected to lead to additional cooperation opportunities in the future, especially in regard of IoT R&D and industrialisation.

The IoT will enter a new phase of Internet of Everything (IoE). Smart wearable equipment, smart home appliances, internet of vehicles, intelligent robots and other equipment will increasingly be linked to the internet, generating a large amount of data. This can lead to daily lives and social management being more intelligent and efficient. The fifth generation of mobile communications technology (5G), narrowband Networking (NB-IoT) and other new technologies will provide a powerful infrastructure supportive capabilities for the IoE.

2.4. Analysis of the impact of China's FI projects

China's R&D efforts in the projects presented above show the good progress the country has made in establishing itself as one of the leading countries in the domains of FI, 5G and IoT. China's investment in R&D in these areas, through its various initiatives and programmes (namely the FYP), demonstrate a strong commitment to take China to the relevant position it holds today, which demonstrates the success of the investment made.

China has made a strong case in the field of Future Internet, starting with the China Next Generation Internet Demonstration Project (CNGI), which mobilised dozens of key national actors, including mobile operators, academia and other stakeholders. The CNGI helped China address problems related to the exhaustion of IPv4 addressed, but also helped its industry be better positioned on FI technologies and related services. It should also be emphasised that China's role in this area has been recognised abroad. This is visible in the fact that Chinese organisations (i.e. BII, CATR, and BUPT) were involved in Future Internet projects funded by the European Commission dating back to 2005, namely in the Go4IT project, funded under FP6. This level of participation would continue into the next European Framework Programme (FP7) with the MyFIRE project, which again involved BII from China. Not only were these two projects relevant for EU-China cooperation, they also allowed Chinese organisations to contact other countries such as Russia and Brazil.

With regard to 5G, the various projects described also show a strong focus in achieving great results in this field. In fact, the projects presented and others not included (developed at the public or private level)

have led China to be one of the frontrunner countries in the 5G race. This is suggested by multiple stories coming out of media outlets that quote experts in the area (although this information must be interpreted with caution). These stories report that "China has the edge in the war on 5G (…)[41]", "China is winning the 5G race[42]", "China, not the US, leads all [in 5G][43]", and question if "(…) China will dominate Future Wireless Internet[44]"

These sources say that China has a dream to take the lead in 5G to avoid being left behind as occurred with the 3G to 4G transition. This is an objective shared by the main telecom operators and the government. Moreover, it is mentioned that government is aware of the possibilities associated to 5G and thus has been preparing the jump for years, namely through the establishment of the IMT-2020 (5G) Promotion Group, which is responsible for the coordination of major actors in the area. Furthermore, the Made in China 2025 programme has as one of its pillars to make China the 5G global leader. The reason for this interest and investment? A predicted RMB 6.3 trillion (€819.8 billion) of economic output by 2030.[44]

It is considered that China shows the best combination of wireless carriers committing to the technology, government support for R&D, a clear deployment plan by 2020 and government commitment of spectrum, or the radio airwaves critical to deliver wireless service.[43] Thus, there is a very clear 'top-down' approach (starting at the government and down to operators) that China is managing well. When considering the projects presented in Section 2.2, it is clear that Government support is transversal to almost all.

With regard to IoT, a number of the projects identified show a slightly different approach, namely a greater involvement of regional and local governments providing support to the implementation of projects. Considering that IoT has such a wide applicability (e.g. smart cities, intelligent transportation, smart manufacturing, smart healthcare), it is understandable that different regions and cities explore the technology according to their own priorities. Yet, considering that IoT applications have been a priority in past national plans funded by MOST or MIIT, it is also evident that IoT is also a central priority for the Government to continue to modernise the country.

In summary, it is considered that although the private sector plays an important role in the implementation of these projects and the achievement of results that have put China in such a reputable position in the area of FI, 5G and IoT; it has also been the government's push and investments that have led China to be a global leader in these domains (as well as in many others).

[41] China 'has the edge' in the war for 5G and the US and Europe could fall behind. CNBC. March 2018. https://www.cnbc.com/2018/03/07/china-has-the-edge-in-the-war-for-5g-us-and-eu-could-fall-behind.html
[42] China is winning the 5G race. AXIOS. April 2018. https://www.axios.com/china-leading-the-5g-race-102aaafa-138b-416a-a446-63f8ff0944cf.html
[43] Who's most ready for 5G? China, not the US, leads all. CNET. April 2018. https://www.cnet.com/news/china-not-the-us-is-most-ready-for-5g/
[44] Race for 5G: Will China Dominate Future Wireless Internet? CKGSB Knowledge. March 2018. http://knowledge.ckgsb.edu.cn/2018/03/21/technology/china-5g-dominate-future-internet/

3. TOPICS FOR FUTURE INTERNET PROJECTS BY 2020

This section provides a systematic review of the key developments in 5G and IoT and in the ICT sector in general, including some areas of interest for projects in the near future. Attention is also given to other areas of social and economic interest in which ICT plays a role.

3.1. 5G and IoT

3.1.1. Background and areas for projects

Both 5G and IoT are highly prioritised in China's 13th FYP plan issued by the NDRC in 2016. The 7th China-EU Dialogue on Information Technology, Telecommunications and Informatisation (2016) marked the start of policies prioritising focus on IoT and 5G. China considers 5G technology fundamental for the implementation of a construction project related to NGI infrastructure. Moreover, 5G networks are also among the priorities for R&D and internationalisation funded by the MOST, as shown in the 5G Mobile Communication System Initial Stage Major Project (See Section 2.2.1). The other projects described in Section 2.2 also showcase the importance given to 5G by the MIIT.

The Centre for International Economic and Technological Cooperation (CIETC) is the division of MIIT in charge of international cooperation. In 2018, CIETEC set as their goal to promote exchanges and cooperation with the USA, the EU (e.g. the United Kingdom and France), ASEAN, Switzerland and Japan in the fields of advanced manufacturing, industrial Internet, 5G, intelligent network of automobile, and others. In addition, it intends to support research and technology cooperation on China-EU aviation science.

The increasing importance of IPR protection also contributed to the development of the 5G and IoT industries (see Section 4). For instance, in wireless access, modulation and core networks, China has about 10% of "5G critical" intellectual property. Huawei has the largest number of IPR among Chinese telecom entities, followed by ZTE, which has been very active in contributing to the development of an IoT platform and standards. The increasing number of patents in relevant technologies has improved the innovative capacity of technology companies and encouraged them to overcome technological barriers.

The Chinese government offers three primary sources of support focusing on 5G and IoT. These are specified below: [45]

Made in China 2025

The Made in China 2025 programme aims to make a comprehensive breakthrough in 5G technology and push forward the R&D of 5G technology and products. It will accelerate the establishment of high-speed broadband network and particularly increase the coverage of 4G network in rural and distant areas. It will emphasise the importance of R&D concerning 5G technology and products, the standard making and improve the maturity of the industry. For this purpose, a pilot telecom universal service project will be implemented to support the broadband construction and upgrading of more than 30,000 administrative villages.

[45] http://www.sohu.com/a/150477179_558682 (Accessed April 3, 2018)

13th Five-Year National Plan (2016-2020)

The objective of the 13th Five-Year National Plan is to actively promote 5G technology research and to launch 5G commercialisation in 2020. During 2016-2020 period, several actions will be implemented to further improve the coverage of national information and communication network infrastructure on land, sea and air, ensuring the comprehensive coverage of 4G network in urban and rural areas, to launch 5G services for commercial purposes, and to foster a new generation of backbone transmission network with high speed, large capacity, and flexible management.

2017-2020 5G Development Plan

Initiated by MIIT and the NDRC, three mobile operators are actively deploying and systematically promoting R&D in 5G. Plans for launching 5G network commercialisation in 2020 have been made.

In addition, in February 2013, the MIIT, MOST and the NDRC established the IMT-2020 (5G) Promotion Group (described in Section 2). The Promotion Group is a platform to jointly launch R&D and international standard promotion initiatives by combining resources from the industry in research and application. The National 863 programme, Key Special Projects and other scientific research projects also deployed R&D missions on 5G to promote the research of key technologies and standards in the field.

China expects to obtain a greater percent of the intellectual property on 5G standards. This would have great influence globally and would give China stronger bargaining power with patent holders overseas, and eventually drive down the costs for telecom equipment manufacturers. Therefore, improving patent protection in China is of strategic significance to the sustainable development of the industry in the long run, since it improves the country's core competence in these key technologies.

3.1.2. Economic and social impact

As a universal technology, 5G will build the key infrastructure for the digital transformation of the economy and society, from online to offline, from consumption to production, from platform to ecology. In other words, 5G is a key enabler in the digital transformation of the economy and society.

The deep integration of 5G with other domains, such as cloud computing, big data, artificial intelligence or virtual augmented reality will connect people, information and things, making it a crucial infrastructure for digital transformation of various industries[46]. The impact brought by the development of 5G and IoT is therefore expected to be profound and long-lasting.

According to estimates of the China Institute of Information and Communications in June 2017, the direct output generated by 5G is expected to reach about 484 billion RMB (€62.9 billion) in the year of 2020, starting from the official commercialisation of 5G in the same year, The number is expected to rise to 3.3 trillion RMB (€429.4 billion) to 6.3 trillion RMB (€819.8 billion) in 2025 and 2030 respectively, with an average compound growth rate (CAGR) of 29% per year over the decade.

Among the strategic emerging industries in China, the new generation of information technology industries, including the IoT, characterised by less resource consumption and less environmental impact, are showing a fast-growing trend. According to estimates and with intelligent services at the centre, as

[46] http://market.chinabaogao.com/dianxin/02531V912018.html (Accessed April 3, 2018)

intelligent transportation, smart grids, smart medical care, smart home, intelligent industry and other key IoT applications unfold gradually, China's IoT production capacity market value will reach more than 1.5 trillion RMB (€195.2 billion) by 2020[47].

On a societal level, the development of the IoT industry plays an important role in speeding up the transformation of China's economic development mode, building intelligent cities, promoting the strategic adjustment of industrial structure, strengthening the country's self-innovation ability, and promoting social and public service capacity.

3.2. ICT

3.2.1. Background and areas for projects

Since 2016, MOST has been funding Key Projects of "Strategic International Cooperation in Science, Technology and Innovation" that have provided support for the joint R&D and demonstration of 13 different areas, including agriculture, energy, transportation, communication, advanced manufacturing, new materials, medical and health, and urbanisation, among others.

Within the initiative, the cooperative research category supported 25 projects for cooperation with countries of the One Belt One Road programme, while the joint laboratory category supported five projects that conducted high-level cooperative research. Among the 13 key areas, communication represents the key priorities linked to ICT and facilitates the development of ICT related areas, such as 5G and IoT.

To date, the NDRC has invested a total of 1.4 billion RMB (€182.2 billion) for the Special Fund Project (2016-2018) in the sectors of Information, Grid, Oil, Gas and Network, including investment in a total of four special funds and 51 projects. Investments in ICT projects take up a big percentage of these investments.

The 13th FYP gives special attention to innovation, Internet Plus, new media and information technology, which constitute some of the main areas for future projects. By means of this Plan, the government's objective is to make the Internet and its related industries a new source of economic growth.[48] Within the plan, and considering key areas for projects, the government will continue to invest in big data projects, new information technology, industrialisation of virtual reality, and interactive film technologies. With this in mind, and in addition to the development of IPR protection in China, there has been a surge in terms of patents received by Chinese companies in the field of ICT, which in turn encouraged innovation in the field by providing proper protection.

Overall, the ICT industry in China has become a mature and independent industry and ranks among the top performing and most advanced countries in ICT development.

[47] http://www.chinadaily.com.cn/china/2017-09/11/content_31833613.htm
[48] China's 13th Five Year Plan: innovation, Internet Plus, new media and information technology. King & Wood Mallesons. April 14, 2016. http://www.kwm.com/en/hk/knowledge/insights/china-13th-5-year-plan-innovation-technology-media-internet-plus-20160414

3.2.2. *Economic and social impact*

ICT refers to technologies that provide access to information through telecommunications. Investing in the sector has proved to have a long-term impact on economic and social development and plays a critical role in advancing the country's digitalisation.

With the advancement of 4G and the emerging application of big data, cloud computing, and the IoT in the ICT sector, the investment in this sector is expected to maintain a steady growth rate in the following years. The development of the telecommunications industry has helped improve people's information quality, quality of life and happiness, and to narrow the digital divide, all of which are basic elements of a harmonious society in the information age.

3.3. Other topics of social and economic interest

Considering the comprehensiveness of ICT, there are a number of other topics that can be mentioned that have a social and economic impact and that are relevant for cooperation.

In this scenario, it is relevant to refer to China's National S&T Major Projects, also known as Mega Projects. These are considered China's biggest and most ambitious projects with the objective to ensure the country's long-term development and economic competitiveness. Initially defined in the National Medium- and Long-term Programme on Science and Technology Development (2006-2020), they began to take shape in 2014. These projects address a wide variety of topics, but many have ICT as a common denominator.[49]

Within the programme, 16 Mega Projects were established. Among them, 10 projects fall under the 'Civilian Mega Projects' category, while the remaining six fall under the 'Military Mega Projects' category. One of the major projects has already been presented in Section 2 – A New Generation of Broadband Wireless Mobile Communication Network (which focuses on 5G). Besides this specific project, and considering the role of ICT in their implementation, the following projects can be highlighted (with descriptions as defined in [49]):

- **Core Electronic Devices, High-end General Chips and Fundamental Software**: focusing on research & development of First Floor Software (FFS) core products related to microwave and millimetre wave devices, high-end universal chips, operating systems, database management systems and middleware.
- **Extremely large-scale Integrated Circuit Manufacturing Equipment and Technologies**: focusing on the (i) production of 90-nanometer manufacturing equipment and localisation of key technologies and components; (ii) R&D of 65-nanometer manufacturing equipment prototypes; (iii) breakthrough of key technologies below 45-nanometer; (iv) core manufacturing technology of ULSI, and (v) generic technologies to establish an initial innovative system for integrated circuit manufacturing in China.
- **Advanced CNC machines and Fundamental Manufacturing Equipment**: focusing on research of two to three varieties of large numerical control mother ships with high precision,

[49] Advance EU Access to Financial Incentives for Innovation in China: Guide for EU Stakeholders on Chinese national STI funding programmes. DEVELOPMENT Solutions Europe, Ltd. January 2018. https://eeas.europa.eu/sites/eeas/files/1.pdf

and development of key digital control machine tools with high precision and basic equipment required in the industries of aviation, aerospace, ship craft, automobile, energy equipment, etc.

The regulations of these Mega Projects encourage foreign participation. However, information on specific projects and their respective activities involving international participation, is rather limited. However, it is expected that foreign participation in these projects would be restricted to minor roles.

With the end of the 13th FYP for Science, Technology and Innovation (in 2020), the Mega Projects will be replaced by new categories of projects. In fact, China's State Council has already defined the 16 new "2030 Innovation Mega Projects" that will be implemented until 2030. Those that are most aligned and can benefit from the broadness of ICT are:

- Quantum communication and computing.
- Cyberspace security.
- Space-ground integrated information networks.
- Big data.
- Smart manufacturing and robotics.
- New Generation Artificial Intelligence.

As abovementioned, these projects are considered of strategic importance for China. Therefore, it is difficult to access detailed information about their implementation and the conditions for international participation. Furthermore, it is expected that these projects would be defined by very strict IP rules, which could be unfavourable to foreign organisations.

Nonetheless, and considering the impact participation in these projects would have for EU and other organisations, it is recommended that foreign organisations try to identify in a timely manner the key Chinese organisations involved in these projects, many of which are specified in advance in the guidelines.

4. IPR AND PATENT MANAGEMENT SYTEM

4.1. China's IPR system

China's IPR system currently comprises of the following major IP laws, as described in Table 1[50]:

Table 1 - China's IPR System

Law or Regulation	Effective Date
Trademark Law / Act	March 1, 1983, amended 2001.
Patent Law	April 1, 1985, amended 2008.
Copyright Law / Act	June 1, 1991, amended 2001
Computer Software Protection Regulation	2002
Anti-unfair Competition Law	December 1, 1993
Regulations on Administration of Audio-Visual Products	October 1, 1994
Regulations on the Customs Protection of Intellectual Property Rights	October 1, 1995
Regulations on the Protection of New Varieties of Plants	October 1, 1997
Regulations on Protection of Integrated Circuit Layout Design	October 1, 2001
Measures for the Administrative Protection of Internet Copyright	May 30, 2005

In the 1980s, China started to lay the foundation for a modern IPR system with the enactment and promulgation of the Trademark Law, Patent Law and Copyright Law. The need to attract foreign investment and to fulfil the obligation articulated in agreements between Chinese and foreign governments on science and technology cooperation demanded the modernisation of China's IPR system.

In the 1990s, China continued to promulgate a series of regulations and laws to further advance their IPR legal system, which ran until 2005. The various IPR laws or regulations that were enacted provided protection for a variety of matters, including trademarks, patents, copyrights and others.

China's effort to develop its legal system also includes joining international treaties regulating IP matters, such as joining the World Intellectual Property Organisation in 1980, attending the Berne Convention for the Protection of Literary and Artistic Works in 1992, joining the Patent Cooperation Treaty in 1994, and joining the WIPO Copyright Treaty in 2007. By recognizing the principles established by the treaties and accepting its rights and obligations, China adopted the international legal framework regarding IPR matters.

The advancement of China's IPR system has also facilitated the development of the ICT sector. For example, since 2009, the IoT Specialised Development Project (launched jointly by MIIT and the Ministry of Finance) has been focusing on cultivating backbone enterprises with strong technological innovation ability, independent intellectual property rights, independent brands and international competitiveness. By 2016, over 600 companies applied for this project. Therefore, integrating IPR

[50] Huang, Can. "Recent Development of the Intellectual Property Rights System in China and Challenges Ahead." *Management and Organisation Review* 13.1 (2017): 39-48.

regulations into the industry in the form of policies helps protect companies' patenting rights and encourages innovation.

4.2. Evolution of the Patent Law amendments

The Chinese Patent Law has been amended three times in recent decades, and the State Intellectual Property Office (SIPO) published a draft of the Fourth Amendments to the Chinese Patent Law (for public comments) on April 1, 2015[51]. The different amendments have shown a pattern focusing on improving patent quality and strengthening patent protection. This can be shown in examples such as the introduction of the range of the statutory damage in the third amendment, and an increase of the range as well as the inclusion of punitive damage in the draft of the fourth amendment. This trend of patent laws has accelerated the internationalisation of China's IPR legal system and puts it at the front among international competitors regarding its protection for patents.

Besides the legislative process, the domestic industry also actively facilitates China's IPR protection. An example is China's major video websites, which started to offer licensed video contents via subscription-based services and advertising, other than videos of low-quality and unlicensed content as in the past. Not only was licensing from content providers heavily invested in, these companies also established strict enforcement strategies via takedown mechanism and litigation. Online music companies also have adopted a similar strategy.

Compared with the USA, who took more than a century from including Patent Law in the Constitution to furthering the protection to foreign works, China took less than three decades from enacting the Patent Law to amending it voluntarily to stimulate innovation and strengthening protection. China has made significant progress in completing its IPR system in a relatively short period of time.

4.3. Judicial System of IPR Protection

At the end of 2014, three specialised IPR courts were established in three major cities in China to improve the efficiency and effectiveness of the IPR protection judicial system. The setup of these courts helped improve the speed of decision-making, the quality and consistency of rulings. The judges are now able to decide on a significantly higher number of cases (3 times the number of cases in 2015 than 2014) and the average awarded damages also witnessed a large increase in their amount.

4.4. Legislative Efforts

Some major efforts in legislative aspects included: the Law on Promoting the Transformation of Scientific and Technological Achievements, which was amended in October 2015 and removed barriers for technology transfer in China; the fourth amendment of the Patent Law; and Service Invention Regulations. These efforts improved the overall competitiveness of China's IPR system by adjusting the incentive system for university patenting and technology transfer and providing provisions on the ownership of service inventions. China's IPR legislative system has gone on the right track since these initiatives were launched and thus has been able to compete internationally.

[51] Lloyd, R. 2016. A new world order. *Intellectual Asset Management*, 76: 29–35.

Prior to the amendment in 2015, Chinese universities had low transfer rates of universities' patent technology due to the following reasons: lack of incentives for university patenting and technology transfer, IPR ownership and decision-making authority over patents and technology transfer, legal risks associated with the transfer or sale of university-owned IPR, and distribution of profits from university owned IPR in the context of technology transfer. The amendment enacted in 2015 granted full authority to universities and public research organisations in China on matters involving technology transfer.

The draft of the Service Invention Regulations represents legislation that provides provisions on the ownership of service inventions, motivated by the fact that there are still many unacknowledged inventors in patent applications. It also allows and protected agreements resulting from negotiation between employer and employee regarding ownership of and award and compensation to service invention. It also calls for the establishment of an internal reporting system which allows inventors to apply for IPR and a system that properly reward employee inventors.

4.5. Recent Trends in Patenting

China has seen a surge in patenting in the past 15 years. The SIPO witnessed a significant increase in the number of invention patent applications received from 2001 to 2015, rising from 63,000 to 1.1 million during this period. A similar pattern was visible in patent filing overseas. Some relevant achievements include:

- In 2011, China surpassed the USA to become the top country in the number of received invention patent applications.
- In 2013, China surpassed Germany, becoming the third largest country in the Patent Cooperation Treaty (PCT), following the USA and Japan in number of patent applications, which also signalled the fast growth of Chinese entities' applications overseas.
- China is among the fastest growing and relatively advanced countries in terms of patenting protection coverage and received applications.

More recently, as of 2017, data from the World Intellectual Property Organisation (WIPO) indicates that China is now second behind the USA in international patent applications. Furthermore, Chinese companies Huawei and ZTE were the first and second in terms of applications in 2017. Among the top 15 countries, China was the only to have recorded double digits in the number of applications filed. In fact, China has registered growths of more than 10% since 2003.[52]

This implies that big tech companies in China have implemented and are maintaining a strong innovative approach and have a very active role in transforming technology to applications.

A number of contributing factors include the pro-patent amendments of the Patent Law, the increasing intensity in R&D of the Chinese economy[53], which led to a rise of patentable technologies, and the incentives provided to domestic companies to increase their competitiveness by applying for patents due

[52] China Drives International Patent Applications to Record Heights; Demand Rising for Trademark and Industrial Design Protection. World Intellectual Property Organization. http://www.wipo.int/pressroom/en/articles/2018/article_0002.html
[53] Hu, A. G., & Jefferson, G. H. 2009. A great wall of patents: What is behind China's recent patent explosion? *Journal of Development Economics*, 90(1): 57–68.

to increasing foreign direct investment, and the increasing protection of IP during the privatisation process of state-owned enterprises.

Another important driver is the introduction of the patent application subsidy, which incentivizes universities, research institutes, firms and individuals who apply for patents; as well as the patent subsidy programme run by the government, which was established in 2009. Other policy incentives include patent remuneration, namely preferential tax treatment and patent application projects that some outstanding inventors and employees are eligible to receive, which essentially reward quantity over quality of patents. The underlying problems of China's IPR incentive system include: the misalignment between performance and incentives system that exists in China's IPR system, where the quantity of patents is valued higher than quality; another problem is the growing trend in which unscrupulous patent applicants abuse China's patent incentives system; and lastly, an imbalance that exists between rewards and punishment for transgressions at the national level (rewards outweigh the punishment).

Some of these problems are also reflected in the industries that have knowingly benefited from the emerging IPR protection. For example, it is argued by experts that despite the many patent applications that ZTE received in the field of IoT, its competitive advantages are not obvious and that the quantity of patents doesn't necessarily suggest it possesses advantages in key technologies. At a larger scale, and because of the weak patent conversion ability, Chinese enterprises have not transformed patent advantages into market advantages, which is reflected in a number of sectors. To promote the development of the IoT industry at a large scale, the participation of enterprises and top-level design and industry standards are required.

4.6. Policy and Future

The innovation-driven development strategy was announced by the Chinese government during the 18th National Congress of the Party in 2012, but a number of challenges remained ahead. One challenge is infringement and inadequate IPR protection[54] [55] [56], to which the Chinese government pledged to enforce more stringent IPR protection [55] going forward. To address the challenges, all stakeholders of the innovation system, including the Chinese government, indigenous inventors, universities and research institutes and industries, should work together to demand more IP protection and enforce it in a more rigorous manner. Several important things to do in order to transform China's IPR system to stimulate innovation are:

- Realign the incentives system to foster the pursuit of high value-added technology activities, raise the thresholds to access incentives.
- Greater freedom is the key to promoting university innovation and technology transfer.
- Regarding the UMP system, China should make continuous efforts in increasing the rigor of its IPR policy and improve its IPR institutional system.

[54] Lewin, A. Y., Kenney, M., & Murmann, J. P. (Eds.). 2016. ***China's innovation challenge: Overcoming the middle-income trap***. Cambridge, UK: Cambridge University Press.
[55] State Council. 2015. Opinions of the state council on accelerating building up the intellectual property strong country under the new situation. [Cited 15 November 2016]. Available from URL: http://www.gov.cn/zhengce/content/2015-12/22/content_10468.htm
[56] World Economic Forum. 2016. China's innovation ecosystem.

5. COOPERATION AND IMPACT IN EU AND OTHER COUNTRIES

The various projects listed in Section 2, focusing on Future Internet, 5G and Standardisation/IoT have either contributed to future EU-China cooperation in the relevant areas addressed by EXCITING or demonstrated China's capability in developing the infrastructure and applying relevant technologies.

While some of the presented projects only focused on domestic development, they showcase China's ability of applying the technologies in discussion and have also increased the attractiveness of the involved Chinese partners to authorities and organisations from EU and other countries. For example, project such as the 13th FYP on IoT provided the guiding principles for domestic development and international cooperation, with specific instructions to actively promote the exchange and cooperation on IoT. These projects have significant impact both at the national level and abroad and can lead to more large-scale cooperation opportunities between China and the EU as well as other countries.

The priorities on ICT, 5G and IoT by the Chinese government are also aligned with international development trends of information technology, and therefore present more cooperation opportunities in these areas (commercialisation of 5G and IPv6 transition technology being good examples) with matching demand from both sides. This should be beneficial to both China and EU countries in terms of development in these technologies.

China and the EU have engaged in a significant level of cooperation in recent years. The EU framework programmes have provided good conditions for EU-China cooperation in S&T (which includes ICT). China was the third largest non-EU participant in FP7. In fact, in FP7 alone, 383 participations from Chinese organisations were registered in 274 projects, resulting in €55.8 million Euros of funding (35.2 coming from the EU). In the most recent H2020 Framework Programme, and as of April 2018, there have been 277 Chinese participations (172 of them unique), with a total budget of approximately €30 million Euros (€3 million coming from the EU). While there are still a number of years before the end of the programme, there is currently less participation in H2020 which can be related to the fact that the EU has limited automatic funding for Chinese participation. Nevertheless, an existing co-funding mechanism in China has contributed to facilitate participation. Considering the ICT area, China was the second largest participant (following the USA), with 56 participations during FP7.[57] In H2020, there have been 10 Chinese participations.[58] The level of cooperation is expected to increase as joint activities in areas such as 5G will be implemented, focusing on the demonstration of technologies and system interoperability for a number of core applications of interest for China and Europe[59].

Within the Chinese environment, there are also mechanisms that encourage EU participation in Chinese programmes. This is the case of the 883 Programme and the National Key R&D Programme, which were open to international participation. While this is a positive sign of encouraging international cooperation, there is still room for improvements, including increased transparency with regard to

[57] Roadmap for EU-China S&T cooperation. European Commission. October 2017. https://ec.europa.eu/research/iscp/pdf/policy/cn_roadmap_2017.pdf
[58] https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/PbZJnb/state/analysis
[59] H2020 call: ICT-22-2018 - EU-China 5G Collaboration. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-22-2018.html

participation. With the new Made in China 2025 Programme[60], new opportunities are expected to be available, but require China to treat foreign organisations at the same level as domestic organisations.

This context shows that the cooperation is strong between the EU and China (not only in ICT) and that mechanisms are in place to facilitate this process in both regions. One of the potential impacts with these opportunities is that they allow organisations (including SMEs) to contact new realities, which otherwise they couldn't (or would be less available to) without these funding programmes. These cooperation opportunities and programmes open new doors to European and Chinese organisations and increase the spreading of experience and knowledge. Furthermore, by being involved in these joint activities, these organisations may then leverage their new contacts and experience and further explore other R&D opportunities in the opposing region.

However, there are still areas to be improved in order to create a better cooperation environment. Reflecting on the IPR and patent management system, while there have been considerable efforts from China's side, there is still room to increase transparency and reduce inconsistencies from the local to the national level. Also, there still exists some inequality against Foreign Invested Enterprises (FIEs) in that the current IPR policies fail to create a fair business environment for them. Furthermore, and for specific target groups, EU-China cooperation could be improved if there was additional flexibility regarding international mobility.[57]

[60] Made In China 2025. http://english.gov.cn/2016special/madeinchina2025/

6. CONCLUSIONS

The last years have been marked by a constant technological innovation. The advances can be seen almost from day to day, bringing many social and economic benefits for the people and changing the face of the world as it is known. However, this unstoppable progress also presents various challenges that need to be addressed efficiently, for which an increasing cooperation between different international actors is required.

In this context, China has been able to adapt and even excel in many of the areas analysed throughout this report. The strategic vision of the government, included in the FYP, and its support, both economically and politically, have been key to place the country among the core players in the Future Internet area worldwide in just a few years. The deep reform of the national STI system, aiming at a centralised management of any initiative in the field, has also had a remarkable contribution to the achievements of China.

By implementing a wide range of projects targeting very specific goals; the country laid the foundations for building the Next Generation Internet (NGI). Furthermore, China has shown its willingness to cooperate in order to jointly face shared challenges, as can be observed through its active participation in various EU framework programmes, including the most recent H2020 Programme.

The China Next Generation Internet Demonstration Project (CNGI) can be highlighted as a pioneering project and one of the main drivers of the country regarding the Next Generation Internet. Many other projects were based on the achievements obtained in CNGI and directed towards a further improvement of the deployment and standardisation of IPv6 across the country. In this line, the collaborations with EU were principally related to the creation and consolidation of an experimental environment for testing facilities.

While the adoption of NGI and the posterior transition to 5G have been a natural consequence of earlier efforts – both topics are specifically addressed in the Made China 2025 programme and various FYP – the commercialisation of the technology, with the necessary tests, demonstration pilots, etc., was another relevant aspect included in the various projects implemented in the area.

Currently, the IoT is drawing a lot of attention from China. The full potential lying within IoT applications is yet to be defined, but the industry, society or the environment have already proved that they can largely benefit from it. In fact, the impact of IoT is considered to be capable of reaching any imaginable field, which will then cause a shift in the present view and the functioning of economy and society. Therefore, IoT adoption and the promotion of its overall development are essential to continue being competitive in the following years.

Consequently, China is very interested in enhancing international cooperation, reinforcing the existing ties with the EU. The country is also aware of the need of involving all national leading actors to achieve this purpose. As a result, the Chinese government is making significant efforts to encourage domestic and international companies to strengthen cooperation in IoT technology, setting up R&D facilities or industrialisation.

Indeed, China intends to hold a strategic position that enables its participation in international standard-setting. Security and safety are foremost concerns for the country and as such, the active involvement

in standardisation procedures allows the government to control, moderate and contribute to any agreement on the matter.

As the most recent plans show (13th Five Year Programme, 5G Development Plan, Made in China 2025), the ICT sector and especially 5G and IoT, will continue to be highly prioritised by the government in the future, which will offer support for their further development and expansion. In addition, since the said priorities are aligned with international development trends, the offer of cooperation opportunities is broader.

In this scenario, China's efforts to reinforce the national IPR and patent management regulations are of relevance. The progress achieved in this regard will not only strengthen protection, promote international cooperation or attract investment, but it will also encourage innovation by adjusting the incentives system to foster the pursuit of high value-added technology activities, facilitating technology transfer, ensuring the ownership of inventions and increasing patent applications. In brief, China is increasingly aiming to create a fair business environment based on equality, reliability and predictability. However, the IPR and patent laws are still far from the desired maturity and the competences of the Chinese infrastructures to enforce them is questionable. This, together with protectionism, discriminatory standardisation policies or unequal financial access for foreign companies works against the innovation capabilities of the China.

In conclusion, the prospects for the Sino-EU cooperation in FI are very optimistic. As aforementioned, both regions share a determination to collaborate to accomplish shared objectives, such as the development of 5G and IoT domains analysed here. For this purpose, China and the EU are trying to elaborate a common roadmap that brings together their innovation ecosystems, facilitating interoperability, formulation of policies or standardisation. The creation of favourable conditions would strengthen the bilateral R&D&I cooperation producing many positive results for both, the EU and China.