Joint Research on IPv6 Network Management: Research Development and Demonstration

International Cooperation:
14 countries, 23 research organizations

Excellent Mix of Key Experiences of
IPv6 Network Management

13 research organizations from 11 Asian countries

TEIN*CC
SingAREN, Singapore
ThaiRen, Thailand
MYREN, Malaysia
LEARN, Sri Lanka
NREN, Nepal
PERN, Pakistan
BdREN, Bengal
CamREN, Cambodia
AfgREN, Afghanistan
University of Computer Studies, Yangon, Myanmar
University of Malaya , Malaysia
Mae Fah Luang University, Thailand

2 research organizations from European countries

University of Gottingen, Germany
University of Surrey, UK

8 Chinese research organizations

Tsinghua University
BUPT
CAS
Bit-Way
Shenzhen Research Institute, HKPU
UESTC
Shandong University
eHualu

Promote Network Technology Innovation and Application Demonstration

Partner:
Research Organizations from 11 Asian Countries

- **Research and education network operators**
- **Members of TEIN and APN**
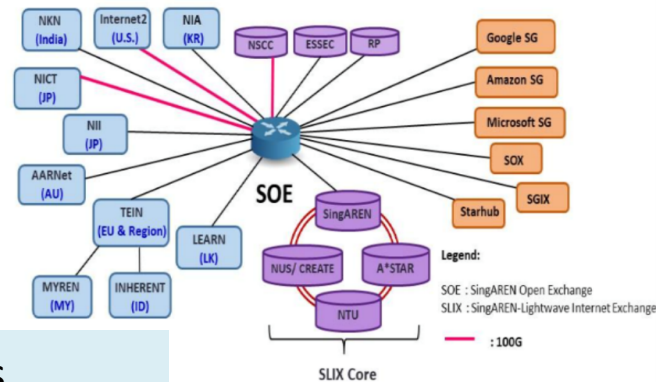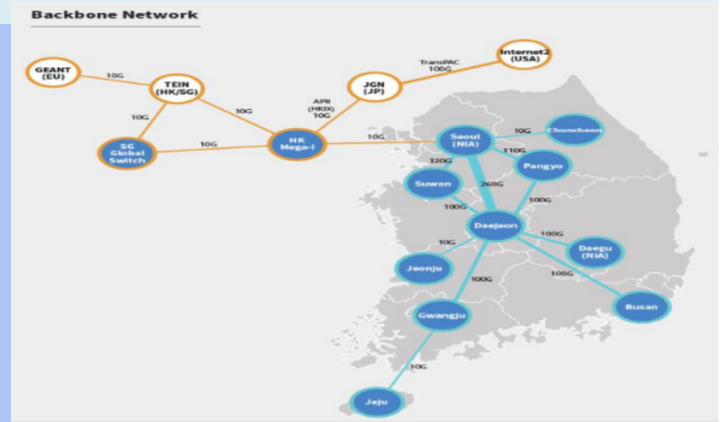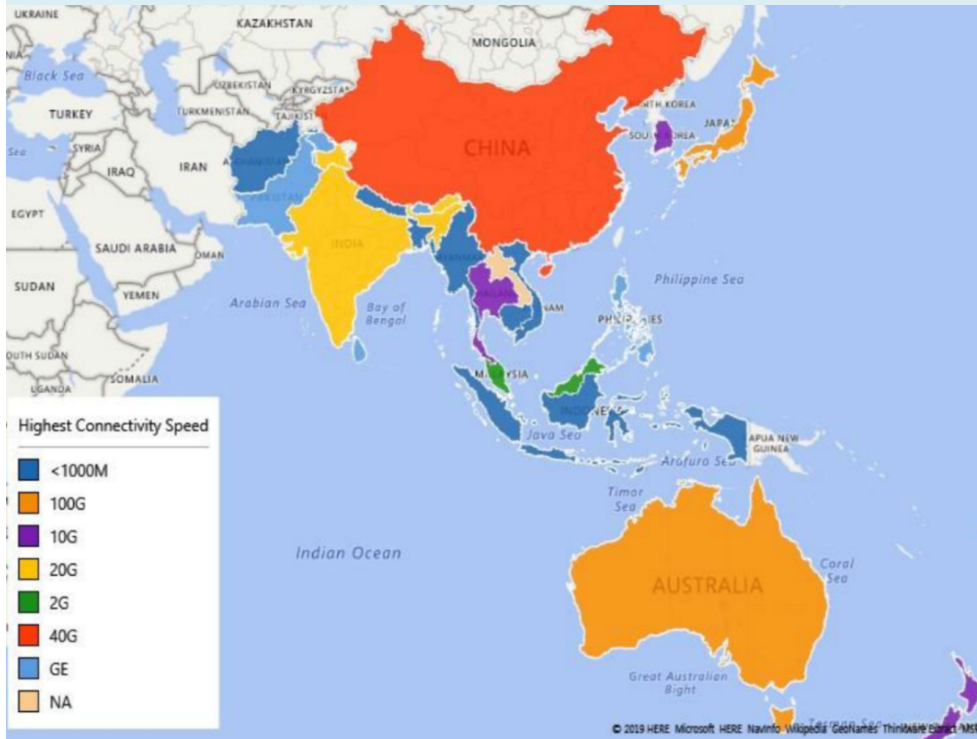
Network of 11 'the Belt and Road' countries

- **Provide heterogeneous network for trial and demonstration**
- **Impose challenges on the design of technologies and rules due to diverse requirements**

TEIN

- Top level intercontinental academic network platform
- Important platform for network collaborative innovation in Europe and Asia
- Cover European Union and 24 Asian countries and areas
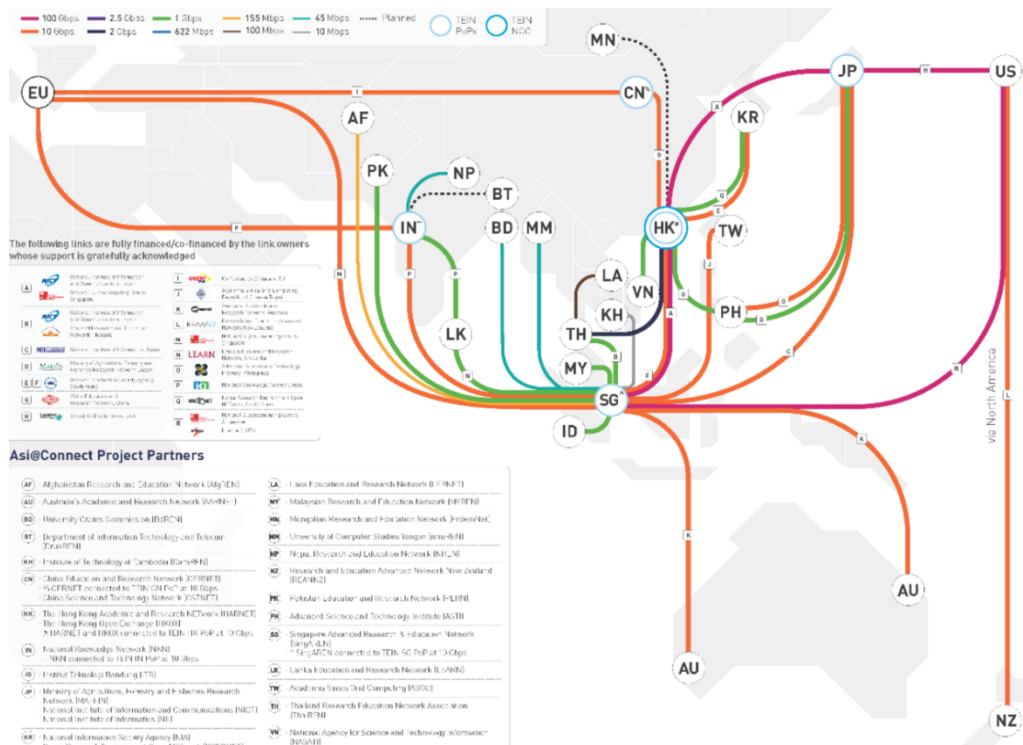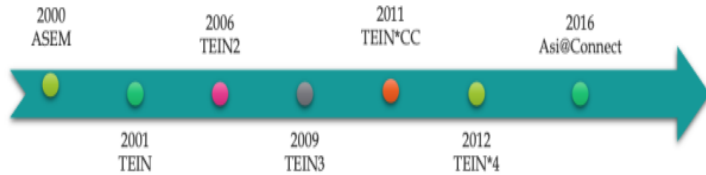
- **TEIN network has been upgraded to fifth generation, in which the bandwidth of some backbone network is up to 100Gbps**

APAN

- A non-profit international consortium, established on 3 June 1997
- Provide an advanced networking environment for the research and education community in the Asia-Pacific region, and promotes global collaboration.

Asia-Pacific Backbone Topology
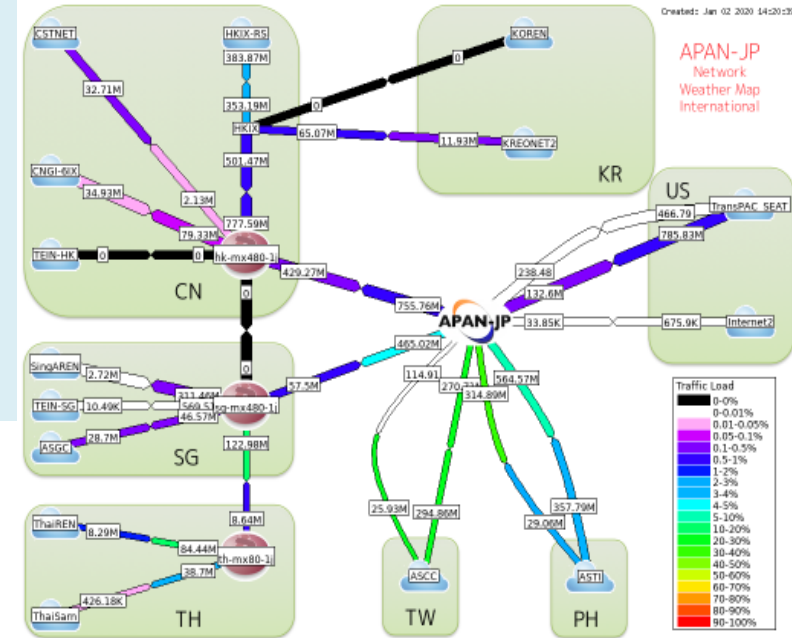
- **Key driver in promoting and facilitating network-enabled research and education activities**
- **Most of the partners are APAN members**

Partner: University of Gottingen, Germany

- **Top 5**, global ranking of universities with thousand-year history
- **45 Noble Prize winners**

- The research of big data in University of Gottingen grow vigorously, responding actively to the strategy of industry 4.0 and AI Made in Germany.

Germany has long term cooperation with China in the filed of life science, management science and Engineering science.

Partner: University of Gottingen, Germany

Prof. Xiaoming Fu

Leader：Prof. Xiaoming Fu

- Full Professor, Leader of Computer Networks (NET) Research Group
- Member of Academia Europaea
- Published over 300 papers

Main Research Areas

- Internet Architecture, Scalable Larger-scale Measurement, Network QoS and QoE, Network Resource Management and IoT Application

National and European Project

- 2018-2022, EC H2020, COSAFE – Cooperative Connected Intelligent Vehicles for Safe and Efficient Road Transport, 202,000 euro
- 2016-2019, EC H2020, ICN2020 – Advancing ICN towards real-world deployment through research, innovative applications, and global scale experimentation, 1,300,000 euro
- 2014-2018, EC FP7, CleanSky - Network for Cloud Computing Ecosystem, 3, 240, 000 euro
- 2014-2016, EC FP7, MobileCloud - Linking Sino-European Research Institutions in the Mobile Cloud Computing Era", 481, 000 euro

Partner: University of Surrey, UK

- First 5G innovation center in the world, built in 2013
- Proposed satellite-ground integrated 5G core network architecture

- Professor G.Q. Max Lu, President
- First principal of top university in the history of British. He attaches importance to cooperation with China and has established partnership with many universities in China.

Britain's Hammond to attend China's Belt and Road forum

- British Chancellor of the Exchequer Philip Hammond attended China's Belt and Road forum in 2019
- China is Britain's second-largest trading partner outside the EU, while Britain is China's largest investment destination in Europe.

UK has been at the forefront of the world in the filed of ICT. UK always mains independent thinking and judgment in terms of cooperation with China.

Partner: University of Surrey, UK
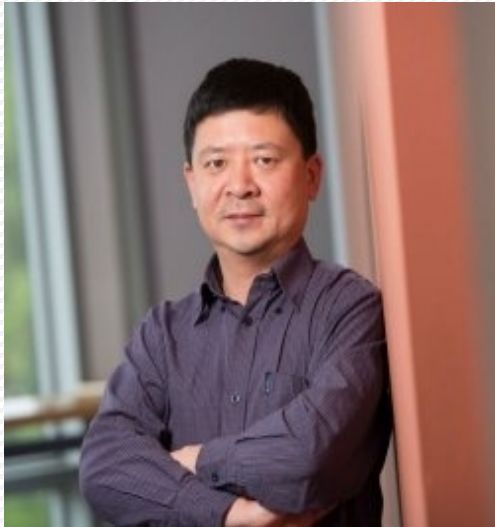
Prof. Ning Wang

Leader: Prof. Ning Wang

- Full Professor, Institute of Communication Systems
- **Team leader** of 5G network edge intelligence and core network development of 5G Innovation Centre (5GIC) since 2013
- Published over 140 papers, appeared in **IEEE Communication Society (ComSoc) Technology News for three times**
- Actively involved in international standardization：**IETF、3GPP、ETSI**

Main Research Areas

- Future Network Design including 5G, Content/Information-Centric Networking, SDN/NFV, Quality of Services/Experiences and IoT applications.

National and European Project

- 2018-2020, NSFC-RS project, NEWTRIP，12,000 pound
- 2017-2022, BT-ESPRC project, Next Generation Convergence Network Infrastructure, 758,000 pound
- 2017-2019, EC FP project, 5G oriented Space-ground integrated network, 580,000t pound
- **2016-2017, British Government project, 5G core network seamless interconnection and resource management in the UK, 10,000,000 pound**
- 2014-2017, EPSRC project, Knowledge Centric Networking, 350,000 pound

Partner: University of Malaya, Faculty of Law

- The University of Malaya is the **oldest, largest and most prestigious university in Malaysia**
- The only university in Malaysia as a member of the Association of Pacific Rim Universities (APRU)
- The UM is always committed to bilateral academic exchanges with China and is the first foreign university to be able to hold graduation ceremony in the Great Hall of the People

- The law school of UM attaches importance to **interdisciplinary research** and established the **Centre for Law and Ethics in Science and Technology** in 2017.

- Covers many research areas such as network law, data protection law, information and communication technology law, and has a excellent research foundation and scientific strength.

Leader: Johan Sabaruddin

- **Dean of the University of Malaya Law School**

- Prestigious scholar in the field of public law, terrorism and rule of law, published nearly 40 academic papers, more than 10 patents.

- Has won several national awards in Malaysia, with excellent influence.

- Has led long-term and in-depth cooperation with Tsinghua University Law School in the field of public law.

Partner: Mae Fah Luang University, School of Law

- The **only national autonomous university in Thailand with all programmes taught in English**, attaches great importance to international exchanges and encourages teachers and students to carry out international academic cooperation
- Has held many international seminars on Chinese culture, academic visits, and is a member of the University Alliance of the Silk Road (UASR)
- 2020 Times Higher Education World University Ranking #1 in Thailand

- Mae Fah Luang University School of Law is renowned as the **newest and most sound practice-oriented law school** in the Greater Mekong Subregion.

- **Features interdisciplinary legal research and teaching**, and has the research strength related to network law and international law.

- Focus on solving regional and international problems, and encourage teachers to carry out international academic exchanges and cooperation, especially in the Greater Mekong Subregion including China.

Leader of faculty: Yodsapon Nitiruchirot

- Graduated from Mae Fah Luang University School of Law majoring in international law, with many academic papers published in well-known law journals.

- Studied in China and was the first foreign doctor granted by South China Sea Institute of Xiamen University.

- **Has led long-term and in-depth cooperation with Tsinghua University Law School in the field of international law.**

Research Problems

How to achieve trust, sharing and collaboration among independent and autonomous management entities

Contradiction between the **independence** of network management and **demand** of **transnational collaborative** management

Contradiction between **non-ergodicity** of massive IPv6 address space and **high efficient** and **accurate** requirement of active measurement

Contradiction between the **high complexity** of encrypted traffic identification and **low processing cost** of passive measure in 100G link

Contradiction between **precise tracing** of specific network behaviors and **the failure to record** complete network behaviors of all network nodes under normal conditions

Contradiction between **high efficiency** management requirements and **low efficiency** of traditional transnational cooperative governance rules

Collaborative Management Architecture Model for IPv6 Cyberspace

Research Contents

Demonstration of IPv6 Cyberspace Collaborative Management
Validation of key technologies, devices, systems and governance rules

Collaborative Management Architecture Model for IPv6 Cyberspace
Open connection of IPv6 management system from different countries, with different types and architectures

IPv6 International Inter-Network Threat Tracing
Online threat discovery, offline threat mining, retention traceability and controllable traceability

Active Measurement of Massive IPv6 Address Space
Massive IPv6 address space scanning, IPv6 network digital asset management, topology discovery, performance and security measurement

Passive Measurement in High-speed IPv6 Network
Encrypted traffic identification, VPN traffic identification and construction of Network Behavior Knowledge Base

New Rules for International Cooperative Governance on IPv6 Cyberspace
International governance credit system of IPv6 cyberspace, compatible with existing international rules

Key Technology   Governance Rule   Demonstration

Research Objectives

Key Technology

- Collaborative Management Architecture Model for IPv6 Cyberspace, active measurement, passive measurement and IPv6 international inter-network threat tracing
- Prototype/system, providing 100Gbps IPv6 traffic measurement capability, supporting more than 10 IPv6 encrypted traffic identification and VPN traffic identification

Governance Rule

- Cooperation with law researchers，investigate new rules for International cooperative governance on IPv6 cyberspace, compatible with existing international rules

Demonstration

- Large-scale demonstration

Collaborative Management Architecture Model for IPv6 Cyberspace

Governing the Internet through collaborative management network, in which a logical management network based on the Internet is established, to achieve facility coordination, interpersonal collaboration and rule collaboration. Support authorized access, information security, and collaborative incentives.
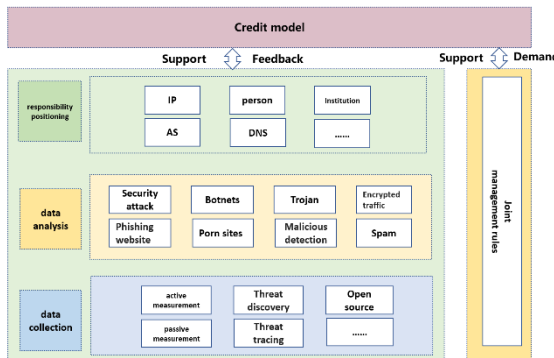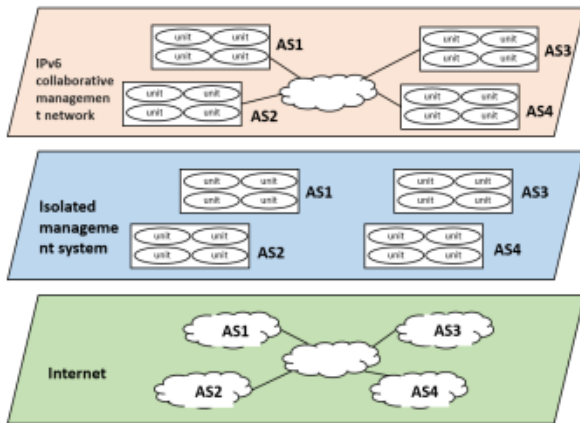
- Establish a credit model to support reliable and consistent credit-based flexible governance decisions and control mechanisms

- Establish a credit consensus mechanism based on blockchain to achieve credibility, reliability and consistency of credit information
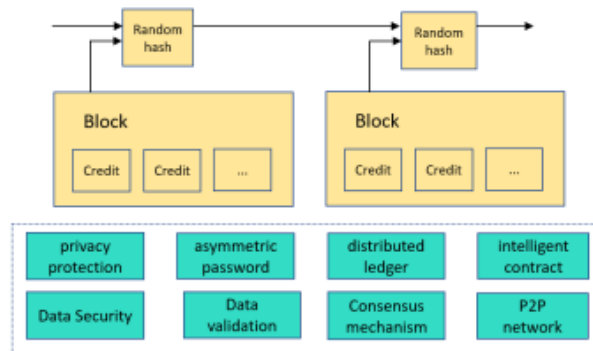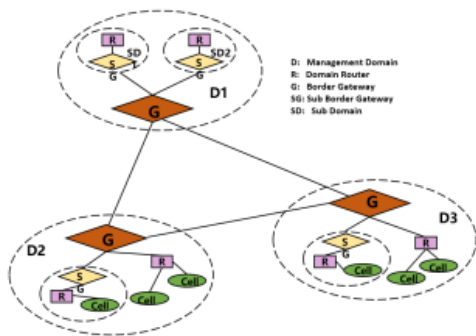
Active Measurement of Massive IPv6 Address Space

Breakthrough massive ipv6 address space scanning technology, and propose IPv6 active measurement technologies including IPv6 network digital asset management, topology discovery, performance and security measurement.

Knowledge Extraction Layer
- IPv6 Knowledg Graph
- Service Knowledge Graph
- National Topology Knowledge Graph
- AS Knowledge Graph

Detection Analysis Layer
- Discovery of IPv6 Active Address
- Discovery of Topology
- Analysis of Application Service
- Calibration of IP Attributes

Intelligent Scheduling Layer
- Containerized Management
- Collaborative Incentives
- Load Balancing
- Load Sensing
- Privacy Computing

Probe Resource Layer
- Hardware-Entity Probe Resources
- Opening Probe Resources
- Software-Entity Probe Resources
- The Belt and Road Network

Task 4 Threat Tracing

Task 1 Architecture

Task 3 Passive Measurement

Massive IPv6 Address Space Scanning

- Active IPv6 address base constructed through network measure and third-party knowledge base
- Multi-dimensional IPv6 address inference model

Distributed and Inter-domain Active Measurement

- IPv6 network digital asset discovery
- Intelligent scheduling mechanism of heterogeneous, discrete and resource constrained measurement resources
- Decentralized data sharing based on secured multi-party cooperation

Key Technology   Governance Rule   Demonstration

Passive Measurement in High-speed IPv6 Network

Based on heterogeneous divided-flow processing technology, a 100Gbps high-performance IPv6 network traffic processing platform is realized. Traffic processing is divided into basic data layer, behavior layer, knowledge layer and decision layer to solve the contradiction of low overhead of traffic processing and high complexity of traffic identification.

Task 2   Task 5

Decision layer

Active measurement   Flexible governance   International exchange

IPv6 address pool   Credit score   Threat intelligence

Knowledge layer

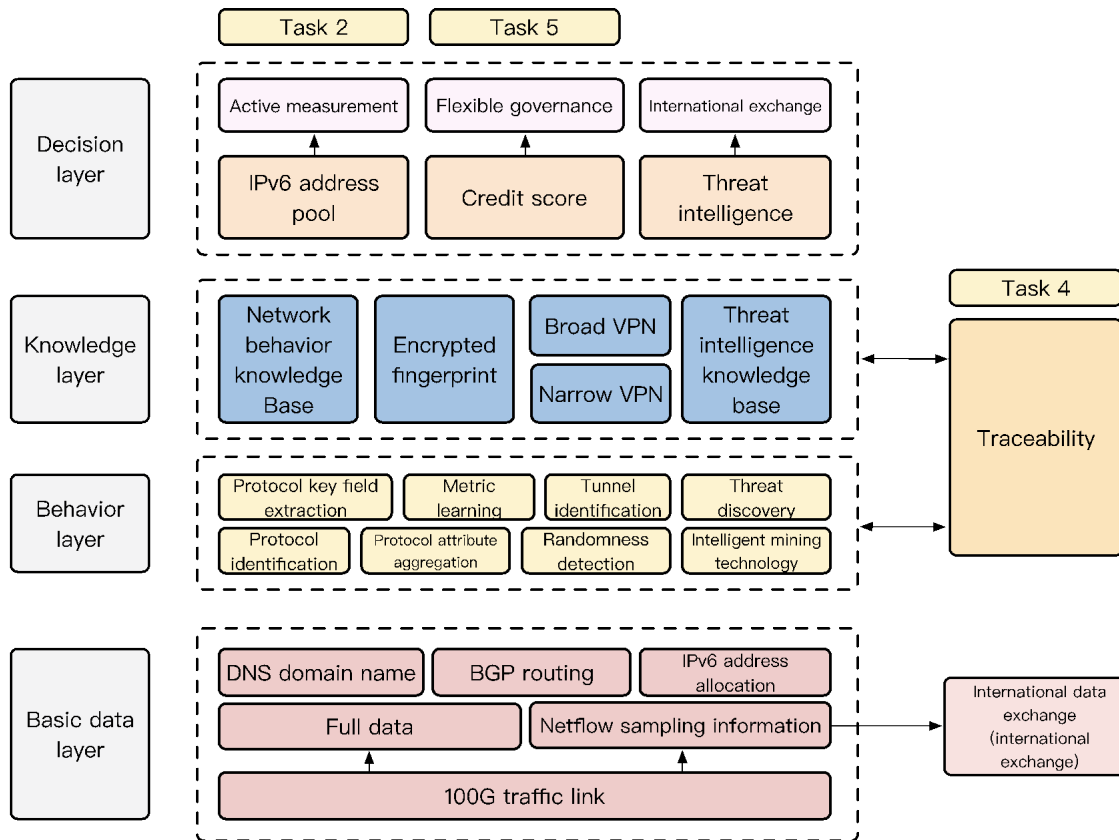Network behavior knowledge Base   Encrypted fingerprint   Broad VPN / Narrow VPN   Threat intelligence knowledge base

Behavior layer

Protocol key field extraction   Metric learning   Tunnel identification   Threat discovery

Protocol identification   Protocol attribute aggregation   Randomness detection   Intelligent mining technology

Task 4

Traceability

Basic data layer

DNS domain name   BGP routing   IPv6 address allocation

Full data   Netflow sampling information

100G traffic link

International data exchange (international exchange)

Identification of Encrypted Traffic in High-speed Network

- Support more than 10 types of IPv6 encrypted application traffic classification
- Support more than 5 types of VPN encrypted traffic classification

Network Behavior Knowledge Base

- The amount of data is not less than 10 million, and the malicious network behavior is not less than 20 kinds

Prototype

- 100Gbps IPv6 traffic measurement capability

Key Technology   Governance Rule   Demonstration

IPv6 International Inter-Network Threat Tracing

Combing network behavior records and source address verification, we propose the retention traceability technology based on network behavior records and the controllable traceability technology based on source address verification, to achieve cross-border and cross-domain threat tracing

International Threat Tracing

Network Trace Retention Technology

Source Address Verification Technology
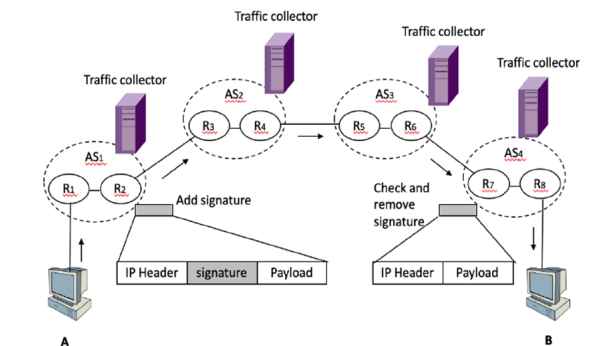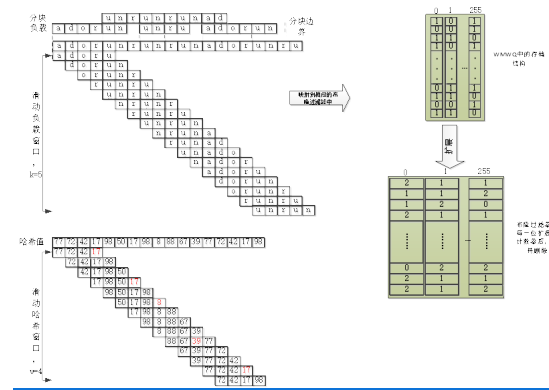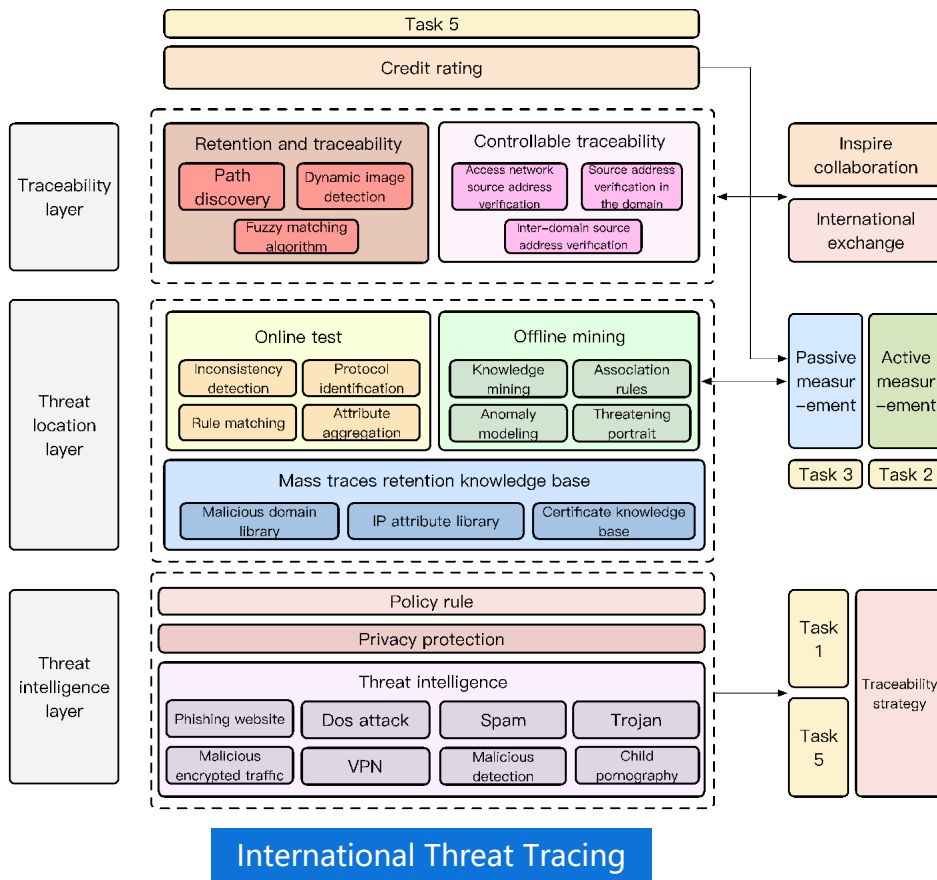
New Rules for International Cooperative Governance on IPv6 Cyberspace

Two lines: cooperative sharing and flexible governance

Problems
- Cyber crime
- Cyber terrorism
- Digital divide

Solutions
- Cooperative sharing mechanism
- Flexible governance based on credit

Form
- A declaration or a draft for cooperative administration of crossing districts on IPV6 among One Belt And One Road countries

Empirical analysis
- Data sharing
- Joint law enforcement

Technology Support Platform for international governance of IPv6

- **Cooperative sharing mechanism**
  - Sovereign mode
  - Governance structure: transparency, equality, effectivity

- **Flexible governance based on credit**
  - General idea
  - The characterization of credit
  - The remedy clauses

- Cyber crime：Lack of balanced, objective, comprehensive and extensible legal provisions
- Cyber terrorism：Lack of a global basis for cooperation
- Digital divide：Lack of a shared cooperation mechanisms

- Data sharing: Privacy protection & Credibility
- Joint law enforcement: Cooperative warning & Efficiency

Key Technology | Governance Rule | Demonstration

Related studies

No.	Organization	Research topics	Research results
1	Center for Applied Internet Data Analysis (CAIDA)	Internet active and passive measurement; Internet inter-domain flow measurement and control	Archipelago (Ark): Network detection architecture and detection tool BGPStream: routing monitoring platform.
2	Reseaux IP Europeens Network Coordination Center (RIPE NCC)	EU Internet number resources allocation and management; distributed network measurement and routing monitoring	RIPE Atlas: a distributed measurement framework and probe tool. The organization has deployed nearly 10,000 entity probes worldwide for network measurement.
3	University of Michigan	Network measurement and analysis, attack and anomaly detection, traffic classification	Zmap: Address scanning tool; ZMapv6: Internet Scanner with IPv6 capabilities
4	FireEye	Network security and threat tracing	Helix security platform; Verodin security instrument; FireEye provides network security services including incident response, security assessment, security enhancement, security transformation services
5	University of Gottingen, Germany	Scalable large-scale network measurement, network security and privacy protection	European Telecommunications Standards Institute (ETSI) IPv6 test standard; ACM SIGCOMM, IEEE INFOCOM and other top conference papers

Tasks

Task 1: Collaborative Management Architecture Model for IPv6 Cyberspace
Partners: Tsinghua University, 11 research organizations from Asian countries, University of Gottingen, Germany, University of Surrey, UK

Task 2: Active Measurement of Massive IPv6 Address Space
Partners: Beijing University of Posts and Telecommunications, Shandong University

Task 3: Passive Measurement in High-speed IPv6 Network
Partners: Chinese Academy of Sciences, Hong Kong Polytechnic University Shenzhen Research Institute

Task 4: IPv6 International Inter-Network Threat Tracing
Partners: Chinese Academy of Sciences, Bit-Way Company, University of Electronic Science and Technology of China

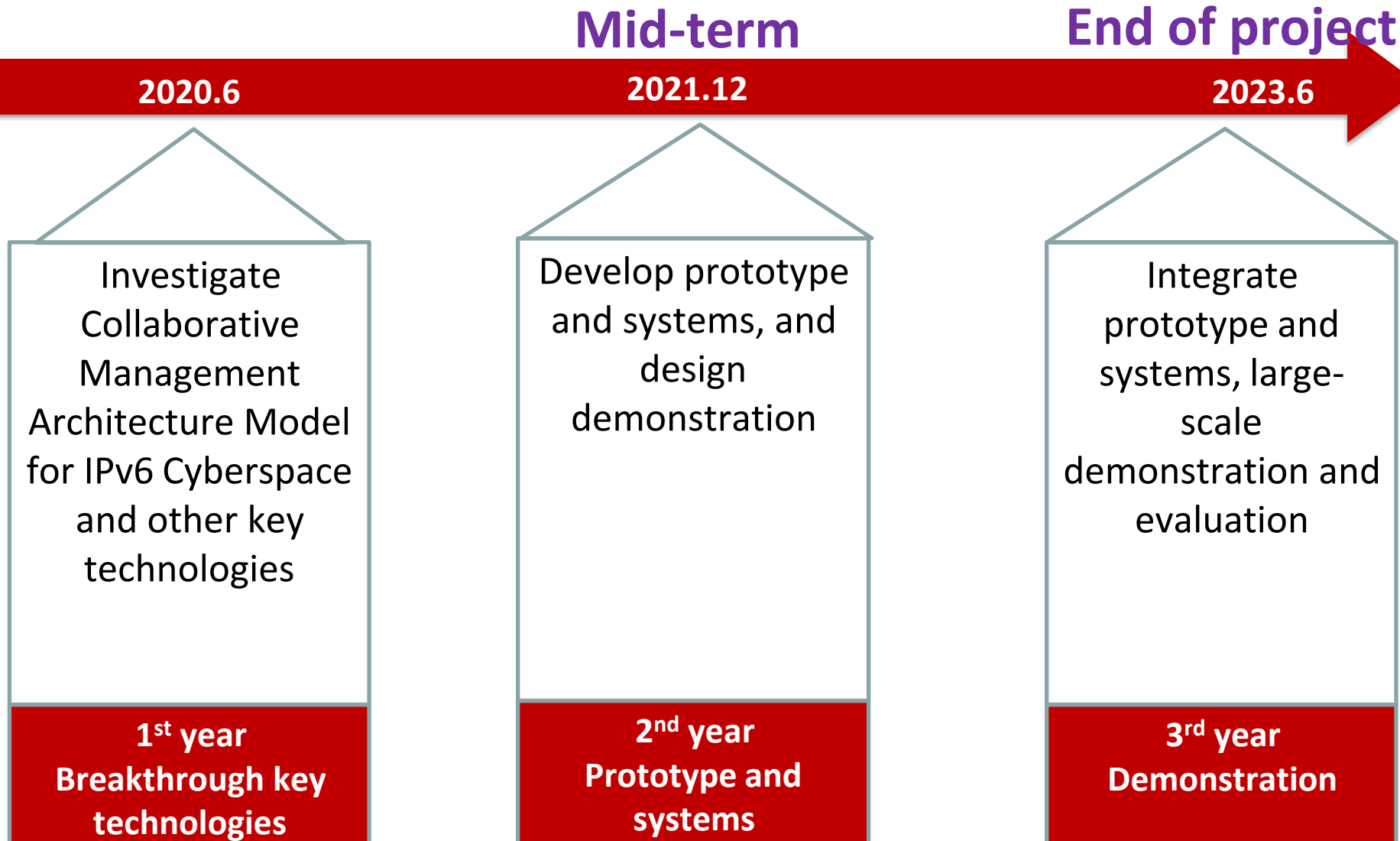**Task 5: New Rules for International Cooperative Governance on IPv6 Cyberspace**
Partners: Tsinghua University, University of Malaya, Malaysia, Mae Fah Luang University, Thailand

Task 6: Demonstration of IPv6 Cyberspace Collaborative Management
Partners: Tsinghua University, eHualu company, 11 research organizations from Asian countries, University of Gottingen, Germany, University of Surrey, UK

Schedule

Mid-term   **End of project**

| 2020.6 | 2021.12 | 2023.6 |

Investigate Collaborative Management Architecture Model for IPv6 Cyberspace and other key technologies

Develop prototype and systems, and design demonstration

Integrate prototype and systems, large-scale demonstration and evaluation

1st year Breakthrough key technologies

2nd year Prototype and systems

3rd year Demonstration

Organization Structure

- Two project meeting and two technology summit each year.
- Open cooperation and research mechanism

General Assembly

Project Office

Advisory Group

Key technology

Governance rule

Demonstration

Task 1: Collaborative Management Architecture Model for IPv6 Cyberspace

Task 2: Active Measurement of Massive IPv6 Address Space

Task 3: Passive Measurement in High-speed IPv6 Network

Task 4: IPv6 International Inter-Network Threat Tracing

Task 5: New Rules for International Cooperative Governance on IPv6 Cyberspace

Task 6: Demonstration of IPv6 Cyberspace Collaborative Management

To make technical contribution to international cyberspace governance

Cyberspace governance is premised on transnational cooperation, involves a large number of transnational network measurement and forensics requirements, involves international law and voluntary norms, and requires all parties to participate and contribute their wisdom.

United Nations Internet Governance Forum (IGF), United Nations Open-ended Working Group on Information Security (OEWG), Resolution 247 of the 74th UN General Assembly, London Declaration in NATO Summit, Global Commission on the Stability of Cyberspace

Thank you!