IEN (Intelligent Eco Netwoking)

What is IEN?

Maybe most of you will have this question when you see this title. What is IEN? The full name of IEN is "**Intelligent Eco Networking**". From the name alone, it is probably a kind of network architecture systems. "**Intelligence**" indicates that there should be feedback and adjustment. "**Eco**" can infer that there should be components interacting with each other. The above is probably all the information we can get from the name, but it is still very vague. In order to have a better understanding, then let me introduce it for you from its background and definition.

It was a novel new idea and research project on-going proposed by Prof. Kai Lei (Peking University , Shenzhen) and his ICNLab Group.

- **IEN Before:**

NDN-Hippo, 2015.07:"A streaming media system over named data networking";

NDNMaze, 2016.12:"A Peer-to-Peer File Sharing System over Named Data Networking";

Centaur, 2016.10 : "A Evolutionary Design of Hybrid NDN/IP Transport Architecture for Streaming Application" ;

BlockNDN, 2017.07: " A bitcoin blockchain decentralized system over named data networking";

- **IEN :**

1st edition IEN paper (a position paper), 2018.08:《Intelligent Eco Networking (IEN): an Advanced Future Internet of intelligence for Digital Social Economic Ecosystem》;

2nd edition IEN paper, 2019.12:《Intelligent Eco Networking (IEN) II: A Knowledge-Driven Future Internet Infrastructure for Value-Oriented Ecosystem》;

Chinese Edition of IEN (Full), 2020.01:《Intelligent Eco Networking (IEN): Knowledge-Driven and Value-Oriented Future Internet Infrastructure》

3rd edition IEN paper, 2020.12, 《Intelligent Eco Networking (IEN) III: A Shared In-network Computing Infrastructure towards Future Internet》.

4th add-on IEN paper, 2021.11, 《A Cooperative Game Theory and Blockchain based Elastic Bilateral Task Allocation Algorithm for In-network Computing》

- **Video Tutorial**

  2021 4th IEEE HotICN 国际学术会议上，北京大学 雷凯 做学术报告《智能生态网络（Intelligent Eco Networking）2021 基于价值数据 NFT 的开放可信数字底座》;

  ①《**区块链风险更复杂多样，需要建立标准与监管共识**》2017 年 1 月 27 日，胡润金融科技大会;

  ②《**区块链：阿凡达文明的缔造之魂，信息中心网络：潘多拉世界砥砺之基**》，2018 年 3 月 2 日，CCF;

  ③《**块游记：区块链如何与 NDN 等未来网络基础设施结合？**》，2018 年 11 月 25 日;

  ④《**IEN II: 知识驱动的边缘智能生态网络设想及初探**》,2019 年 5 月 23 日，南京未来网络大会;

  ⑤《**面向 5G 的命名数据网络物联网研究综述**》，计算机科学, 2020 年;

  ⑥《**智能生态网络:知识驱动的未来价值互联网基础设施**》，应用科学学报，2020 年 1 月;

  ⑦《**面向边缘人工智能计算的区块链技术综述**》，应用科学学报，2020 年 1 月;

⑧《**IEN III: 5G 边缘算力网络**》，2020 年 6 月 4 日，南京未来网络大会；
⑨《**IEN 3.X: 区块链与命名机制在未来网络体系结构中的先进原理**》，21 年 6 月，南京未来网络大会；

- Patents:

1. US patent(authorized), 2019: "NDN and IP fusion network content control method and apparatus, and storage medium（一种 NDN 和 IP 融合网络的内容管控方法、装置及存储介质）";
2. US patent(authorized), 2019: "Method and apparatus for forwarding an interest packet based on a probability tree in an information network （信息中心网络下基于概率树的兴趣包转发的方法）;
3. US patent(authorized), 2019: "Method and Apparatus for Sending Target Data to and Acquiring Target Data from Network";
4. Chinese patent (authorized) 授权专利：基于网络传输的数据包的加密解密方法与终端，ZL201310688322.5，授权日： 2018 年 1 月；
5. Chinese patent (authorized) 授权专利：信息中心网络下兴趣包转发的方法和转发终端，ZL201410476456.5，授权：2017 年 7 月。
6. Chinese patent (authorized) 授权专利：信息中心网络下的流媒体系统及其使用方法，ZL201410345816.8，授权：2017 年 6 月。
7. Chinese patent (authorized) 授权专利：一种基于 NDN 网络架构的 P2P 文件传输方法，ZL201310339690.9，授权日：2016 年 5 月。
8. Chinese patent (authorized) 授权专利：支持消费者移动的数据预取方法、接入基站和终端，ZL201410204197.0，授权日：2017 年 6 月。
9. Chinese patent (authorized) 授权专利：TCP/IP 协议与 NDN 协议之间的数据转换传输方法，ZL201310137990.9，授权日：2017 年 2 月。
10. Chinese patent (in processing)："一种自组网络的分布式入侵检测方法和系统"，201810179320.6，申请日期，2018 年 3 月 8 日【NDN Blockchain】
11. Chinese patent (in processing)："一种 CCN 中基于区块链的密钥管理方法、装置及存储介质"，201810878557.3，申请日期，2018 年 8 月 3 日【NDN Blockchain】
12. Chinese patent (in processing)："基于 NDN 的区块链同步方法和装置"，201710400368.0，申请日期，2017 年 5 月 31 日【NDN Blockchain】
13. Chinese patent (in processing)："一种联盟区块链共识方法"，201810122889.9，申请日期，2018 年 2 月【Blockchain】
14. Chinese patent (in processing)："一种区块链系统的测试系统和方法"，201711320172.7，申请日期，2017 年 12 月 12 日【Blockchain】
15. Chinese patent (in processing)："一种基于区块链的数字资产交易方法和系统"，201810247448.1，申请日期，2018 年 3 月 23 日【Blockchain】
16. Chinese patent (in processing)："一种活动社交网络中节点可信度的计算方法"，201710132298.5，申请日期，2017 年 3 月 8 日【Blockchain】

Background

With the increasing computation and communication in the age of Big Data and IoT, traditional network architecture is unable to adapt to today's **social and economy ecosystem**. This incompatibility is reflected in all aspects from network physical infrastructure devices to network software applications.

- Traditional network infrastructure devices are bundled with the functionality it

provides, which lead to inefficient, costly and inflexible deployment of new network services.

- Address-based packets delivering service provided by TCP/IP is insensitive to content, making it complex and inaccessible to content that users need.
- Traditional network has poor perception of the network environment, which makes it impossible to quickly and intelligently take effective traffic control measures when network environment changes.
- In the era of the Internet of Everything, various IoT devices with different performances are connected to the Internet, which makes the complexity of the network scene far more than the concept of original designers.

The emergence of some technologies has attracted people's attention. ICN and NDN enable the network to perceive the content more granular; NFV and SDN provide more flexible network traffic control measures; Cloud computing and edge computing offer users elastic computing and storage resources; Blockchain ensures data security with a decentralized consensus framework. Blockchain over ICN can implement a simplier and more straight-forward decentralized system, and the **BlockNDN** can improve effective use of weak connectivity, reduce broadcasting overhead and increases network efficiency. However, there is still no a network system that can integrate these technologies well.

Motivation

IEN proposes to call for attention of taking the **Valuable Knowledge Data (VKD，** excluding those excess data,even virus or poison data**) and Data Knowledge Technologies** into design of Future Internet (In term of "into", which means to be imported into lower network layers) . Generally, data with certain meaning can be interpreted as information. In order to build a fair and reciprocal network economy, IEN focuses on the value of the information itself for economic settlement, rather than data flow originally. ***VKD*** has three main characteristics:

1. VKD can be a variety of different expressions (data from different IoT devices, utilize different encoding methods or compression formats);
2. VKD contrusts a value system for recognition and has to achieve trust maintenance;
3. VKD can be directly used for transactions. Value maintenance and circulation of the cross value system can be guaranteed since valuable content data itself is a transaction object.

A new network system, especially as for a future Internet, has to handle these problems in need. The goal of IEN is to establish a prosperous mutual-contributed and mutual beneficial knowledge-oriented networking industry ecosystem for future IoT, Vehicle, Robot Networks and beyond.

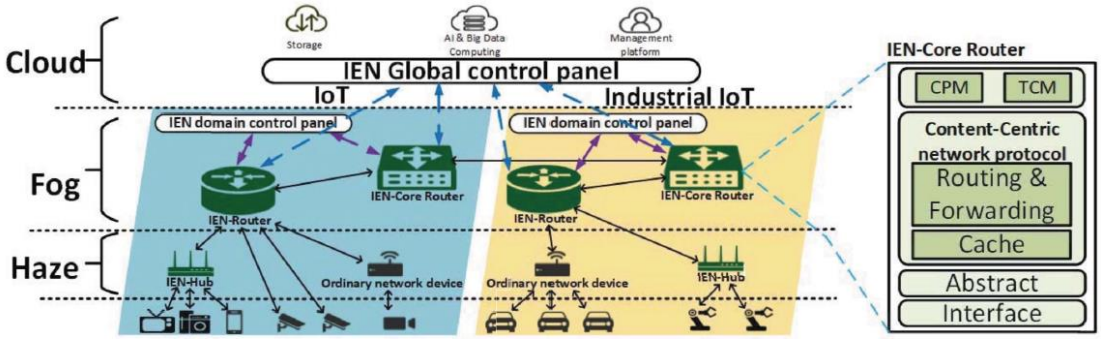
With all the mentioned, we have a roughly knowledge about the requirement and goal of IEN. And in addition, It will be better to understand with the detailed definition of IEN.

Difinition

Intelligent Eco Networking (IEN) aims to gradually evolve to be an advanced infrastructure for future ***Internet of intelligence*** which treats ***valuable knowledge*** as the first-class entity, motivated by data exchange, manipulated by artificial intelligence, based on the approaches of software defined, virtualized and programmable devices, additionally by comprehensively measuring the ***cost and gain*** of storage, computing and network resources, it also integrates decentralized consensus ***trust*** preservation and ***tokenized*** fine-grained allocation

mechanism of ***blockchain*** to establish a prosperous mutual-contributed and mutual beneficial ***value-oriented networking*** industry ecosystem.

The basic architecture of Intelligent Eco Networking is mainly composed of Network functions configurable device, Multi-layer controller system, Content-Centric network protocol, Trust management and Cloud/Fog/Haze computing group. For IoT, the IEN architecture combines with content center, blockchain and AI. The details of its infrastructures are as follows:



Architecture Concept

A. *Network function configurable device*

As shown in the figure, the network function configurable device can be the IEN-Hub, the IEN-Router, or IEN-Core Router, depending on its performance. The multi-layer control system can realize different network transmission functions by configuring control processing module (CPM) in the device to achieve different network transmission functions. The traffic collection module (TCM) can periodically collect network environment information (eg. route table, cache queue length) and traffic information (eg, packet size and receiving frequency). This information will be uploaded to the control panel to assist in formulating transmission strategy. The network function configurable device implements a physical abstraction layer that contains multiple customizable physical interfaces (eg, 5G, wifi, Bluetooth). It makes software applications do not need to consider the underlying heterogeneous environment, and simultaneously access to devices with different performances and different communication methods.

It should be noted that the IEN-Hub is loosely managed by the controller because of its too low computing capability to burden heavy tasks, which only serves as a unified access point for various heterogeneous terminals but can be stimulated for sharing valuable content to earn IEN coins, acting like ''small miners". And the IEN-Router and IEN-Core Router can not only perform complex network forwarding, but also provide computing and storage for the Cloud/Fog/Haze hierarchical framework, which will be explicated in section E.

B. *Multi-layer control system*

It intelligently implements transmissions control through configurable device by combining AI Big Data with operator-customized service policies.

As shown in the figure, we will divide the control system into the IEN domain control panel and the IEN Global control panel. The IEN Global control panel sets regulating the overall network and developing different service forwarding strategies for different services. By learning network flow information with cloud computing, it classifies different data streams into different services and provides corresponding service processing methods. The IEN

control panel is responsible for the data forwarding path in the local area network. By learning the network environment information with fog computing, it can plan the forwarding path that is most suitable for the data flow.

C. Content-Centric network protocol

The IEN network protocol uses the content name instead of the address as the data packet header of the network protocol stack. By matching the content name in the data packet, the network can find corresponding data which is needed by users. Each packet content name also carries a mandatory data signature, which ensures the network security. The Content-Centric protocol has a network layer caching function. Transmitted content will be cached in each switch that it traverses, to response that requests for the same content come, switches could search their cache to find the corresponding content and achieve a faster response.

D. *Distributed Trust management*

To ensure the security and stability of the network infrastructure, IEN builds a trust management model to validate data packets. The trust model is based on blockchain technology. The reliability of the trust anchor and the certificates that it issues are guaranteed through distributed consensus. At the same time, the hierarchical structure makes the content name highly expressive and provides a sufficient context for content verification. The trust model supports content based confidentiality. Content producers can encrypt content after producing it and assign corresponding decryption keys to authorized consumers. In this way, the confidentiality of the content does not depend on the intermediate device to ensure authentic end-to-end confidentiality, end-to-end confidentiality.

E. Cloud/Fog/Haze hierarchical framework

The traditional IoT service framework relies entirely on the computing storage capacity provided by the cloud. With the increase of IoT devices, this frame work faces challenges in terms of latency, bandwidth, and device energy consumption. At the same time, more and more network devices still have idle computing and storage resources besides satisfying their own functions.

Therefore, we propose a Cloud/Fog/Haze hierarchical framework for the IoT. The Cloud consists of computer clusters with supercomputing and storage capabilities, providing IoT network with big data analysis and data persistence storage service. The Fog consists of network devices that have better computing and storage performance, such as IEN-Router and IENCore Router. The Fog is closer to users and provides a more low-latency and intelligent services. The Haze, which is the closest part of framework to users, consists of network devices with relatively poor performance such as IEN-Hub.

The Cloud/Fog/Haze hierarchical framework is more sensitive to users behavior than the traditional IoT service framework, providing smarter and lower latency services. Besides, the cloud/ fog/haze frame work effectively improves the resource utilization of network devices. By employing this kind of framework, the centralized management and charging model of resources is transformed into a sharing model, forming a new network model and ecology.