

Contrat doctoral – ED Galilée

Titre du sujet : Generative Artificial Intelligence for Network Protocol Design

- Unité de recherche : Laboratoire de Traitement et Transport de l'Information (L2TI)
- Discipline : Informatique
- Direction de thèse : Thi-Mai-Trang Nguyen (Université Sorbonne Paris Nord, France)
et My T. Thai (University of Florida, USA)
- Contact : thimaitrang.nguyen@univ-paris13.fr
- Domaine de recherche : Réseaux et Intelligence Artificielle
- Mots clés : Architecture des réseaux, conception de protocoles, apprentissage automatique, intelligence artificielle

PhD proposal description

Can Generative Artificial Intelligence (GAI) help us better design network protocols? That is the main question of this PhD thesis. As evident, Machine Learning (ML) and Artificial Intelligence (AI) can recommend the best composition of control mechanisms and build the most suitable network protocols for an application over a network topology and under specific network conditions [1, 2].

Network protocol is based on the composition of basic functional blocks and control mechanisms. A data transmission protocol is composed of the definition of a Protocol Data Unit (PDU) and the associated control mechanisms such as error control, data retransmission, flow control, congestion control, encryption, resource reservation or medium access control. A protocol stack is composed of a set of layered protocols designed for a specific network type or a specific application.

A case study is the design of new network protocols for 6G. The current 5G network architecture defined the concept of slicing as a virtual logical network overlaying a physical network infrastructure. Different slices are supposed to serve network traffic having different characteristics. However, network protocols used for carrying user data within a slice are always Transmission Control Protocol / Internet Protocol (TCP/IP) which is not always optimized for all traffic patterns. It is expected that ML/AI can select the best composition of existing protocols or even generate new protocols optimized for a given slice.

The first challenging task in the PhD thesis is to identify the features characterizing the applications, network topology and physical network conditions which allow ML/AI algorithms to make pertinent decisions. For example, a mobile broadband application such as video transmission can imply the use of a transport protocol without retransmission and large PDU size. On the contrary, IoT traffic implies small size PDU with potential data aggregation units integrated in intermediate nodes. A new transport protocol which is simpler than TCP but more complex than User Datagram Protocol (UDP) can also be generated and proposed by ML/AI algorithms.

The second challenge is to design a suitable ML/AI framework for network protocol design based on network functionality composition. ML/AI has been very well developed for image generation or text generation. A new character in a science fiction movie can be created by combining the eyes, nose, mouth, hair, etc. following some design criteria. Chat-GPT can generate pertinent text to answer

questions prompted by users. In this PhD thesis, it is expected that a ML/AI model can be found in the way that it fits into the area of networking. Network functionalities can be composed to build a network protocol. Protocols can be composed to build a protocol stack. Network entities with integrated protocol stack can be generated and composed to build a network architecture.

The main expected outcome of the PhD thesis is an ML/AI engine which is capable of reasoning and generating pertinent composition of elementary mechanisms for a network protocol design. The resulting protocol or protocol stack may be an existing one or a completely new one. There is no limitation on the context or the use case. The above-mentioned case study is only an example. The proposed method should be evaluated by simulation using a network simulator such as NS3 or OMNeT++. The connection between AI/ML engine and network simulator is possible [3]. A proof-of-concept based on Linux is not mandatory but definitely encouraged if time permits.

Candidate profile

We are seeking for candidates having the following profile:

- Highly motivated Master students in computer science or last year students in engineering schools
- Strong background in networking
- Good knowledge in applied ML/AI
- Excellent academic records
- Autonomy in research
- Good English writing and presentation skills

Interested candidates are invited to send the following documents to thimaitrang.nguyen@univ-paris13.fr before 15th May 2024.

- Cover letter
- CV
- Academic transcripts

References

[1] Jianping Pan, Lin Cai, Shen Yan and Xuemin Shen, "*Network for AI and AI for Network: Challenges and Opportunities for Learning-Oriented Networks*", IEEE Network, November 2021.

[2] Yudong Huang, Minrui Xu, Xinyuan Zhang, Dusit Niyato, Zehui Xiong, Shuo Wang and Tao Huang, "*AI-Generated Network Design: A Diffusion Model-based Learning Approach*", IEEE Network, October 2023.

[3] Hao Yin, Pengyu Liu, Keshu Liu, Liu Cao, Lytianyong Zhang, Yayu Gao and Xiaojun Hei, "*ns3-ai: Fostering Artificial Intelligence Algorithms for Networking Research*", Workshop on NS-3 (WNS3), Maryland, USA, June 2020.