# 张 晗 Han Zhang

副教授

清华大学 网络科学与网络空间研究院

中国 北京

zhhan@tsinghua.edu.cn • netsyscode.github.io/netsyslab • Google Scholar • github.com/netsyscode


## 研究概述

本人的研究面向 **AI / 网络基础设施**，构建**测量**、**资源调度**、**智能运维与安全防护**技术，覆盖互联网（BGP、RPKI、DNS、Web PKI）、运营商骨干网与城域网、**FITI / CERNET / CERNET2** 国家级试验设施以及智算中心。研究聚焦国家战略需求、注重产学研深度融合，分为三个方向，服务于同一个目标——让 *AI / 网络基础设施看得清、调得优、管得好、守得住*：

1. **AI / 网络基础设施测量**。以线速、零应用改造的方式让生产基础设施可观测：基于 eBPF 的零代码分布式追踪（SIGCOMM'23、SIGCOMM'25、ICSE'26）；SRv6 探测与时延瓶颈诊断（ICNP'25、ToN'26）；可编程交换机上的流测量（TPDS'22）；以及面向 Looking Glass 服务、AS 商业关系与域间路由的互联网级测量（WWW'26、ToN'25、ICNP'26）。
2. **AI / 网络基础设施资源调度**。把测量结果转化为高效、抗故障的带宽与算力调度：基于混合链路保护的可靠性路由（IPCCC'14、ICC'15、JCN'20），已应用于中国电信城域网；具备可用性保障的跨数据中心广域网流量工程（CoNEXT'21、ToN'22）；FITI 试验设施资源调度与试验服务；集中式网络效用最大化（ICNP'22、ToN'25）；路由代数（INFOCOM'25）；可编程交换机上的网内加速（INFOCOM'24、TPDS'22）；面向网络功能的 FaaS 平台（TPDS'23）；服务功能链部署与调度（TPDS'26）；以及面向企业云的即插即用网络管理（NSDI'27）。
3. **AI / 网络基础设施智能运维与安全防护**。在配置错误、故障与攻击扩散之前验证、诊断并阻断：运营商规模的配置验证（TIFS'24、CoNEXT'25、INFOCOM'26）；可编程交换机上的在线入侵检测，已在 ISP 生产环境运行（SIGCOMM'25、SIGCOMM'26）；可解释、能应对正常态漂移的异常检测（CCS'21、NDSS'23）；基于溯源图的 APT 检测与 Serverless 钱包耗尽攻击检测（TIFS'22、TIFS'25、CCS'22、ToN'26）；以及证书、Web PKI 与路由的互联网信任基础设施态势感知（WWW'25、CCS'26）。

## 学术计量

| 1,730 | 17 | 29 | 近 100 | 13 |
|---|---|---|---|---|
| 引用次数 | h 指数 | i10 指数 | 论文 | 在读学生 |

数据来源 Google Scholar，2026 年。已在 ACM SIGCOMM、USENIX NSDI、ACM CCS、NDSS、ACM CoNEXT、ACM WWW、ACM ICSE、IEEE INFOCOM、IEEE/ACM ToN、IEEE TIFS、IEEE TPDS 等国际顶级会议与期刊发表论文近百篇。

## 教育背景

2013.09 – 2018.07　**工学博士**，计算机科学与技术
清华大学，中国 北京　导师：尹霞教授

2009.09 – 2013.07　**工学学士**，计算机科学与技术
吉林大学，中国 长春

## 工作履历

现任　**副教授**、博士生导师
清华大学网络科学与网络空间研究院

曾任　**助理教授**
清华大学网络科学与网络空间研究院

## 主要奖励与荣誉

- **世界互联网大会领先科技奖**，2026。国际
- **Applied Networking Research Prize（ANRP）**，IRTF / Internet Society，2023。国际
- **中国通信学会科学技术奖一等奖**——《城域云网关键技术及规模应用》，2025。国家级学会
- **NSGA 杰出研究者奖（Best Researcher Award）**，2025。
- **ACM TURC SIGCSE 中国新星奖**，2023。
- **优秀服务奖（Excellent Service Award）**，IEEE/ACM ICA3PP 2023。

## 代表性论文

**加粗**为本人；* 表示通信作者。完整列表见下一节。

### AI / 网络基础设施测量

[1] Junxian Shen, **Han Zhang***, Yang Xiang, Xingang Shi, Xinrui Li, Yunxi Shen, Zijian Zhang, Sicheng Wang, Yanhui Yang, Yu Zhou, Mingwei Xu, Jilong Wang. "Network-Centric Distributed Tracing with DeepFlow: Troubleshooting Your Microservices in Zero Code." *ACM SIGCOMM 2023*, pp. 420–437.
↪ 以网络为中心的追踪平面与隐式上下文传播，完全无需修改应用代码。已开源并成为云原生可观测性的事实标准（CNCF Sandbox，4000+ stars，部署于数万台主机）。

[2] Yantao Geng, **Han Zhang***, Zhiheng Wu, Yahui Li, Jilong Wang, Xia Yin. "Low-Overhead Distributed Application Observation with DeepTrace: Achieving Accurate Tracing in Production Systems." *ACM SIGCOMM 2025*, pp. 1056–1069.
↪ 基于事务的无侵入追踪：利用请求内容中的 API 端点与事务字段将请求归入不同事务，避免误合并不同事务的追踪；高并发下准确率仍超过 95%，已被数十家企业用于生产环境。

[3] Yantao Geng, **Han Zhang***, Zhiheng Wu, Yahui Li, Jilong Wang, Xia Yin. "Non-Intrusive Distributed Tracing with Method-Level Delay Estimation for Microservices Troubleshooting." *ACM/IEEE ICSE 2026*, pp. 1661–1673.
↪ FlowScope 通过互相关分析估计请求间的方法级因果时延分布，并在多重约束下迭代重建追踪，追踪准确率相比 DeepFlow 与 TraceWeaver 提升 51%。

[4] Kaiyang Zhao, **Han Zhang***, Yao Tong, Yahui Li, Xingang Shi, Zhiliang Wang, Xia Yin, Jianping Wu. "SRmesh: Deterministic and Efficient Diagnosis of Latency Bottleneck Links in SRv6 Networks." *IEEE ICNP 2025*, pp. 1–12.
↪ 以确定性路径的 SR 探测、基于时延的多路径推断与渐进式诊断，定位 SRv6 网络中的时延瓶颈链路，探测开销最多降低 91.9%。

[5] Yunze Wei, Xingang Shi, **Han Zhang***, Tianyu Zhang, Yahui Li, Xia Yin. "GlassMiner: Mining Looking Glass Services via Structure-Semantics Fusion for Web Observability." *ACM WWW 2026*, pp. 7576–7587.
↪ 融合结构与语义特征并借助大模型分类，发现 3867 个 Looking Glass 网页和 7558 个此前未被公开列表收录的观测点（发现量为已有方法的 1.82 倍、挖掘效率为 3.43 倍），并据此分析两家大型 CDN 的路由绕行。

### AI / 网络基础设施资源调度

[6] Kaiyang Zhao, **Han Zhang***, Tianpeng Zhang, Yantu Tong, Zeji Xiao, Xuefeng Liu, Xia Yin, Jianping Wu. "Kuiper: Enterprise Cloud Plug-and-Play Network Management Platform." *USENIX NSDI 2027*.
↪ 面向企业云的统一智能运维控制面：在同一套遥测与验证基底上整合故障管理、安全事件响应与配置管理。

[7] **Han Zhang**, Xingang Shi*, Xia Yin, Jilong Wang, Zhiliang Wang, Yingya Guo, Tian Lan. "Boosting Bandwidth Availability over Inter-DC WAN." *ACM CoNEXT 2021*, pp. 297–312.
↪ 面向跨数据中心广域网的带宽可用性流量工程：在线准入控制比最优策略快 30×（误拒率低于 4%），相比 FFC 与 TEAVAR 多满足 23%–60% 的可用性需求。

[8] Yi Qiao, **Han Zhang***, Jilong Wang. "NetFEC: In-Network FEC Encoding Acceleration for Latency-Sensitive Multimedia Applications." *IEEE INFOCOM 2024*, pp. 2348–2357.
↪ 将时延敏感多媒体应用的 FEC 编码整体卸载到可编程交换芯片，以 ghost packet 机制兼容拥塞控制、发送节奏控制与统计功能；与 WebRTC 集成后消除服务器 CPU 负担，额外开销可忽略。

[9] Heng Yu, **Han Zhang***, Junxian Shen, Yantao Geng, et al. "Serpens: A High-Performance FaaS Platform for Network Functions." *IEEE Transactions on Parallel and Distributed Systems*, vol. 34, no. 8, pp. 2448–2463, 2023.
↪ 面向网络功能的高性能 FaaS 平台：可复用的 NF 运行时、本地状态访问与改进的服务链机制，相比在现有 FaaS 平台上运行的 NF 与服务链，吞吐提升 10 倍以上、时延降低 90% 以上。

[10] Ying Tian, Zhiliang Wang*, Xia Yin, Xingang Shi, Jiahai Yang, **Han Zhang***. "Centralized Network Utility Maximization with Accelerated Gradient Method." *IEEE Transactions on Networking*, 2025.
↪ 通过光滑的效用与惩罚函数，使 Nesterov 加速梯度法可用于集中式网络效用最大化，收敛速率达 $O(d/t^2)$，对流数量可扩展，并支持多路径上的带优先级流。

### AI / 网络基础设施智能运维与安全防护

[11] **Han Zhang**, Xuefeng Liu, Linqiang Qian, Guyue Liu, Tianyu Zhang, Kaiyang Zhao, Yantu Tong, Zeji Xiao, Dongbiao He, Yahui Li, Ke Ruan, Jilong Wang, Yongqing Zhu, Xia Yin. "Towards High-Performance Intrusion Detection with Robustness Guarantees on Programmable Switches at ISP Scale." *ACM SIGCOMM 2026*, pp. 1282–1298.
↪ 部署于可编程交换机的在线入侵检测系统，保护接入 ISP 的企业园区：双平面特征提取、仅用良性流量训练的单类模型与在线更新机制；已在生产环境运行三年以上，可在数分钟内以约 90% 的准确率检出恶意流量。

[12] **Han Zhang**, Guyue Liu*, Xingang Shi, Yahui Li, Jilong Wang, Yongqing Zhu, Ke Ruan, Jie Liang, Xia Yin. "Achieving High-Speed and Robust Encrypted Traffic Anomaly Detection with Programmable Switches." *ACM SIGCOMM 2025*, pp. 1254–1256.
↪ 双平面特征提取 + 轻量单类分类模型，化解深度学习精度与交换芯片资源约束之间的长期矛盾；已在生产环境运行两年，发现 10 余起重大攻击事件，为两家 ISP 保护超过 1000 万台服务器。

[13] Yunze Wei, Xingang Shi, Minghao Zhang, Zhaozhen Wang, Qiang Ma, **Han Zhang**, Yahui Li, Xia Yin. "Parade: Unified and Data-Driven Prefix-AS Semantics for BGP Anomaly Detection." *ACM CCS 2026*.
↪ 统一的数据驱动前缀—AS 语义模型，把碎片化的 BGP 观测转化为可用于异常检测的一致性基准事实。

[14] Junxian Shen, **Han Zhang***, Yantao Geng, Jiawei Li, Jilong Wang, Mingwei Xu. "Gringotts: Fast and Accurate Internal Denial-of-Wallet Detection for Serverless Computing." *ACM CCS 2022*, pp. 2627–2641.
↪ 在商用 Serverless 平台上实测内部钱包耗尽（DoW）攻击，并以指标采集代理结合马氏距离异常分析进行检测：性能开销低于 1.1%，平均检测时延 1.86 秒，准确率超过 95.75%。

[15] Dongqi Han, Zhiliang Wang*, Wenqi Chen, Ying Zhong, Su Wang, **Han Zhang**, Jiahai Yang, Xingang Shi, Xia Yin. "DeepAID: Interpreting and Improving Deep Learning-based Anomaly Detection in Security Applications." *ACM CCS 2021*, pp. 3197–3217.
↪ 面向安全领域无监督深度异常检测模型的解释框架，使运维人员能够诊断模型误判并显著降低误报率。

[16] Dongqi Han, Zhiliang Wang*, Wenqi Chen, Kai Wang, Rui Yu, Su Wang, **Han Zhang**, et al. "Anomaly Detection in the Open World: Normality Shift Detection, Explanation, and Adaptation." *NDSS 2023*.
↪ 针对零正样本异常检测中的正常态漂移（仅用良性数据训练的模型在正常行为变化时受影响最大），实现漂移的检测、解释与自适应。

[17] Tianyu Zhang, **Han Zhang***, Yunze Wei, Yahui Li, Xingang Shi, Jilong Wang, Xia Yin. "ACME++: A Secure Authorization Mechanism for ACME Clients in the Web PKI Ecosystem." *ACM WWW 2025*, pp. 1058–1067.
↪ 披露 *ACME Authz* 缓存攻击——攻击者无需控制域名即可获取欺诈证书（在 Let's Encrypt 上实证），

并提出开销可忽略的账户绑定缓解机制。

[18] XinZhe Liu, Yahui Li*, **Han Zhang**, Xia Yin, Xingang Shi, Zhiliang Wang, Gang Ren, Jilong Wang, Jiangyuan Yao. "Scalable and Interpretable Overlay Network Checking via Ensemble Verification." *ACM CoNEXT 2025*.
↪ 首个面向 overlay/underlay 网络的控制平面验证器；部署于全国性 FITI 试验设施，发现 22 处配置错误，相比 Batfish+ 最高提速 102×。

[19] Yahui Li, **Han Zhang***, Jilong Wang, Xingang Shi, Xia Yin, Zhiliang Wang, Jiankun Hu, Congcong Miao, Jianping Wu. "Proactively Verifying Quantitative Network Policy across Unsafe and Unreliable Environments." *IEEE Transactions on Information Forensics and Security*, vol. 19, pp. 10099–10113, 2024.
↪ 定量网络验证（QNV）不仅检查可达性等布尔策略，还能检查链路过载等定量策略，并覆盖故障场景；借助收敛转发的符号化模型，大规模网络也能在数分钟内完成验证。

## 论文列表（按年份）

**加粗**为本人；* 表示通信作者。

### 2027

[1] Kaiyang Zhao, **Han Zhang***, Tianpeng Zhang, Yantu Tong, Zeji Xiao, Xuefeng Liu, Xia Yin, Jianping Wu. "Kuiper: Enterprise Cloud Plug-and-Play Network Management Platform." *USENIX NSDI 2027*. （待刊）

### 2026

[1] **Han Zhang**, Xuefeng Liu, Linqiang Qian, Guyue Liu, Tianyu Zhang, Kaiyang Zhao, Yantu Tong, Zeji Xiao, Dongbiao He, Yahui Li, Ke Ruan, Jilong Wang, Yongqing Zhu, Xia Yin. "Towards High-Performance Intrusion Detection with Robustness Guarantees on Programmable Switches at ISP Scale." *ACM SIGCOMM 2026*, pp. 1282–1298.

[2] Yunze Wei, Xingang Shi, Minghao Zhang, Zhaozhen Wang, Qiang Ma, **Han Zhang**, Yahui Li, Xia Yin. "Parade: Unified and Data-Driven Prefix-AS Semantics for BGP Anomaly Detection." *ACM CCS 2026*. （待刊）

[3] Yunze Wei, Xingang Shi, **Han Zhang***, Tianyu Zhang, Yahui Li, Xia Yin. "GlassMiner: Mining Looking Glass Services via Structure-Semantics Fusion for Web Observability." *ACM WWW 2026*, pp. 7576–7587.

[4] Yantao Geng, **Han Zhang***, Zhiheng Wu, Yahui Li, Jilong Wang, Xia Yin. "Non-Intrusive Distributed Tracing with Method-Level Delay Estimation for Microservices Troubleshooting." *ACM/IEEE ICSE 2026*, pp. 1661–1673.

[5] Junxian Shen, **Han Zhang***, Wenxue Lin, Yantao Geng, Jiawei Li, Jilong Wang, Mingwei Xu. "Clover: Workload Verification for Real-Time Detection of Contention-Induced Slowdowns in Serverless Platforms." *IEEE/ACM Transactions on Networking*, vol. 34, pp. 4700–4715, 2026.

[6] Kaiyang Zhao, **Han Zhang***, Yao Tong, Yahui Li, Xingang Shi, Zhiliang Wang, Xia Yin, Jianping Wu. "Efficient Slice-Parallel Distributed Probing in SRv6 Networks." *IEEE/ACM Transactions on Networking*, vol. 34, pp. 5588–5600, 2026.

[7] XinZhe Liu, Yahui Li, **Han Zhang**, Renrui Tian, Xia Yin, Xingang Shi, Zhiliang Wang, Gang Ren, Jilong Wang, Jiangyuan Yao. "Comprehensive Network Configuration Verification via Effective Environment Reduction." *IEEE INFOCOM 2026*, pp. 1–10.

[8] Letong Sun, Xingang Shi, Fengyan Han, Liyuan Chang, Xia Yin, Zhiliang Wang, **Han Zhang**. "A Comparative Approach for Studying Control-Plane and Data-Plane Mismatch in Interdomain Routing." *IEEE ICNP 2026*. （待刊）

[9] Letong Sun, Xingang Shi, Fengyan Han, Xia Yin, Zhiliang Wang, **Han Zhang**. "The Anatomy of ROV Rollout: A Sub-AS and Longitudinal Perspective." *IEEE ICNP 2026*. （待刊）

[10] Weihan Chen, Zhiliang Wang, **Han Zhang**, Xia Yin, Xingang Shi. "Delay-Aware Service Function Chain Embedding and Scheduling in Edge Clouds." *IEEE Transactions on Parallel and Distributed Systems*, vol. 37, no. 11, pp. 2539–2553, 2026.

[11] Shuhuan Wang, Zhiyu Wang, Hao Sun, Zhi Jiang, Xia Yin, Dongbin Han, **Han Zhang**, Xingang Shi, Jiahai Yang. "The Evolution of Provenance-Based Intrusion Detection Systems: A Review of Approaches, Limitations, and Future Directions." *IEEE Network*, 2026.

[12] 李秋香, **张晗***, 曲豫宾, 吴建平. "MASTER：基于知识注入与意图强化的大语言模型漏洞验证代码生成框架." 电子学报, vol. 54, no. 4, pp. 1802–1822, 2026.

### 2025

[1] Tianyu Zhang, **Han Zhang***, Yunze Wei, Yahui Li, Xingang Shi, Jilong Wang, Xia Yin. "ACME++: A Secure Authorization Mechanism for ACME Clients in the Web PKI Ecosystem." *ACM WWW 2025*, pp. 1058–1067.

[2] Yantao Geng, **Han Zhang***, Zhiheng Wu, Yahui Li, Jilong Wang, Xia Yin. "Low-Overhead Distributed Application Observation with DeepTrace: Achieving Accurate Tracing in Production Systems." *ACM SIGCOMM 2025*, pp. 1056–1069.

[3] **Han Zhang**, Guyue Liu*, Xingang Shi, Yahui Li, Jilong Wang, Yongqing Zhu, Ke Ruan, Jie Liang, Xia Yin. "Achieving High-Speed and Robust Encrypted Traffic Anomaly Detection with Programmable Switches." *ACM SIGCOMM 2025*, pp. 1254–1256.

[4] XinZhe Liu, Yahui Li*, **Han Zhang**, Xia Yin, Xingang Shi, Zhiliang Wang, Gang Ren, Jilong Wang, Jiangyuan Yao. "Scalable and Interpretable Overlay Network Checking via Ensemble Verification." *ACM CoNEXT 2025*.

[5] Renrui Tian, Yahui Li*, **Han Zhang**, XinZhe Liu, Xia Yin, Xingang Shi, Zhiliang Wang, Jilong Wang. "Poster: ERIS — Evaluating ROV via ICMPv6 Rate Limiting Side Channels." *ACM CCS 2025*.

[6] Kaiyang Zhao, **Han Zhang***, Yao Tong, Yahui Li, Xingang Shi, Zhiliang Wang, Xia Yin, Jianping Wu. "SRmesh: Deterministic and Efficient Diagnosis of Latency Bottleneck Links in SRv6 Networks." *IEEE ICNP 2025*, pp. 1–12.

[7] Zhaozhen Wang, Xingang Shi*, Haijun Geng, **Han Zhang**, Xia Yin, Zhiliang Wang. "On Non-Commutative Routing." *IEEE INFOCOM 2025*, pp. 1–10.

[8] Zhiyun Tang, Yahui Li, Xingang Shi, Jilong Wang, Yongqing Zhu, Ke Ruan, Xia Yin, **Han Zhang***. "Probabilistic Analysis of Overload-Free Property for Critical Traffic." *IEEE/ACM IWQoS 2025*, pp. 1–6.

[9] Su Wang, Hongbin Sun, Zhiliang Wang, Tao Zhou, Xia Yin, Dongqi Han, **Han Zhang**, Xingang Shi, Jiahai Yang. "End-to-End Attack Scene Reconstruction in a Host with Rules and Anomaly-Based Detection Models." *IEEE Transactions on Information Forensics and Security*, 2025.

[10] Ying Tian, Zhiliang Wang*, Xia Yin, Xingang Shi, Jiahai Yang, **Han Zhang***. "Centralized Network Utility Maximization with Accelerated Gradient Method." *IEEE Transactions on Networking*, 2025.

[11] Xingang Shi, Zitong Jin*, Bin Xiong, Xinyao Huang, Xiaotian Xi, Dan Li, **Han Zhang**, Zhiliang Wang, Xia Yin. "HELA: Inferring AS Relationships with a Hybrid of Empirical and Learning Algorithms." *IEEE Transactions on Networking*, 2025.

[12] Weiting Zhang, Jiadong Ren, Tao Zheng, Ruibin Guo, **Han Zhang**, Shiwen Mao, Hongke Zhang*. "GenNet: Computing-Efficient Generative AI for Deterministic Transmission Scheduling in 6G Networks." *IEEE Communications Magazine*, vol. 63, no. 8, pp. 48–55, 2025.

[13] Yanxu Fu, Pei Zhang*, **Han Zhang**, Xiaohong Huang, Kun Xie, Dandan Li. "BGPFlow: Flow-Based Feature Extraction for BGP Anomaly Detection." *ACM SIGCOMM NGNO Workshop 2025*, pp. 13–20.

### 2024

[1] Yi Qiao, **Han Zhang***, Jilong Wang. "NetFEC: In-Network FEC Encoding Acceleration for Latency-Sensitive Multimedia Applications." *IEEE INFOCOM 2024*, pp. 2348–2357.

[2] Yahui Li, **Han Zhang***, Jilong Wang, Xingang Shi, Xia Yin, Zhiliang Wang, Jiankun Hu, Congcong Miao, Jianping Wu. "Proactively Verifying Quantitative Network Policy across Unsafe and Unreliable Environments." *IEEE Transactions on Information Forensics and Security*, vol. 19, pp. 10099–10113, 2024.

[3] XinZhe Liu, Yahui Li*, **Han Zhang**, Xia Yin, Xingang Shi, Zhiliang Wang, Gang Ren, Jiangyuan Yao. "Poster: Scalable and Interpretable Multilayer Overlay Network Checking via Ensemble Verification." *ACM SIGCOMM 2024 Posters & Demos*.

[4] Weihan Chen, Zhiliang Wang*, **Han Zhang**, Xia Yin, Xingang Shi. "Cost-Efficient Flow Migration for SFC Dynamical Scheduling in Geo-Distributed Clouds." *Computer Networks*, vol. 249, 2024.

[5] Jun He, Yahui Li*, **Han Zhang***, Changqing An, Jilong Wang. "ROV-GD: Improving the Measurement of ROV Deployment Using Graph Difference." *IEEE ISCC 2024*, pp. 1–7.

[6] Kunling He, Fenghua Li, Jessie Hui Wang, **Han Zhang**, Yiren Zhao. "AB-TCAD: An Access Behavior-Based Two-Stage Compromised Account Detection Framework." *IFIP Networking 2024*, pp. 104–112.

### 2023

[1] Junxian Shen, **Han Zhang***, Yang Xiang, Xingang Shi, Xinrui Li, Yunxi Shen, Zijian Zhang, et al. "Network-Centric Distributed Tracing with DeepFlow: Troubleshooting Your Microservices in Zero Code." *ACM SIGCOMM 2023*, pp. 420–437.

[2] Dongqi Han, Zhiliang Wang*, Wenqi Chen, Kai Wang, Rui Yu, Su Wang, **Han Zhang**, et al. "Anomaly Detection in the Open World: Normality Shift Detection, Explanation, and Adaptation." *NDSS 2023*.

[3] Heng Yu, **Han Zhang***, Junxian Shen, Yantao Geng, et al. "Serpens: A High-Performance FaaS Platform for Network Functions." *IEEE Transactions on Parallel and Distributed Systems*, vol. 34, no. 8, pp. 2448–2463, 2023.

[4] Yahui Li, **Han Zhang***, Jilong Wang, Xia Yin, Xingang Shi, Jianping Wu. "A General Approach to Generate Test Packets with Network Configurations." *IEEE Transactions on Parallel and Distributed Systems*, vol. 34, no. 4, pp. 1362–1375, 2023.

[5] Pei Zhang, Fangzhou He, **Han Zhang***, Jiankun Hu, et al. "Real-Time Malicious Traffic Detection with Online Isolation Forest over SD-WAN." *IEEE Transactions on Information Forensics and Security*, vol. 18, pp. 2076–2090, 2023.

[6] Tianbo Wang, Huacheng Li, Chunhe Xia*, **Han Zhang**, Pei Zhang. "From the Dialectical Perspective: Modeling and Exploiting of Hybrid Worm Propagation." *IEEE Transactions on Information Forensics and Security*, vol. 18, pp. 1610–1624, 2023.

[7] Yantao Geng, **Han Zhang***, Jilong Wang. "Delay-Based Congestion Control for Cross-Datacenter Networks." *IEEE/ACM IWQoS 2023*.

[8] Jiawei Li, **Han Zhang***, Jilong Wang. "PUVAR: Minimize Idle Resource SLO Violations by Uncertainty-Aware Scheduling in Cloud Platforms." *IEEE ICWS 2023*.

[9] Ming Wang, Yahui Li, **Han Zhang**, Anlun Hong, Jun He, Jilong Wang. "Knocking Cells: Latency-Based Identification of IPv6 Cellular Addresses on the Internet." *IEEE ISCC 2023*.

[10] Allen Hong, Yahui Li*, **Han Zhang***, Ming Wang, Changqing An, Jilong Wang. "A Cheap and Accurate Delay-Based IP Geolocation Method Using Machine Learning and Looking Glass." *IFIP Networking 2023*.

[11] Jun He, Yahui Li*, **Han Zhang***, Ming Wang, Changqing An, Jilong Wang. "Be Careful of Your Neighbors: Injected Sub-Prefix Hijacking Invisible to Public Monitors." *IEEE ICC 2023*.

[12] Shuanghong Yu, Fenghua Li*, **Han Zhang**, Kunling He, Xingkun Yao. "GapReplay: A High-Accuracy Packet Replayer." *IEEE ICC 2023*.

### 2022

[1] Junxian Shen, **Han Zhang***, Yantao Geng, Jiawei Li, Jilong Wang, Mingwei Xu. "Gringotts: Fast and Accurate Internal Denial-of-Wallet Detection for Serverless Computing." *ACM CCS 2022*, pp. 2627–2641.

[2] **Han Zhang**, Xia Yin, Xingang Shi*, Jilong Wang, Zhiliang Wang, Yingya Guo, Tian Lan, Yahui Li, Yongqing Zhu, Ke Ruan, Haijun Geng. "Achieving High Availability in Inter-DC WAN Traffic Engineering." *IEEE/ACM Transactions on Networking*, 2022.

[3] Su Wang, Zhiliang Wang*, Tao Zhou, Hongbin Sun, Xia Yin, Dongqi Han, **Han Zhang**, et al. "THREATRACE: Detecting and Tracing Host-Based Threats in Node Level through Provenance Graph Learning." *IEEE Transactions on Information Forensics and Security*, vol. 17, pp. 3972–3987, 2022.

[4] Yi Qiao, Menghao Zhang, Yu Zhou, Xiao Kong, **Han Zhang***, et al. "NetEC: Accelerating Erasure Coding Reconstruction with In-Network Aggregation." *IEEE Transactions on Parallel and Distributed Systems*, vol. 33, no. 10, pp. 2571–2583, 2022.

[5] Zongyi Zhao, Xingang Shi*, Zhiliang Wang, Qi Li, **Han Zhang**, Xia Yin. "Efficient and Accurate Flow Record Collection with HashFlow." *IEEE Transactions on Parallel and Distributed Systems*, vol. 33, no. 5, pp. 1069–1083, 2022.

[6] Ying Tian, Zhiliang Wang*, Xia Yin, Xingang Shi, Jiahai Yang, **Han Zhang**. "Centralized Network Utility Maximization with Accelerated Gradient Method." *IEEE ICNP 2022*.

[7] Heng Yu, Junxian Shen, **Han Zhang***, Jilong Wang, Congcong Miao, Mingwei Xu. "Scorpius: Proactive Code Preparation to Accelerate Function Startup." *IEEE/ACM IWQoS 2022*.

[8] Shangbin Han, Qianhong Wu, **Han Zhang***, Bo Qin. "Light-Weight Unsupervised Anomaly Detection for Encrypted Malware Traffic." *IEEE DSC 2022*.

[9] Shangbin Han, Qianhong Wu, **Han Zhang**, Bo Qin, Jiangyuan Yao, Willy Susilo. "Autoperman: Automatic Network Traffic Anomaly Detection with Ensemble Learning." *ICAIS 2022*.

[10] Yongkang Chen, Ming Zhang*, Jin Li, Xiaohui Kuang, Xurong Zhang, **Han Zhang**. "Dynamic and Diverse Transformations for Defending against Adversarial Examples." *IEEE TrustCom 2022*.

### 2021

[1] **Han Zhang**, Xingang Shi*, Xia Yin, Jilong Wang, Zhiliang Wang, Yingya Guo, Tian Lan. "Boosting Bandwidth Availability over Inter-DC WAN." *ACM CoNEXT 2021*, pp. 297–312.

[2] Dongqi Han, Zhiliang Wang*, Wenqi Chen, Ying Zhong, Su Wang, **Han Zhang**, Jiahai Yang, Xingang Shi, Xia Yin. "DeepAID: Interpreting and Improving Deep Learning-Based Anomaly Detection in Security Applications." *ACM CCS 2021*, pp. 3197–3217.

[3] Shangbin Han, Qianhong Wu, **Han Zhang***, Bo Qin, Jiankun Hu, et al. "Log-Based Anomaly Detection with Robust Feature Extraction and Online Learning." *IEEE Transactions on Information Forensics and Security*, vol. 16, pp. 2300–2311, 2021.

[4] Yingya Guo, Weipeng Wang, **Han Zhang**, Wenzhong Guo, Zhiliang Wang, Ying Tian, et al. "Traffic Engineering in Hybrid Software-Defined Network via Reinforcement Learning." *Journal of Network and Computer Applications*, vol. 189, 2021.

[5] Weihan Chen, Zhiliang Wang*, **Han Zhang**, Xia Yin, Xingang Shi. "Cost-Efficient Dynamic Service Function Chain Embedding in Edge Clouds." *IEEE CNSM 2021*.

[6] Ying Tian, Zhiliang Wang*, Xia Yin, Xingang Shi, Jiahai Yang, **Han Zhang**, Yingya Guo, et al. "Traffic Engineering with Segment Routing Considering Probabilistic Failures." *IEEE CNSM 2021*.

[7] Haijun Geng, **Han Zhang***, Yangyang Zhang. "Efficient Routing Protection Algorithm in Large-Scale Networks." *Computers, Materials & Continua*, vol. 66, no. 2, pp. 1733–1744, 2021.

### 2020

[1] Yahui Li, Zhiliang Wang*, Xia Yin, Xingang Shi, Jianping Wu, Fangdan Ye, Jiangyuan Yao, **Han Zhang**. "Assisting Reachability Verification of Network Configurations Updates with NUV." *Computer Networks*, vol. 177, 2020.

[2] Haijun Geng, **Han Zhang**, Xingang Shi*, Zhiliang Wang, Xia Yin. "Efficient Computation of Loop-Free Alternates." *Journal of Network and Computer Applications*, vol. 151, 2020.

[3] Haijun Geng, **Han Zhang**, Xingang Shi*, et al. "A Hybrid Link Protection Scheme for Ensuring Network Service Availability in Link-State Routing Networks." *Journal of Communications and Networks*, vol. 22, no. 1, pp. 46–60, 2020.

[4] Weihan Chen, Zhiliang Wang, **Han Zhang**, Xia Yin, Xingang Shi, Lei Sun. "Joint Optimization of Service Function Chain Elastic Scaling and Routing." *IEEE INFOCOM Workshops 2020*.

### 2019

[1] **Han Zhang**, Haijun Geng, Yahui Li, et al. "DA&FD: Deadline-Aware and Flow Duration-Based Rate Control for Mixed Flows in DCNs." *IEEE/ACM Transactions on Networking*, vol. 27, no. 6, pp. 2458–2471, 2019.

[2] Zhiliang Wang, **Han Zhang***, Xingang Shi, et al. "Efficient Scheduling of Weighted Coflows in Data Centers." *IEEE Transactions on Parallel and Distributed Systems*, vol. 30, no. 9, pp. 2003–2017, 2019.

[3] Yahui Li, Xia Yin, Zhiliang Wang*, Jiangyuan Yao, Xingang Shi, Jianping Wu, **Han Zhang**, et al. "A Survey on Network Verification and Testing with Formal Methods: Approaches and Challenges." *IEEE Communications Surveys & Tutorials*, vol. 21, no. 1, pp. 940–969, 2019.

[4] Yahui Li, Zhiliang Wang*, Jiangyuan Yao, Xia Yin, Xingang Shi, Jianping Wu, **Han Zhang**. "MSAID: Automated Detection of Interference in Multiple SDN Applications." *Computer Networks*, vol. 153, 2019.

[5] Yingya Guo, Zhiliang Wang*, **Han Zhang**, Xia Yin, Xingang Shi, Jianping Wu. "Joint Optimization of Tasks Placement and Routing to Minimize Coflow Completion Time." *Journal of Network and Computer Applications*, vol. 135, 2019.

### 2018 年及以前

[1] Xiao Ma, Chuang Lin, **Han Zhang***, Jianwei Liu. "Energy-Aware Computation Offloading of IoT Sensors in Cloudlet-Based Mobile Edge Computing." *Sensors*, 2018.

[2] Zhifeng Liu, Xia Yin, Zhiliang Wang, Xingang Shi, Yiqiang Hua, Xiaohong Huang, Liang Wei, Jiangyuan Yao, **Han Zhang**, et al. "Design and Construction of Hierarchical and Cross-Regional SDN Verification and Demonstration System." *Telecommunications Science*, 2018.

[3] **Han Zhang**, Xingang Shi*, Xia Yin, Zhiliang Wang. "Yosemite: Efficient Scheduling of Weighted Coflows in Data Centers." *IEEE ICNP 2017*.

[4] **Han Zhang**, Xingang Shi*, Yingya Guo, Zhiliang Wang, Xia Yin. "More Load, More Differentiation — Let More Flows Finish before Deadline in Data Center Networks." *Computer Networks*, vol. 127, 2017.

[5] **Han Zhang**, Xingang Shi, Yingya Guo, Haijun Geng, Zhiliang Wang, Xia Yin. "Joint Source Selection and Transfer Optimization for Erasure Coding Storage System." *IEEE IPCCC 2017*.

[6] **Han Zhang**, Xingang Shi, Xia Yin, Zhiliang Wang, Yingya Guo. "FDRC: Flow Duration Time

Based Rate Control in Data Center Networks." *IEEE/ACM IWQoS 2016*.

[7] M. Gharaibeh, **Han Zhang**, C. Papadopoulos, J. Heidemann. "Assessing Co-Locality of IP Blocks." *IEEE INFOCOM Workshops 2016*.

[8] Zongyi Zhao, Qi Li, Mingwei Xu, Xingang Shi, **Han Zhang**. "Reduce Completion Time and Guarantee Throughput by Transport with Slight Congestion." *IEEE ICC 2016*.

[9] **Han Zhang**, Xingang Shi, Xia Yin, Fengyuan Ren, Zhiliang Wang. "More Load, More Differentiation — A Design Principle for Deadline-Aware Congestion Control." *IEEE INFOCOM 2015*.

[10] Haijun Geng, Xingang Shi, Xia Yin, Zhiliang Wang, **Han Zhang**. "Algebra and Algorithms for Efficient and Correct Multipath QoS Routing in Link State Networks." *IEEE/ACM IWQoS 2015*.

[11] Haijun Geng, Xingang Shi, Xia Yin, Zhiliang Wang, **Han Zhang**. "An Efficient Link Protection Scheme for Link-State Routing Networks." *IEEE ICC 2015*.

[12] Yingya Guo, Zhiliang Wang, Xia Yin, Xingang Shi, Jianping Wu, **Han Zhang**. "Incremental Deployment for Traffic Engineering in Hybrid SDN Network." *IEEE IPCCC 2015*.

[13] **Han Zhang**, C. Papadopoulos. "BotTalker: Generating Encrypted, Customizable C&C Traces." *IEEE HST 2015*.

[14] Haijun Geng, Xingang Shi, Xia Yin, Zhiliang Wang, **Han Zhang**, Jiangyuan Yao. "A Hybrid Link Protection Scheme for Link-State Routing Networks." *IEEE IPCCC 2014*.

[15] Haijun Geng, Xingang Shi, Xia Yin, Zhiliang Wang, **Han Zhang**, Jiangyuan Yao. "Let More Nodes Have a Second Choice." *IEEE IPCCC 2014*.

## 科研项目

- **国家自然科学基金面上项目**（No. 62572269）——基于网络行为分析的分布式微服务架构应用异常检测技术研究。**项目负责人**。
- **国家自然科学基金青年项目**（No. 62002009）——面向批量传输的数据中心广域网资源分配研究。**项目负责人**。
- **国家自然科学基金重大项目**（No. 62394322）——智算融合网络组网与路由关键技术研究。**子课题负责人**。
- **国家自然科学基金重点项目**（No. 61932011）——基于区块链的物联网安全技术研究。**子课题负责人**。
- **工信部重点研发项目**（No. TC220A04A-78）——高精度北斗车规级定位芯片及终端定位系统。**项目负责人**。
- **科技部国家重点研发计划**（No. 2018YFB1800400）——大规模安全可信寻址路由关键技术。参与。
- **企业合作项目**（均为**项目负责人**）：中国电信——大规模广域网感知与优化技术研究；腾讯科技——大规模微服务系统可观测性技术；深信服——应用行为感知的广域网传输优化技术；绿盟科技——安全试验设施关键技术研究。

## 生产系统与开源成果

- **DeepFlow**——面向云原生与 AI 基础设施的零代码 eBPF 可观测性平台（Kubernetes、服务网格、Serverless 平台、LLM / AI 智能体流水线）。**CNCF Sandbox 项目**；GitHub 4000+ stars、450+ forks；部署于数万台主机。SIGCOMM'23
- **DeepTrace**——面向智算中心与大规模微服务的无侵入分布式应用追踪与故障监控；高并发下准确率超过 95%，已被数十家企业用于生产环境。170+ stars。SIGCOMM'25、ICSE'26
- **SRmesh 探测工具包**——切片并行 SRv6 探测，以 $O(1)$ 轮次获得全网状时延图；在国家级 FITI 试验设施上验证。ICNP'25、ToN'26
- **IScan**——持续的互联网主动 / 被动探测（IP 空间、BGP/RPKI 路由、CT 日志与 Web-PKI），汇聚为可查询的互联网知识库。WWW'25、WWW'26

- **Kuiper / 智算中心智能运维**——整合故障管理、安全事件响应、配置管理与网络验证的全栈 AIOps 平台；在生产 GPU 集群环境中将 MTTR 降低 5×。NSDI'27、ICNP'25、ToN'26
- **SiteGuard / 智算中心出入口防护**——智算中心出入口流量监测与机器学习威胁检测，可运行于可编程交换机（P4/Tofino）、DPU、SmartNIC 与 eBPF，达到 Tbps 量级线速。SIGCOMM'25、SIGCOMM'26
- **NetVerify 套件**——面向配置、覆盖网与定量策略的静态验证与仿真工具族，已应用于 FITI 与 CERNET。TIFS'24、CoNEXT'25、INFOCOM'26
- **公开数据集**——GlassMiner Looking-Glass 语料（WWW'26）；带标注的加密流量 IDS 基准数据集（SIGCOMM'25/'26、CCS'21、NDSS'23）。

## 成果转化与国家级影响

- **中国电信城域网与骨干网**——混合链路保护技术应用于城域网，5 年降低建设成本超 40%，服务 1.2 亿用户（2025 年中国通信学会科学技术奖一等奖、2026 年世界互联网大会领先科技奖）；线速加密流量异常检测；大规模广域网感知与优化。
- **未来互联网试验设施（FITI）**——资源调度与试验服务系统保障设施稳定运行 3 年（全国 40 个节点、100 余项大型试验）；配置与覆盖网验证；可编程交换机入侵检测与 SRv6 诊断。相关技术应用于华为等 32 家企业及腾讯。
- **证书系统态势感知平台**——国内首个，应用于电信、银行等行业，检测全部央企及 2000 余家政府和关键事业单位，发现证书部署威胁上百个。
- **CERNET / CERNET2**——基于 DeepFlow 的可观测性与路由异常分析，覆盖中国教育和科研计算机网。
- **腾讯云**——大规模微服务系统可观测性；跨数据中心广域网流量工程联合设计。
- **深信服**——面向企业 SD-WAN 产品的应用感知广域网传输优化。
- **绿盟科技**——安全试验设施与大规模流量分析关键技术。
- 相关技术累计服务于电信运营商、国防军队、教育网与公有云，**惠及数亿终端用户**。

## 发明专利

形成两个专利组合——**网络测量与安全**（27 项）与**网络智能**（19 项），其中绝大多数为第一发明人。代表性专利：

- 基于可编程交换机的高速加密流量双平面特征提取技术。
- 基于频域增强与单类自适应学习的加密流量异常检测技术。
- 基于内核态与用户态双路径协议特征解析的分布式请求追踪方法。
- 基于本地异常感知的元数据驱动型分布式请求追踪方法。
- 面向 SD-WAN 的基于 AE-DQN 的双阶段自适应异常流量检测系统。
- 深度学习恶意流量检测的预训练数据源审计方法。
- 基于 ACME 协议的安全验证方法、系统及相关装置。
- 面向跨域分段路由的可信验证方法技术。
- 基于带内网络遥测的 OSPF 路由异常检测方法技术。
- 一种面向网络快速重路由的完美路由树构建方法。
- 互联网测量服务挖掘方法；互联网路由器地理定位方法。
- 服务等级目标违规诊断方法、装置、设备及介质。

## 学术服务

- **程序委员会共同主席**——ACM SIGCOMM NGNO Workshop 2025。
- **差旅资助共同主席**——ACM APNet 2025。
- **程序委员会委员**——USENIX NSDI 2027（Spring）；USENIX Security 2027；IEEE INFOCOM 2023、2024、2025、2027；ACM CoNEXT 2025、2026；IEEE ICNP 2024、2025。

- **期刊编委**——《通信技术》。**客座编辑**——MDPI *Electronics*；*IEEE Journal on Selected Areas in Communications*（JSAC）。
- **期刊审稿人**——IEEE/ACM Transactions on Networking；IEEE Transactions on Parallel and Distributed Systems；IEEE Transactions on Information Forensics and Security。

## 教学工作

| | |
|---|---|
| 2023、2024 秋季学期 | **互联网工程**——本科生课程，32 学时。涵盖路由、流量工程、可观测性与互联网测量，含实验环节。 |
| 2022–2024 秋季学期 | **网络优化理论与方法**——研究生课程，32 学时。 |
| 2022–2025 春季学期 | **网络异常检测**——研究生课程，32 学时。 |

## 指导学生

### 在读（13 人）

| | | |
|---|---|---|
| 赵铠阳 | 博士 · 五年级 | SRv6 探测（ICNP'25、ToN'26）；与尹霞教授、吴建平院士联合指导 |
| 耿彦涛 | 博士 · 四年级 | DeepTrace 负责人（SIGCOMM'25、ICSE'26） |
| 高杨宸严 | 博士 · 四年级 | 与赵有健教授联合指导 |
| 刘雪枫 | 博士 · 三年级 | 网络验证 |
| 肖泽基 | 博士 · 三年级 | 与王继龙教授联合指导 |
| Boyang Wang | 博士 · 二年级 | 与尹霞教授联合指导 |
| 童彦图 | 博士 · 一年级 | SRv6 / 网络测量 |
| 李 卓 | 硕士 · 三年级 | 加密流量入侵检测 |
| Hanyang Lin | 硕士 · 二年级 | eBPF 可观测性 |
| 武志衡 | 硕士 · 二年级 | 分布式追踪 |
| 钱林强 | 硕士 · 一年级 | 可编程数据平面 |
| 佟 瑶 | 硕士 · 一年级 | 与尹霞教授联合指导 |
| 彭可心 | 硕士 · 一年级 | 与赵有健教授联合指导 |

### 已毕业（6 人）

| | | |
|---|---|---|
| 沈俊贤 | 博士 | 华南理工大学助理教授 （SIGCOMM'23、'25；ToN'26） |
| Heng Yu | 博士 | 中关村实验室 （TPDS'23） |
| Yi Qiao | 博士 | 中国航天科技集团 （INFOCOM'24；TPDS'22） |
| Shangbin Han | 博士 | 泉城实验室 （TIFS'21） |
| 汤之揾 | 硕士 | 华为技术有限公司 |
| 李嘉睿 | 硕士 | 阿里云 |

正在招收 2027 年秋季入学的博士 / 硕士研究生，具备系统编程经验者尤佳。