Large Language Models and Networking: What are the Challenges and Opportunities?

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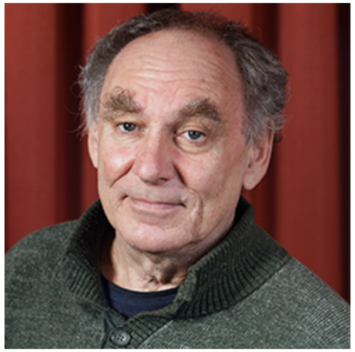

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Large Language Models and Networking: What are the Challenges and Opportunities

ThirdAI

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20th Sept,

GenAI/LLMs has our full Attention!

Generated by ChatGPT

- LLMs and ChatGPT are powerful AI technologies that can help enterprises streamline and automate a wide range of tasks, from customer service and support to content creation and marketing.

- They represent a powerful new tool for enterprises looking to stay ahead of the curve in an increasingly competitive and data-driven business landscape.

Early use case for almost all enterprises:

- ChatGPT Assistants on their “domain” text/data with Ownership of the process
- **In Future**: Customized to Fine-grained (or individual) level.

Many Challenges for Enterprises

- Manage Expectations Well

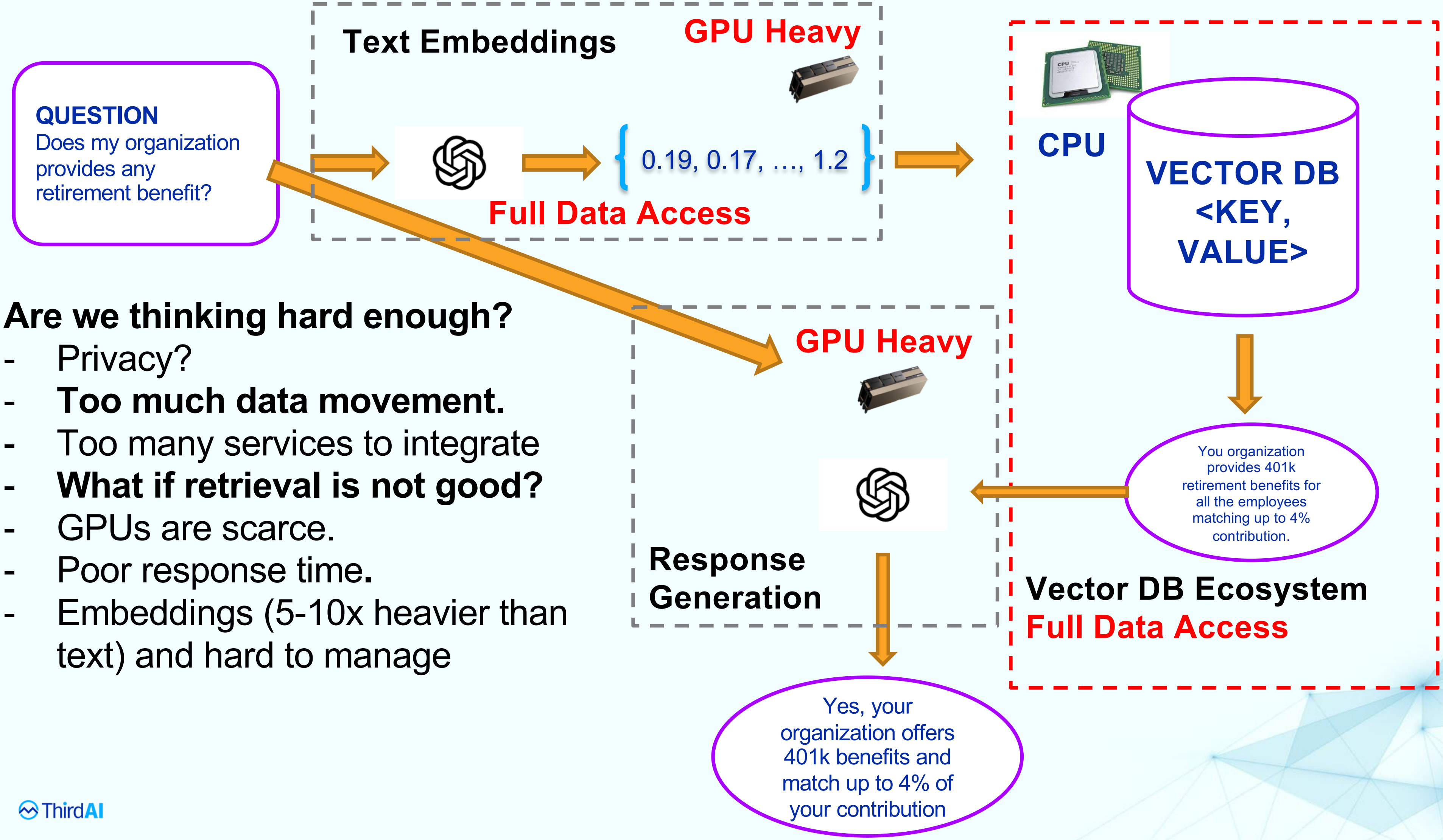
- Finding the Right Use Cases

- Understanding data privacy and data residency

- Careful with “essentially free” services in production.

- Putting LLM in production is very different and potentially much harder than making a demo.

Case Study RAG: Why Current Stack is Fundamentally Hard for Production!



Are we thinking hard enough?

- Privacy?
- **Too much data movement.**
- Too many services to integrate
- **What if retrieval is not good?**
- GPUs are scarce.
- Poor response time.
- Embeddings (5-10x heavier than text) and hard to manage

ThirdAI

Photoelectric Moment in AI: AI is about to be rewritten

1. Our understanding of AI/ML is challenged in a positive way.

2. This is the first iteration of LLMs and it will refine quickly

3. We will surely give LLMs (Mega-AI Models) full chance to solve our hardest problems. After all, what other ideas do we have that we have not tried.

Efficiency will be the guiding factor!

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Large Language Models and Networking Challenges and Opportunities

Elisa Bertino

Purdue U.

Opportunity

Automatic Vulnerability Detection through Conflicts from NL Cellular Protocol Specifications using LLM

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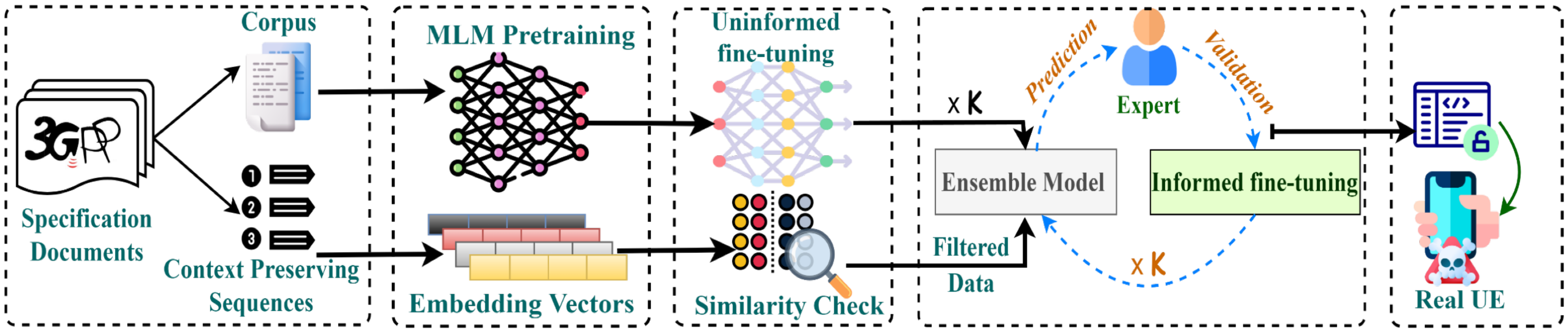
Challenges

- LLMs are not domain specific
- How do we know where to look for conflicting pairs?
- Formulation: How can LLMs detect inconsistencies?
- No-ground truth for supervised training

Solution Design



As part of the solution we created SPEC5G a dataset of NL sentences specific to 5G

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Slide by Dr.Imtiaz Karim (Purdue University)

Opportunity

Automatic Generation of Code

Challenge: correctness of generated code

Initial evaluations [1] on GITHUB COPILOT

- Analysis carried out on code generated by Copilot in scenarios relevant to high-risk cybersecurity weaknesses (e.g. those from MITRE's "Top 25" 2021 CWE list)
- Copilot's performance evaluated on three distinct code generation axes—diversity of weaknesses, diversity of prompts, and diversity of domains
- A total of 1,689 programs were generated
- Of these, 40% were found to be vulnerable

[1] H. Pearce et al. "Asleep at the Keyboard? Assessing the Security of GitHub Copilot's Code Contributions" IEEE S&P, 2022

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2021 CWE Top 25 Most Dangerous Software Weaknesses

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Rank	ID	Name	Score	2020 Rank Change
[1]	CWE-787	Out-of-bounds Write	65.93	+1
[2]	CWE-79	Improper Neutralization of Input During Web Page Generation ('Cross-site Scripting')	46.84	-1
[3]	CWE-125	Out-of-bounds Read	24.9	+1
[4]	CWE-20	Improper Input Validation	20.47	-1
[5]	CWE-78	Improper Neutralization of Special Elements used in an OS Command ('OS Command Injection')	19.55	+5
[6]	CWE-89	Improper Neutralization of Special Elements used in an SQL Command ('SQL Injection')	19.54	0
[7]	CWE-416	Use After Free	16.83	+1
[8]	CWE-22	Improper Limitation of a Pathname to a Restricted Directory ('Path Traversal')	14.69	+4
[9]	CWE-352	Cross-Site Request Forgery (CSRF)	14.46	0
[10]	CWE-434	Unrestricted Upload of File with Dangerous Type	8.45	+5
[11]	CWE-306	Missing Authentication for Critical Function	7.93	+13
[12]	CWE-190	Integer Overflow or Wraparound	7.12	-1
[13]	CWE-502	Deserialization of Untrusted Data	6.71	+8
[14]	CWE-287	Improper Authentication	6.58	0
[15]	CWE-476	NULL Pointer Dereference	6.54	-2
[16]	CWE-798	Use of Hard-coded Credentials	6.27	+4
[17]	CWE-119	Improper Restriction of Operations within the Bounds of a Memory Buffer	5.84	-12
[18]	CWE-862	Missing Authorization	5.47	+7
[19]	CWE-276	Incorrect Default Permissions	5.09	+22
[20]	CWE-200	Exposure of Sensitive Information to an Unauthorized Actor	4.74	-13
[21]	CWE-522	Insufficiently Protected Credentials	4.21	-3
[22]	CWE-732	Incorrect Permission Assignment for Critical Resource	4.2	-6
[23]	CWE-611	Improper Restriction of XML External Entity Reference	4.02	-4
[24]	CWE-918	Server-Side Request Forgery (SSRF)	3.78	+3
[25]	CWE-77	Improper Neutralization of Special Elements used in a Command ('Command Injection')	3.58	+6

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HKU-Cambridge
AI to Advance Well-being
& Society (AI-WiSe)
Research Platform

HKU-AI WiSe

Shaping Large Language Models for Decision-making in Networking

Prof. Victor OK Li
Director, HKU-AI WiSe

Faculty of Engineering
THE UNIVERSITY OF HONG KONG

香 港 大 學
THE UNIVERSITY OF HONG KONG

Outline

- HKU-AI WiSe mission
- Advantages and limitations of Large Language Models (LLMs)
- LLMs can be used to support network decision-making
- Can LLMs answer causal questions to support decision-making?
- Can we make LLMs causal?
- Conclusion

Our Mission: AI for Social Good

Bring incremental and disruptive changes to the societies, by improving the health and quality-of-life of the people, through the innovation and adoption of AI and big data technologies.

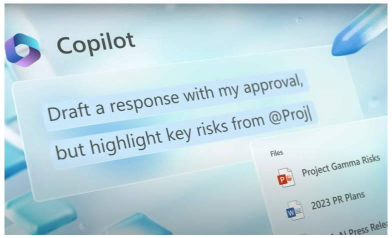
Innovations in AI and Big Data Technologies

Improving Health and Quality-of-life

Incremental and Disruptive Changes to the Societies

Advantages of LLMs

- Significant increase in performance at large model scale, showing some human-like language abilities [1]
- A key building block in many traditional natural language processing (NLP) tasks, such as machine translation and text summarization [2]
- Integrated into consumer AI to facilitate daily routine tasks
  - Productivity apps
  - Coding/writing assistant
  - …



[1] Wei, J., Tay, Y., Bommasani, R., Raffel, C., Zoph, B., Borgeaud, S., ... & Fedus, W. (2022). Emergent abilities of large language models. arXiv preprint arXiv:2206.07682.
[2] Min, B., Ross, H., Sulem, E., Veyseh, A. P. B., Nguyen, T. H., Sainz, O., ... & Roth, D. (2021). Recent advances in natural language processing via large pre-trained language models: A survey. arXiv preprint arXiv:2111.01243.

Limitations of LLMs

- However, they have limitations when used for decision-making
- Social biases and unfairness [1]
  - Trained on data biased towards certain groups of people
  - Results could be discriminatory towards those groups
- Hallucinations [2]
  - Giving answers that sound plausible and confident but are incorrect
  - Tend to generate factual statements that cannot be verified
- Unreliable reasoning capabilities [2]
  - ChatGPT is 63.41% accurate on average in 10 different reasoning categories.
  - Bad at performing complex tasks such as multi-hop reasoning
- Inconsistencies: giving inconsistent answers depending on the phrasing of prompts [3]

[1] Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. Learning and Individual Differences, 103, 102274.
[2] Bang, Y., Cahyawijaya, S., Lee, N., Dai, W., Su, D., Wilie, B., ... & Fung, P. (2023). A multitask, multilingual, multimodal evaluation of ChatGPT on reasoning, hallucination, and interactivity. arXiv preprint arXiv:2302.04023.
[3] Krügel, S., Ostermaier, A., & Uhl, M. (2023). ChatGPT's inconsistent moral advice influences users' judgment. Scientific Reports, 13(1), 4569.

Can LLMs Help Network Operation and Decision-making?*

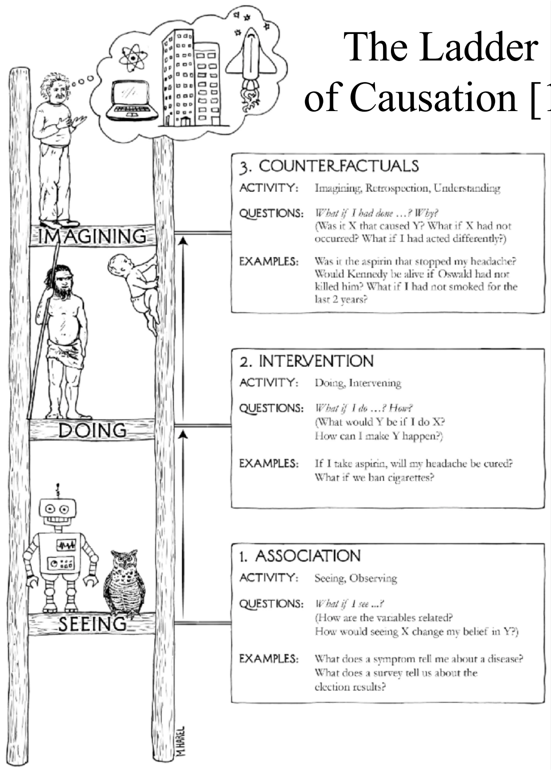
- Predictive Maintenance: LLMs can analyze data from network equipment and predict potential failures.
- Customer Service: LLMs can provide personalized customer support to subscribers.
- Network Optimization: LLMs can analyze network traffic data and identify areas where network capacity may need to be increased.
- Fraud Detection: LLMs can be used to analyze call and data usage patterns and identify potential instances of fraud.

*From ChatGPT

Can LLMs Answer Causal Questions?

- Scale is not everything
  - Trained on observational data only
  - Correlation does not imply causation
- It remains challenging for LLMs to
  - Understand causal relationships rather than correlations in data
  - Explain what causes a decision
- Answering causal questions is central in *human* decision-making, making humans unique from robots (see the Ladder of Causation)

The Ladder of Causation [1]

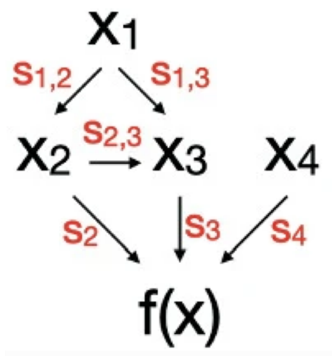


Can LLMs climb to the rung of causal reasoning?

[1] Pearl, J., & Mackenzie, D. (2018). The book of why: the new science of cause and effect. Basic books.

Causal Models

- Injecting causality into AI models
  - A causal graph: X->Y means X “causes” Y
  - Causal Shapley values: variable attribution guided by a causal graph [1]



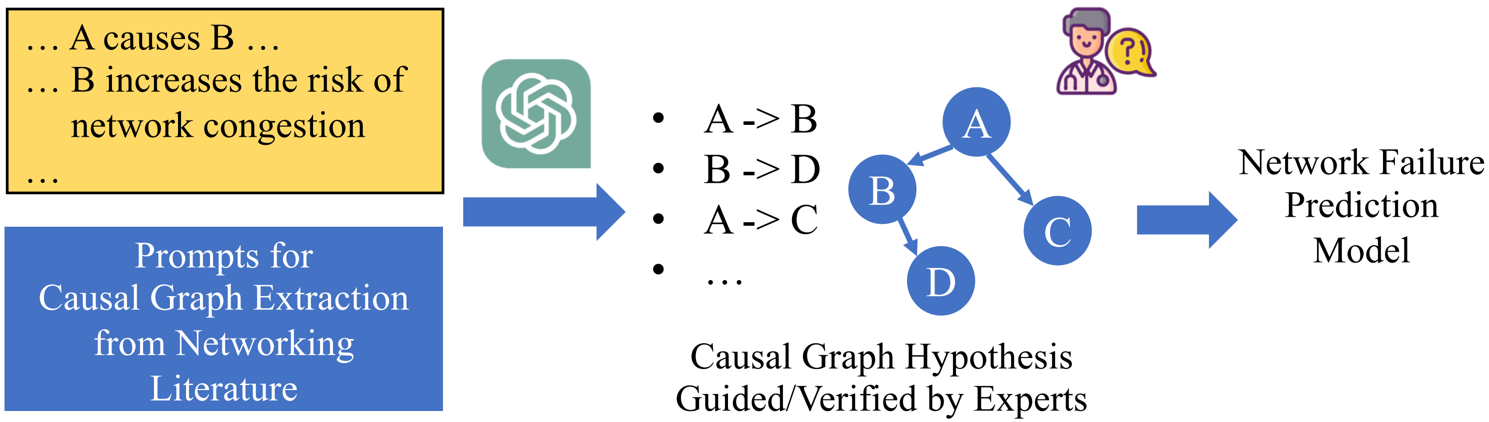
- “What-if” causal explanations [2]
  - Sufficient explanations: an action leading to a particular output, e.g., from X = x to Y = y
  - Counterfactual explanations: which variables would have had to be different for the outcome to be different?

[1] Holzinger, A., Saranti, A., Molnar, C., Biecek, P., & Samek, W. (2022, April). Explainable AI methods-a brief overview. In xxAI-Beyond Explainable AI: International Workshop, Held in Conjunction with ICML 2020, July 18, 2020, Vienna, Austria, Revised and Extended Papers (pp. 13-38).

[2] Beckers, S. (2022, June). Causal explanations and XAI. In Conference on Causal Learning and Reasoning (pp. 90-109). PMLR.

Can We Make LLMs Causal?

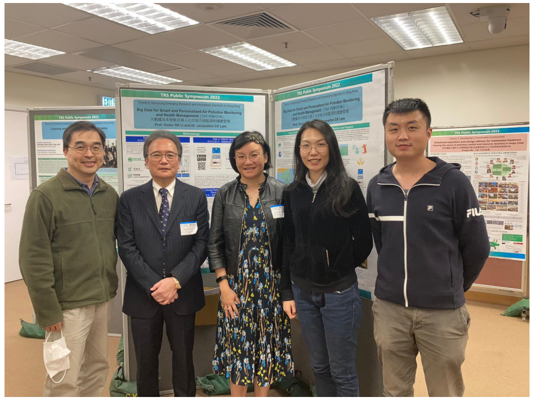
- ChatGPT can be used for text mining of existing networking literature, based on well-designed prompts
- Potential causal relationships between different network entities can be identified
- Such findings can be verified by networking experts



Conclusion

- AI is a tool to serve humans.
- LLMs have advantages and limitations.
- We need to understand how to best use this tool to our advantage.
- Human beings are unlikely to follow a decision without understanding the rationales.
- Explainability/interpretability is an important step towards trust in AI systems and making AI more useful in decision-making.

HKU-AI WiSe Team



Call for Papers

Special Issue of Data and Policy, Cambridge University Press

Generative AI for Sound Decision-Making: Challenges and Opportunities

Guest editors: Victor OK Li, Jacqueline CK Lam, and Jon Crowcroft

Paper submission deadline: December 5 2023

Publication: 2024

https://www.cambridge.org/core/journals/data-and-policy/announcements/call-for-papers/call-for-papers-generative-ai-for-sound-decision-making-challenges-and-opportunities

Next event: Lessons learned from 40+ years of the Internet

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Organizer: **Henning Schulzrinne**, Columbia U, National Telecommunications and Information Administration

Highlights from the May 2023 Dagstuhl Seminar

Lessons Learned From 40+ Years of the Internet

(May 01 – May 04, 2023)

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