KATch

A Fast Symbolic Verifier for NetKAT

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The Control Plane and Network Defense Agents

Control Plane

- Computes routing tables
- Ensures network connectivity
- Enforces network policies

Network Defense Agents

- Detects and responds to network attacks
- Example: Security breach containment
- Example: DDoS mitigation
- **Action space?**
- **Modify routing tables?**

Neural and Symbolic AI

Neural Strengths

- General pattern recognition
- Learns from experience
- Adaptability to new situations
- Ideal when explicit programming is difficult

Symbolic Strengths

- Domain specific reasoning
- Guarantees correctness
- Verifiable and explainable
- Ideal when strict compliance with rules is required

Neural+Symbolic AI in Network Defense: Idea

Neural

- Utilizes deep learning for real-time attack detection and response
- Adapts to evolving network threats
- Modifies routing tables dynamically
- Example: Detecting and rerouting traffic to mitigate DDoS attacks
- Example: Detecting and isolating compromised hosts

Symbolic

- Computes consequences of routing changes
- Ensures correctness of routing tables
- Verifies adherence to network policies and security rules
- Example: Validating routing paths for security compliance
- Example: Verifying reachability of critical network services

NetKAT: Symbolic Network Reasoning

NetKAT: network specification language for SDN

- Network topology
- Routing tables
- Network-wide policies

Verification of network policies

- Security properties, e.g. slice isolation
- Operational properties, e.g. reachability
- Verified in a common framework

Problem: NetKAT verification is slow
Not suitable for real-time network defense

KATch

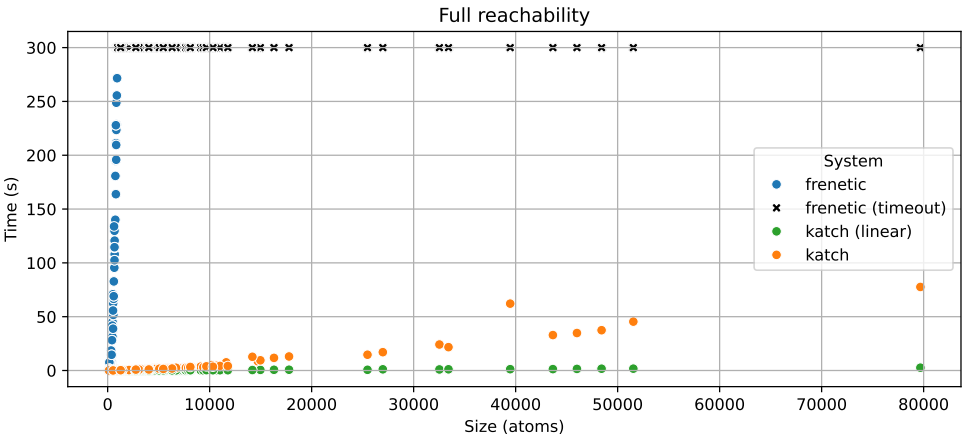
A Fast Symbolic Verifier for NetKAT

KATch

A new NetKAT verifier that is

- **Fast:** 1000× faster
- **Symbolic:** explains verification failures
- **Scalable:** handles larger networks

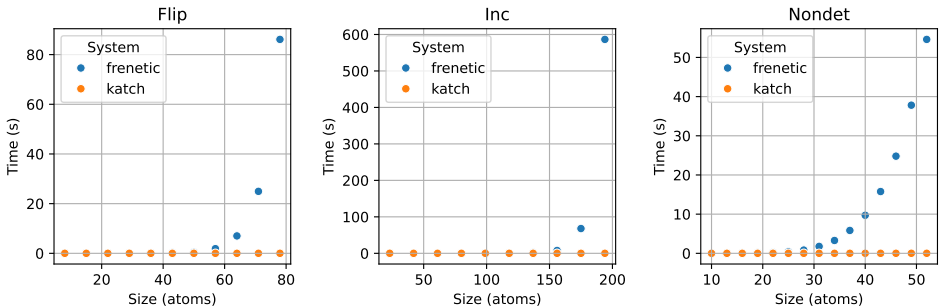
Full Reachability



Detailed comparison: (un)reachability and slice isolation

Name	Size (atoms)	Reachability		Unreachability		Slicing		Min Speedup
		KATch	Frenetic	KATch	Frenetic	KATch	Frenetic	
Layer42	135	0.00	0.04	0.00	0.04	0.01	0.07	7×
Compuserv	539	0.01	0.36	0.01	0.38	0.01	0.85	36×
Airtel	785	0.01	0.83	0.01	0.84	0.02	2.08	83×
Belnet	1388	0.01	3.17	0.01	3.16	0.04	7.99	200×
Shentel	1865	0.02	4.01	0.02	4.00	0.04	9.80	200×
Arpa	1964	0.01	4.32	0.02	4.32	0.05	10.99	216×
Sanet	4100	0.04	23.46	0.03	25.23	0.12	62.70	522×
Uunet	5456	0.04	81.54	0.04	81.92	0.15	204.85	1366×
Missouri	9680	0.11	161.28	0.10	165.85	0.27	519.46	1658×
Telcove	10720	0.09	464.15	0.08	465.27	0.28	1274.24	4551×
Deltacom	27092	0.31	2392.56	0.30	2523.03	0.75	7069.54	7718×
Cogentco	79682	0.97	22581.39	0.88	23300.87	1.78	53066.82	23280×

Synthetic combinatorial benchmarks



Conclusion

NetKAT verification can be fast

Can we combine neural and symbolic AI?