Automated Black-Box Verification of Networking Systems

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Project

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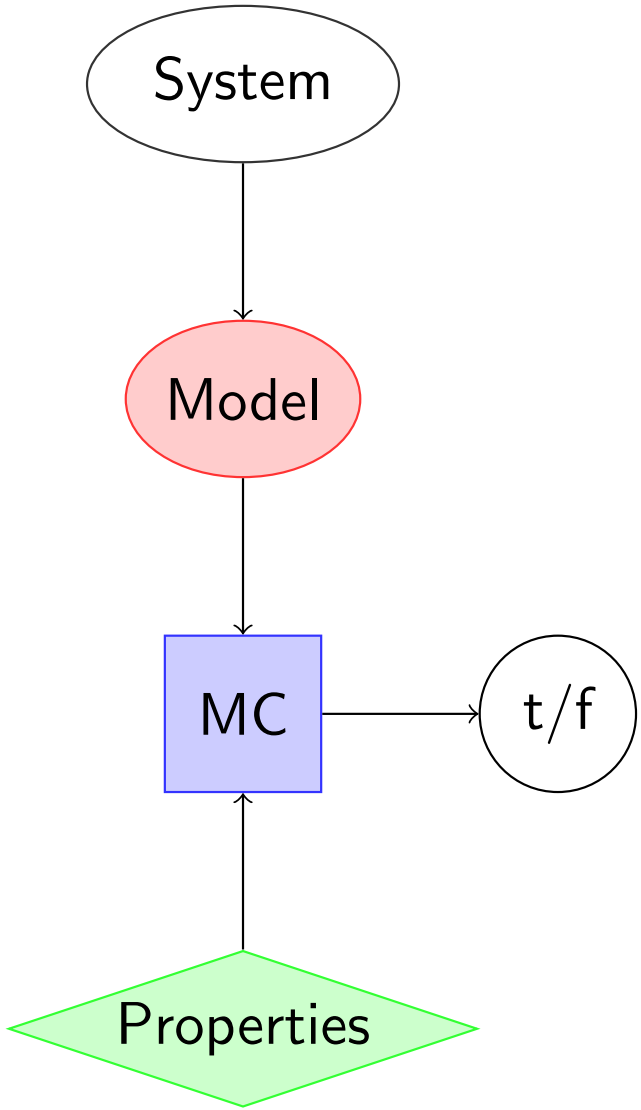
Introduction

Can host A send packets to host B?

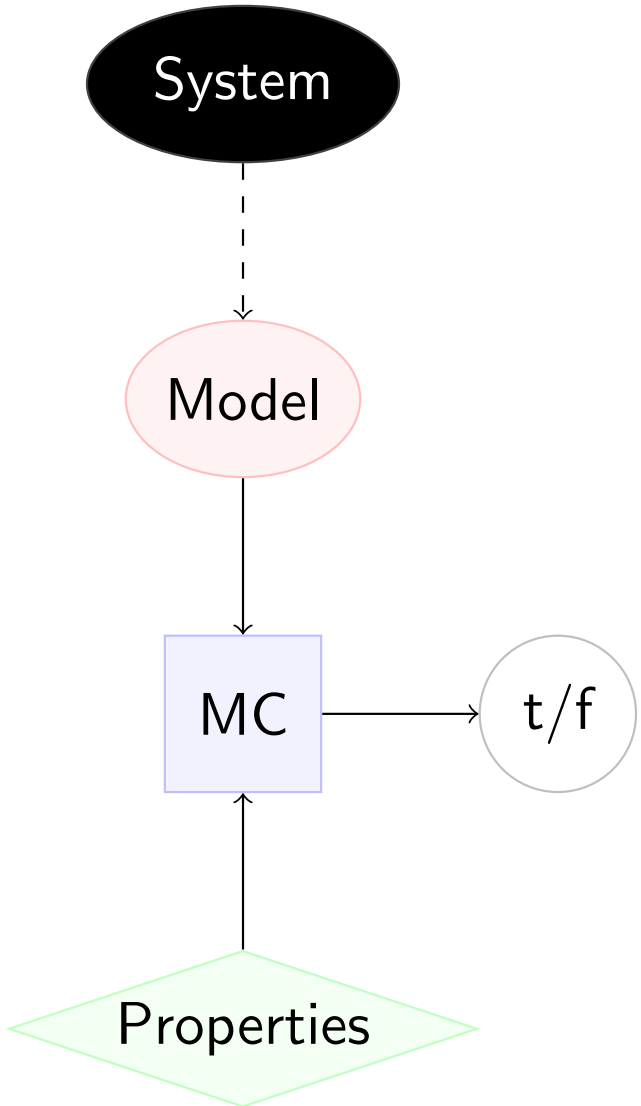
Do all packets from A to C pass B?

Is there a loop involving A?

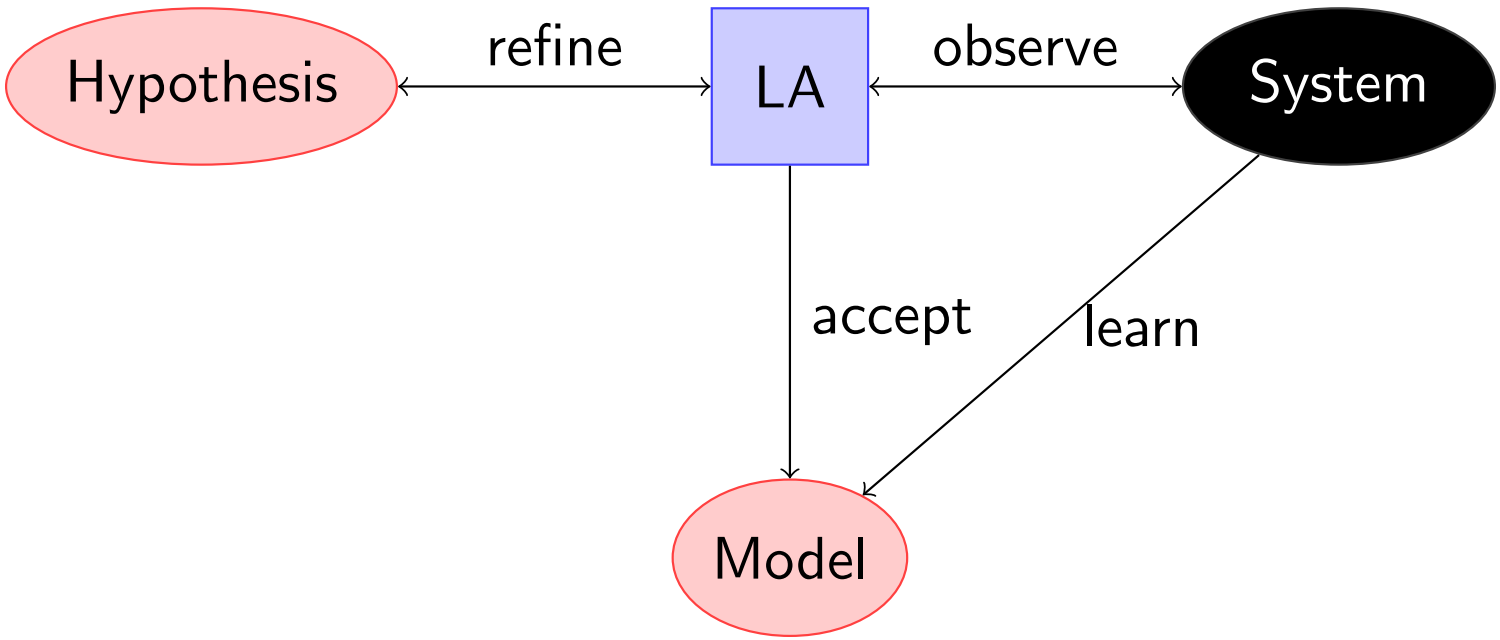
White box vs. Black box



White box vs. Black box



Black box learning



$L^\star$: Example

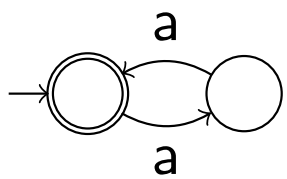
- Actions $A = \{a\}$
- Behaviour $\mathcal{L} = \{w \in A^* \mid |w| \neq 1\} = 1 + a \cdot a \cdot a^*$

	ε
ε	1
a	0

$\rightarrow$

	ε
ε	1
a	0
aa	1

$\rightarrow$



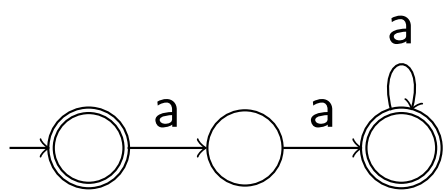
$\rightarrow$

	ε
ε	1
a	0
aa	1
aaa	1
aaaa	1

$\rightarrow$

	ε	a
ε	1	0
a	0	1
aa	1	1
aaa	1	1
aaaa	1	1

$\rightarrow$



$\mathrm{L}^{\star}_{T}$

$$X \to FTX$$

Deterministic Automata $FX = X^A \times 2$ $TX = X$	Non-deterministic Automata $FX = X^A \times \mathcal{P}(1)$ $TX = \mathcal{P}(X)$
Partial Automata $FX = X^A \times (1 + 1)$ $TX = 1 + X$	Weighted Automata $FX = X^A \times \mathbb{S}^1$ $TX = \mathbb{S}^X$
Writer Automata $FX = X^A \times (1 \times \mathbb{M})$ $TX = X \times \mathbb{M}$	NetKAT Automata $FX = X^{\mathsf{Pk}} \times (2^{\mathsf{Pk}})^{\mathsf{Pk}}$ $TX = X^{\mathsf{Pk}}$

NetKAT

NetKAT =
Kleene Algebra with Tests (KAT) +
Expressions for the modification and
filtering of packets

NetKAT

$$sw = A; pt = 1; pt \leftarrow 2 + sw = B; \text{drop}$$

"Let switch A only forward packets from port 1 to port 2, and let switch B drop all packets"

$$sw = A; pt = 1; sw \leftarrow B; pt \leftarrow 2$$
$$+ sw = B; pt = 2; sw \leftarrow A; pt \leftarrow 1$$

"There exists a bidirectional link between the port 1 of switch A and the port 2 of switch B"

NetKAT automata

NetKAT automata read packets:

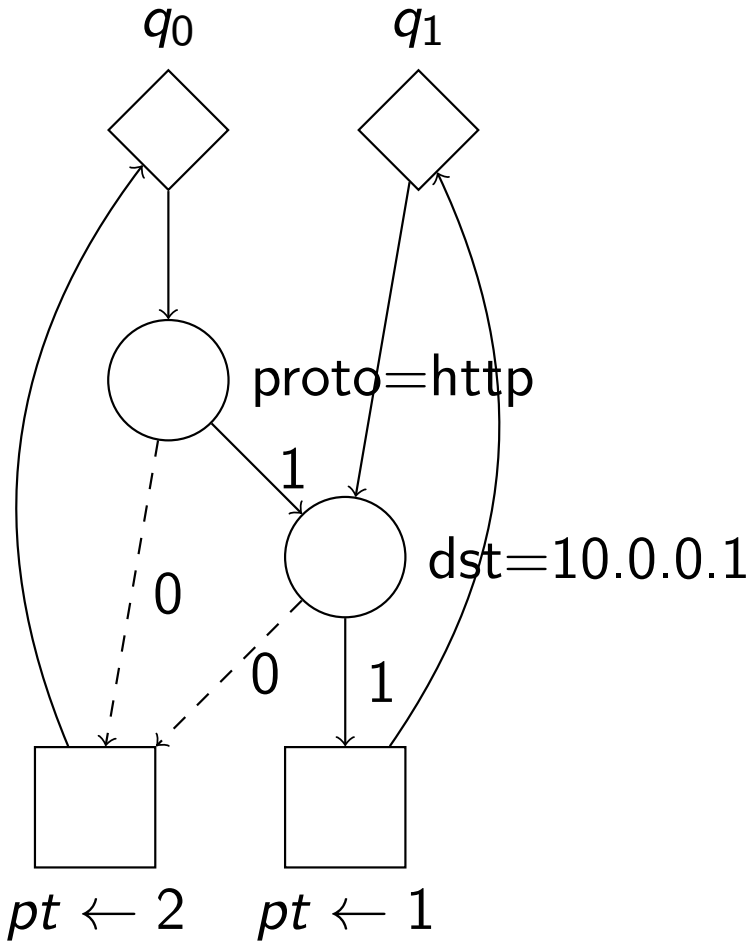
(sw=A; pt=80; dst=10.0.2.1; proto=http; ...),
(sw=B; pt=22; dst=10.0.0.2; proto=ssh; ...),
(sw=X; pt=25; dst=10.0.0.1; proto=smtp; ...),
(sw=D; pt=20; dst=10.0.3.1; proto=ftp; ...),
(sw=E; pt=443; dst=10.0.7.1; proto=https; ...),
...

NetKAT automata accept packet traces:

$$h = p_1 :: p_2 :: ... :: p_n :: []$$

Symbolic NetKAT automata

$$X \to (X^{\mathsf{Pk}})^{\mathsf{Pk}} \times (2^{\mathsf{Pk}})^{\mathsf{Pk}}$$



Learnable?