galois

BALBOA

Bobbing and Weaving around Network Censorship

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56%

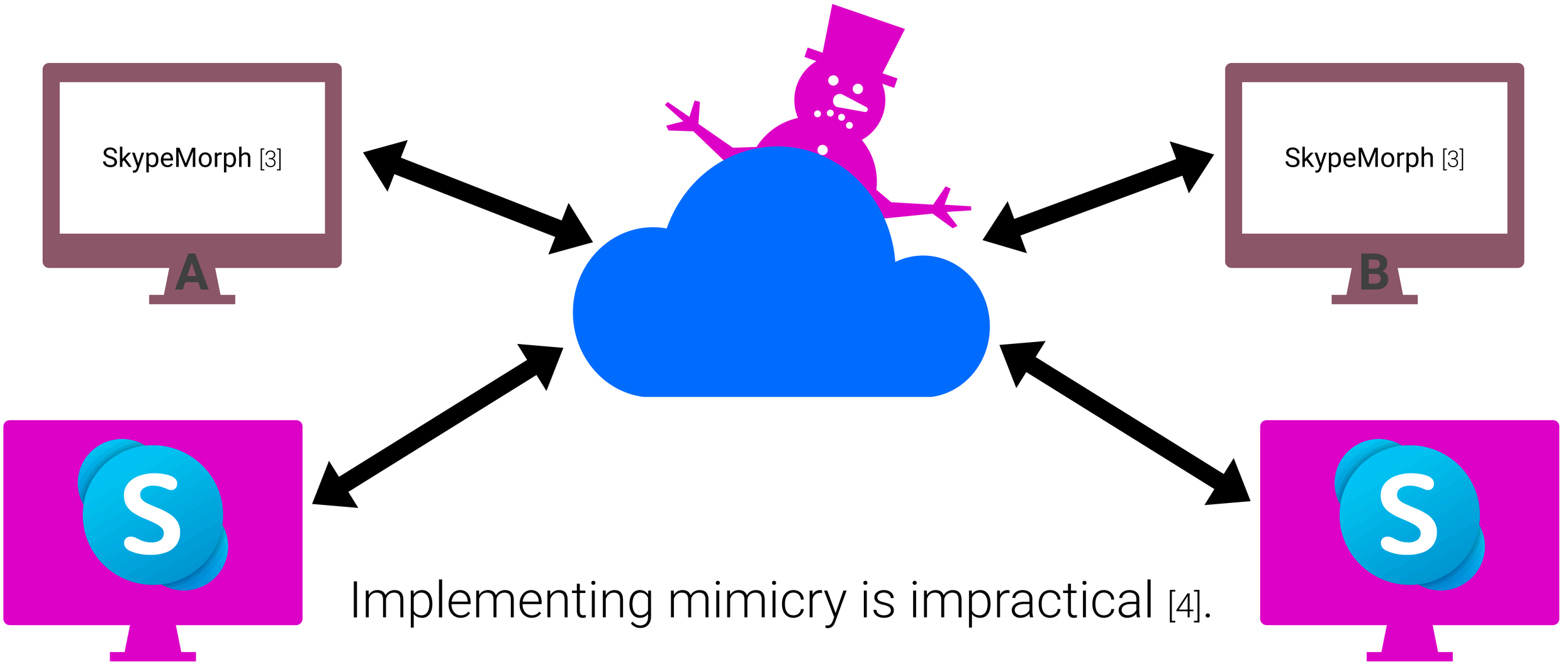
of global internet users “live in countries where political, social, or religious content was blocked online.” [1]

Link Obfuscation

Look-Like Something

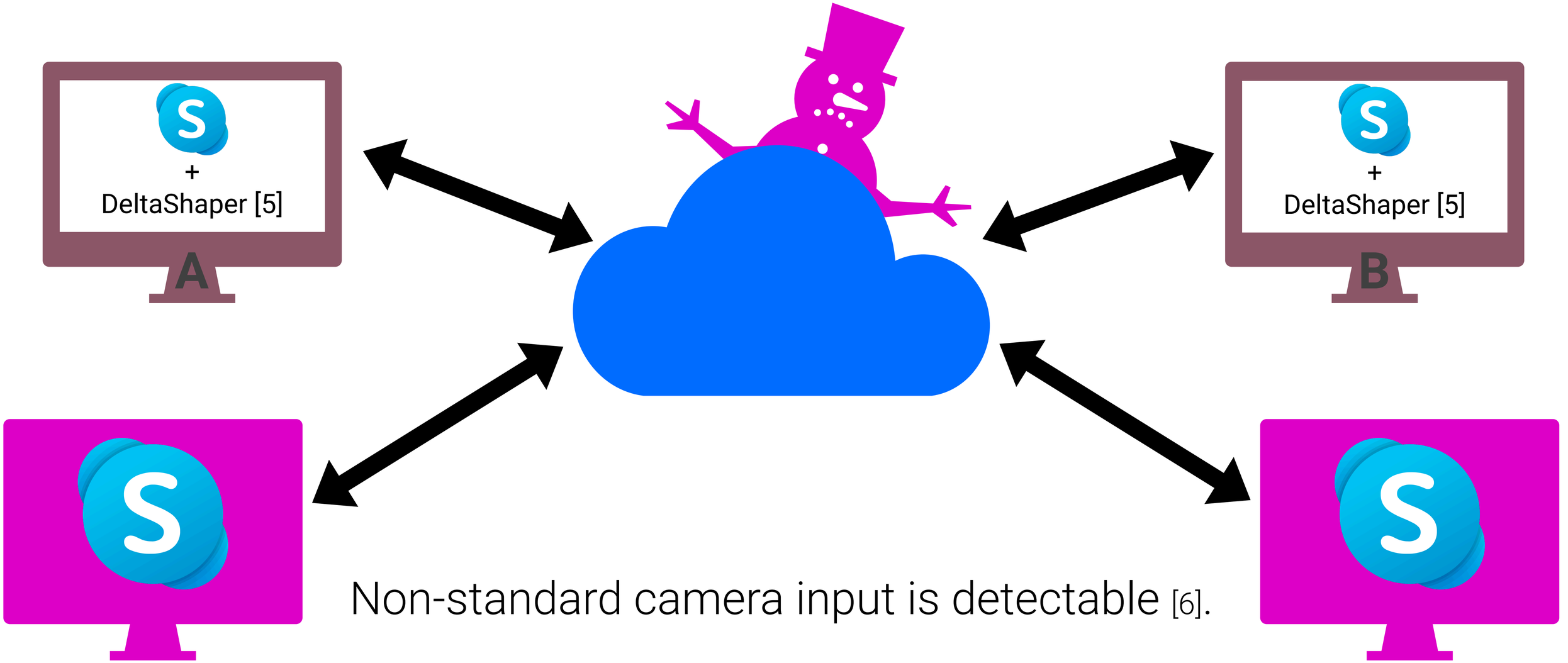
Encryption doesn’t hide metadata [2].

Mimicry



Implementing mimicry is impractical [4].

Tunneling



Non-standard camera input is detectable [6].

To be indistinguishable to the censor, we want to…

(1) run a standard instance of a target application,

(2) with a standard input,

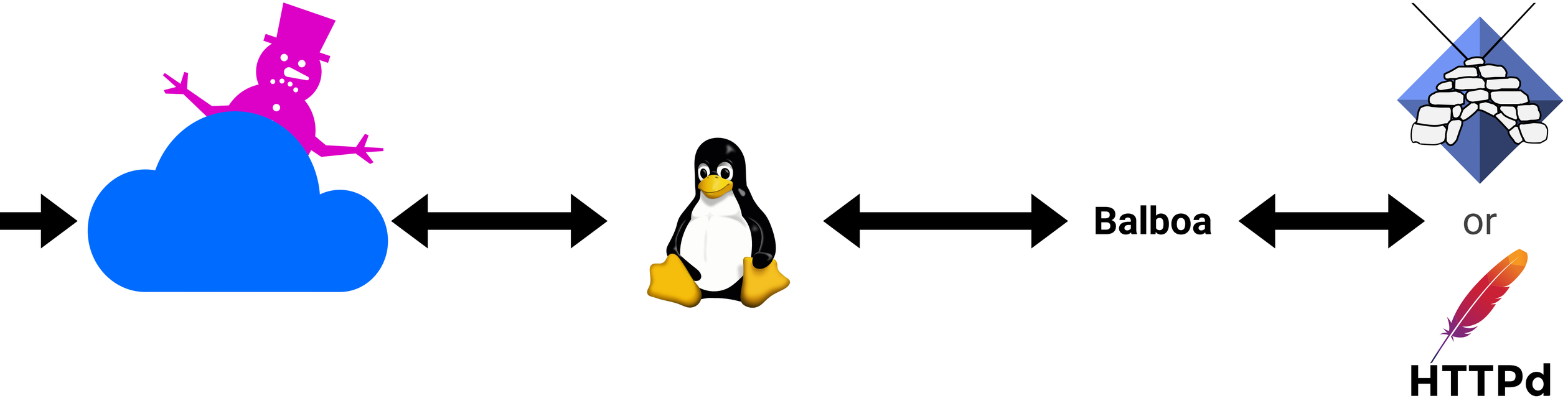
(3) while embedding data into the stream

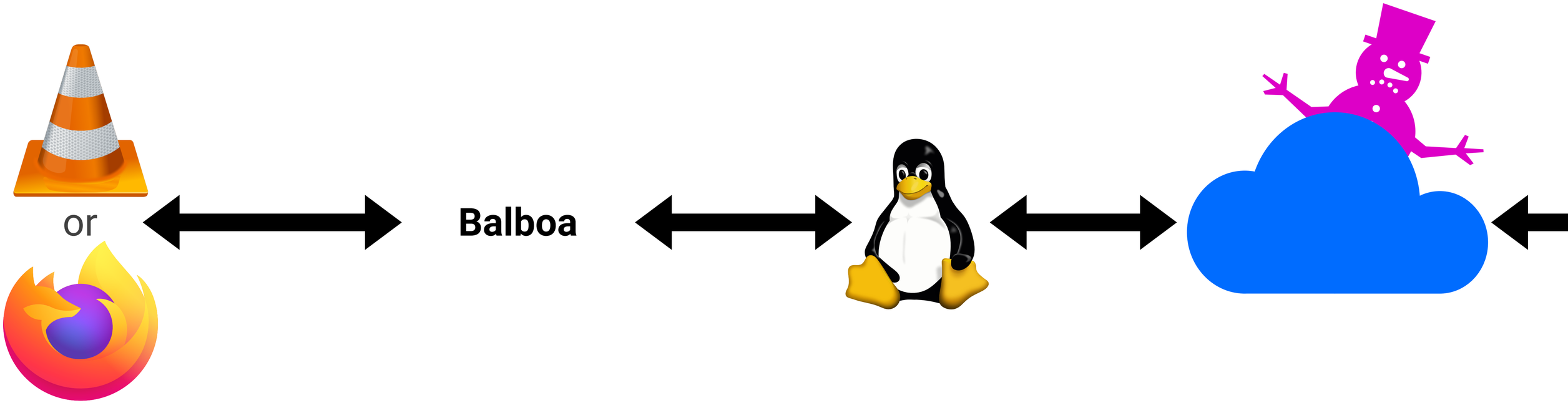
Balboa is a framework which…

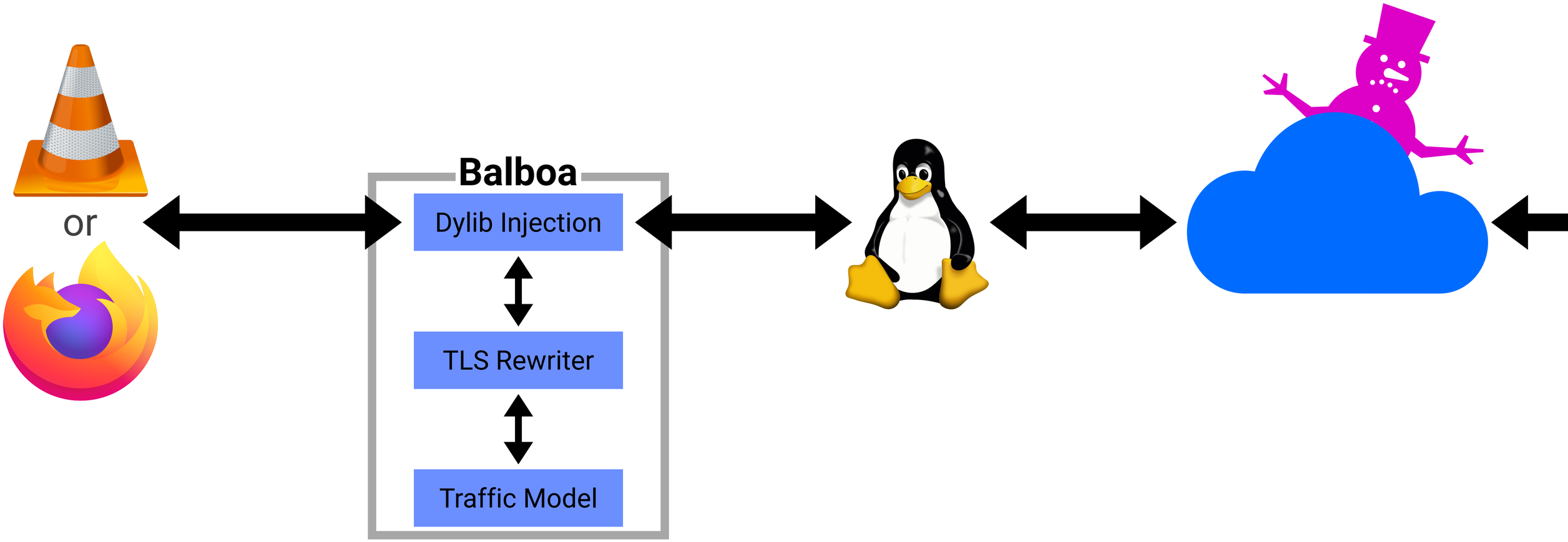
(1) runs an *unmodified* binary of a TLS-enabled target application,

(2) on its standard input,

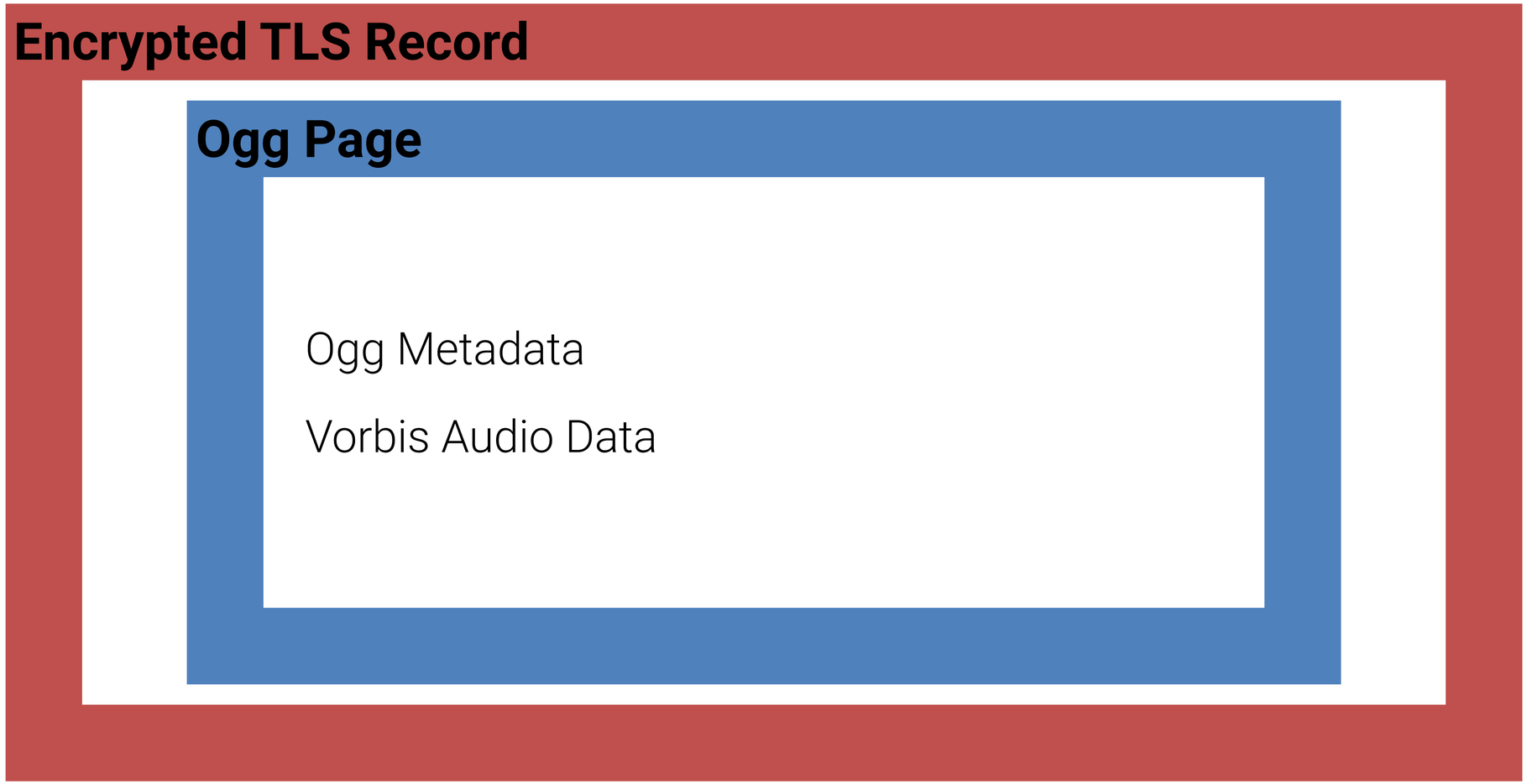
(3) while manipulating its TCP stream to embed/extract covert data

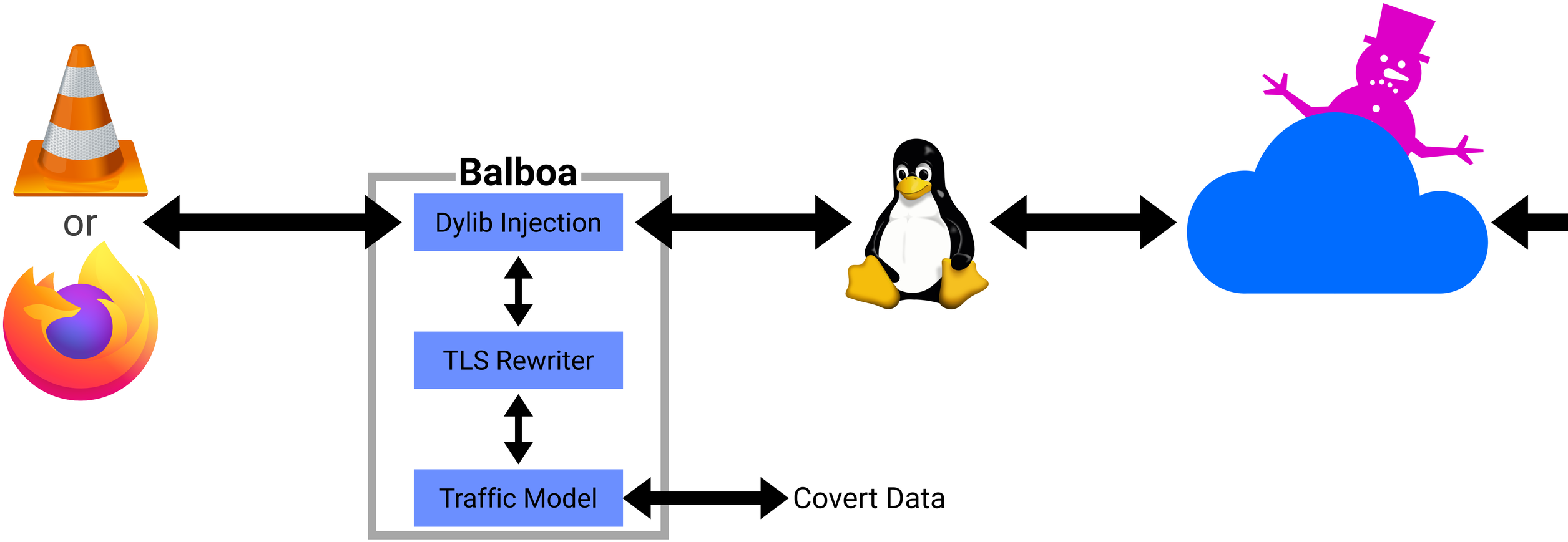






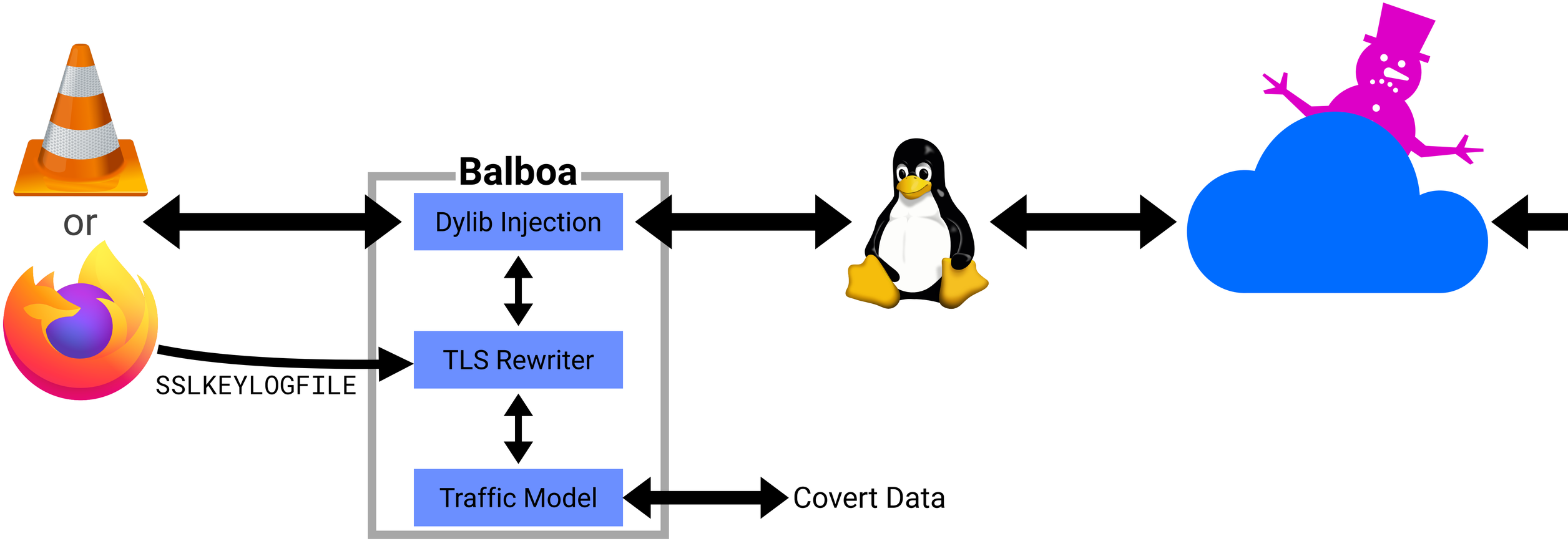
Traffic Model: Internet Radio

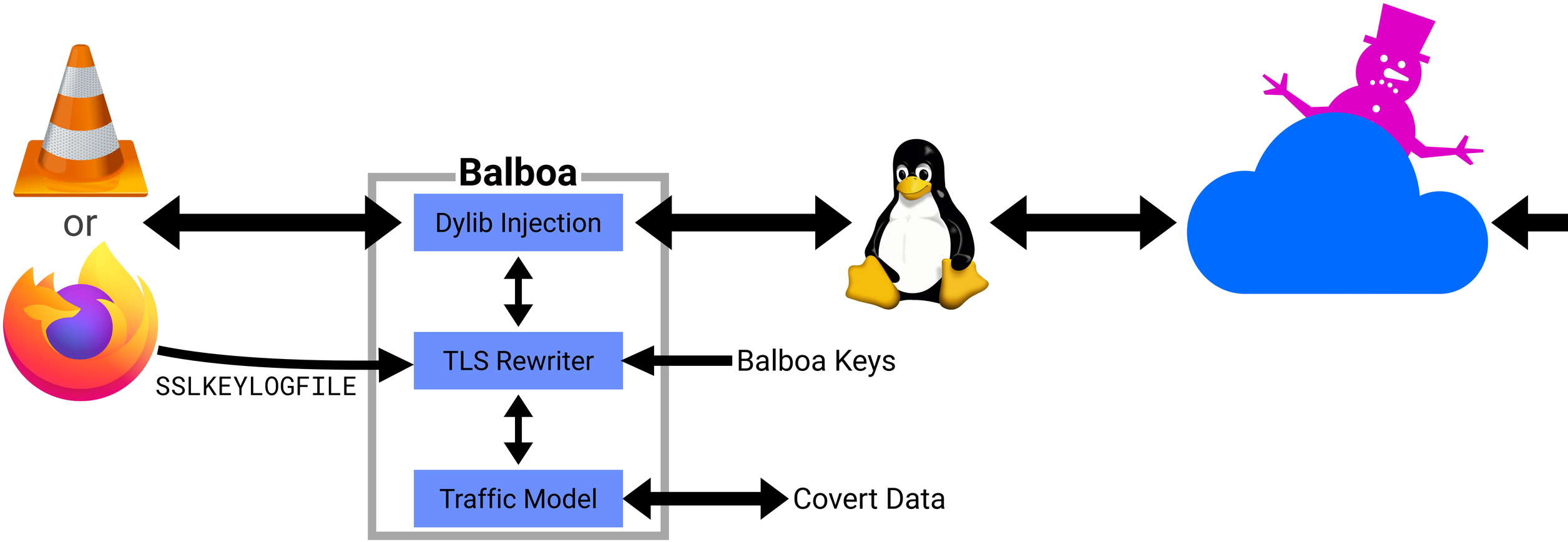




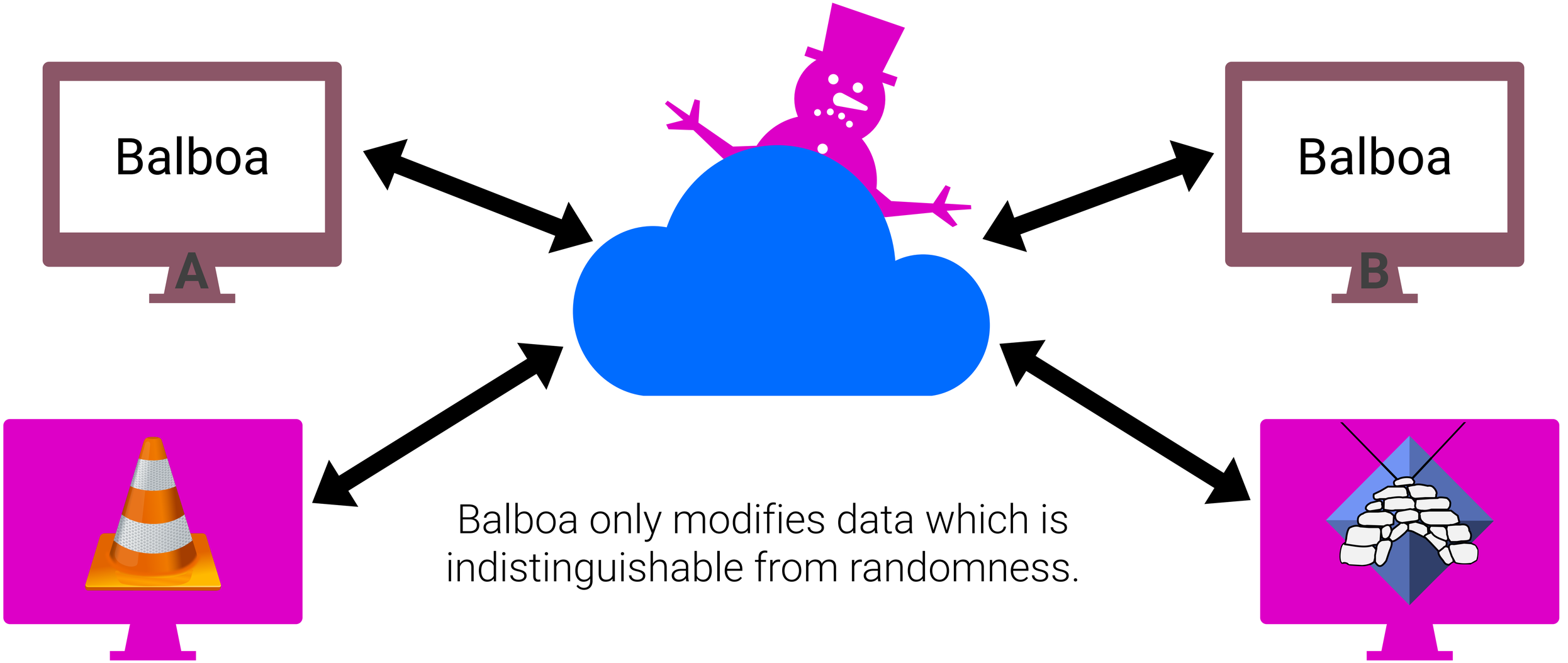
Dynamic Library Injection

```
connect(client_fd, ip, port)

write(client_fd, buffer, len) → bytes_written

read(client_fd, buffer, len) → bytes_read
```





Security Evaluation



Evaluation: Internet Radio

	VLC	MPlayer	MPV	Audacious
Accuracy with 5ms ± 1ms latency	0.72 ± 0.08	0.50 ± 0.10	0.53 ± 0.09	0.73 ± 0.06
Accuracy with 10ms ± 1ms latency	0.67 ± 0.09	0.55 ± 0.10	0.55 ± 0.09	0.68 ± 0.06

Evaluation: Web Browsing

	Firefox	Curl
Scenario	Browsing Wikipedia	File Download
Accuracy with 5ms ± 1ms latency	0.69 ± 0.01	0.71 ± 0.08
Accuracy with 10ms ± 1ms latency	0.66 ± 0.01	0.79 ± 0.08

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Questions? Email us! balboa@galois.com

https://github.com/GaloisInc/balboa
https://github.com/GaloisInc/stallone

Citations

1. https://freedomhouse.org/sites/default/files/2020-10/10122020_FOTN2020_Complete_Report_FINAL.pdf
2. Charles V. Wright, Lucas Ballard, Scott E. Coull, Fabian Monrose, and Gerald M. Masson. Uncovering spoken phrases in encrypted voice over IP conversations. *ACM Transactions on Information and System Security (TIS- SEC)*, 13(4):1–30, 2010.
3. Hooman Mohajeri Moghaddam, Baiyu Li, Mohammad Derakhshani, and Ian Goldberg. Skypemorph: Protocol obfuscation for tor bridges. In *Proceedings of the 2012 ACM conference on Computer and communications se- curity*, pages 97–108, 2012.
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6. Diogo Barradas, Nuno Santos, and Luís Rodrigues. Effective detection of multimedia protocol tunneling using machine learning. In *USENIX Security Symposium*. USENIX, 2018.