I Want My Voice to Be Heard:

IP over Voice-over-IP for Unobservable Censorship Circumvention

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Internet Censorship

- The Internet is a big **threat** to repressive regimes!

- Repressive regimes **censor** the Internet:
  - IP filtering, DNS hijacking, Deep packet-inspection, etc.

- Circumvention systems

New stage in the arms race

- The threat model has changed

➤ Past: detect circumvention end-points

➤ Now: detect circumvention traffic also

We need traffic unobservability

against **passive**, **active**, or **proactive** analysis

A recent approach

- A promising approach: **hide** circumvention traffic within **popular** Internet protocols
  - Censors are unlikely to completely block that protocol

- A new trend: **mimic** the target protocol
  - SkypeMorph, StegoTorus, and CensorSpoofer (CCS'12)

FLAWED

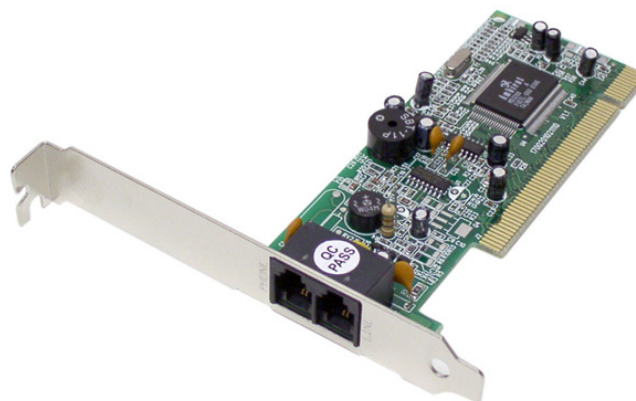- It's hard to imitate network protocols

  The Parrot is Dead: Observing Unobservable Network Communications [Oakland'13]
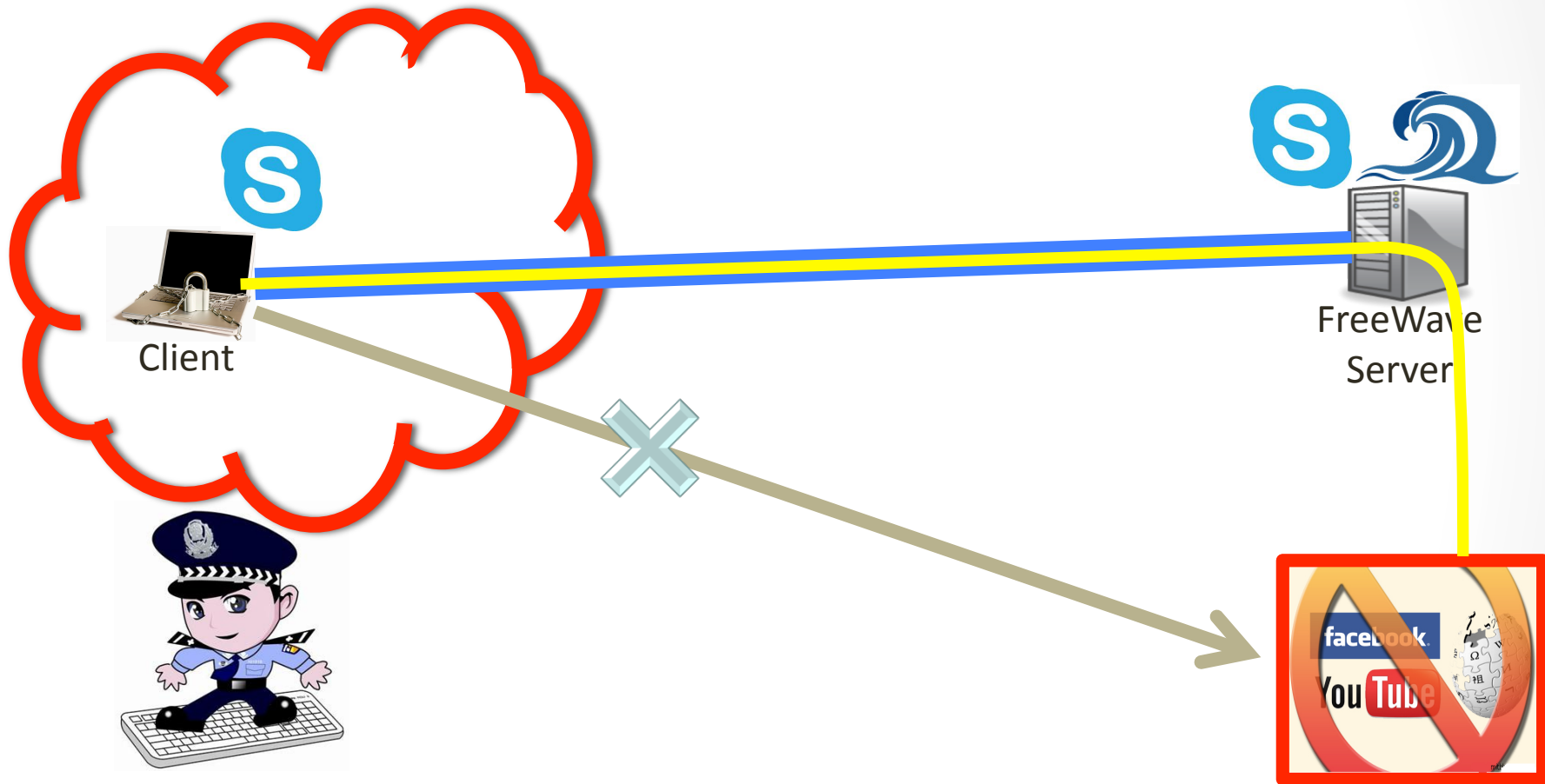
Our approach

- We seek the same objective, but take a different approach:

  Run the target protocol

- By running the target protocol no need to worry about implementation quirks, bugs, protocol details

- Challenge: how to *efficiently* encapsulate traffic into the target protocol

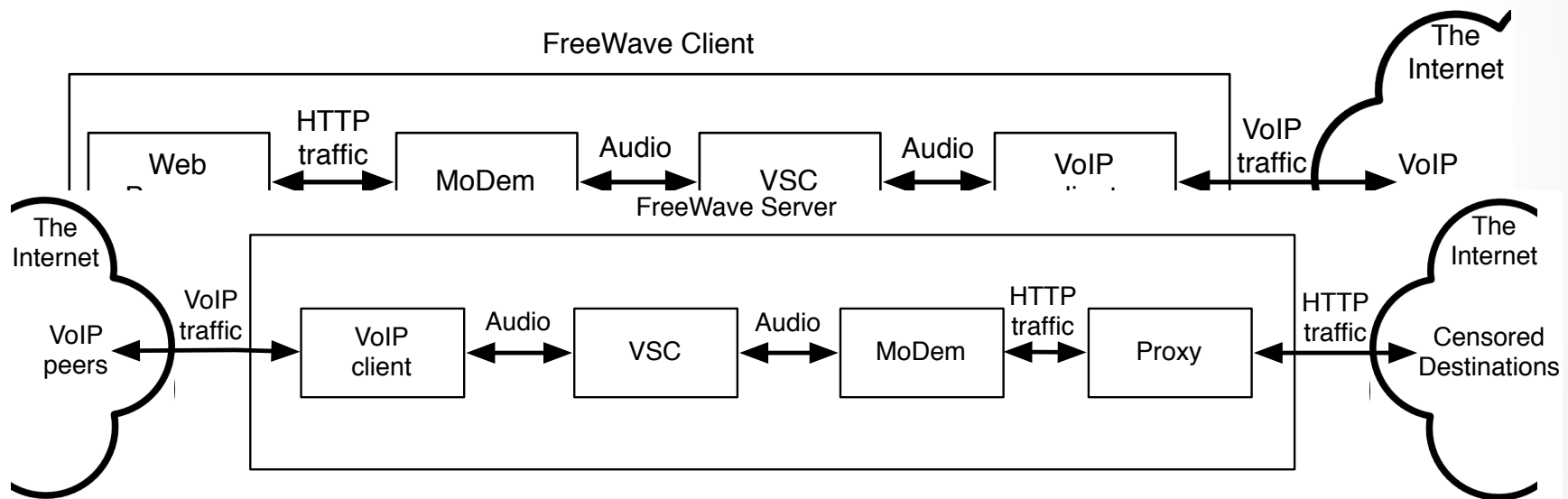# FreeWave: IP over Voice-over-IP

- Target protocol: Voice-over IP (VoIP)

- Why VoIP
  - Widely used protocol (only 663 Million Skype users)
    - Collateral damage to block
  - Encrypted

- How to hide?
  - The dial-up modems are back!

FreeWave architecture

Client

FreeWave Server

System components

FreeWave Client

The Internet

| | HTTP traffic | | Audio | | Audio | | VoIP traffic | |
| Web | | MoDem | | VSC | | VoIP | | VoIP |

FreeWave Server

The Internet

| VoIP peers | VoIP traffic | VoIP client | Audio | VSC | Audio | MoDem | HTTP traffic | Proxy | HTTP traffic | Censored Destinations |

The Internet
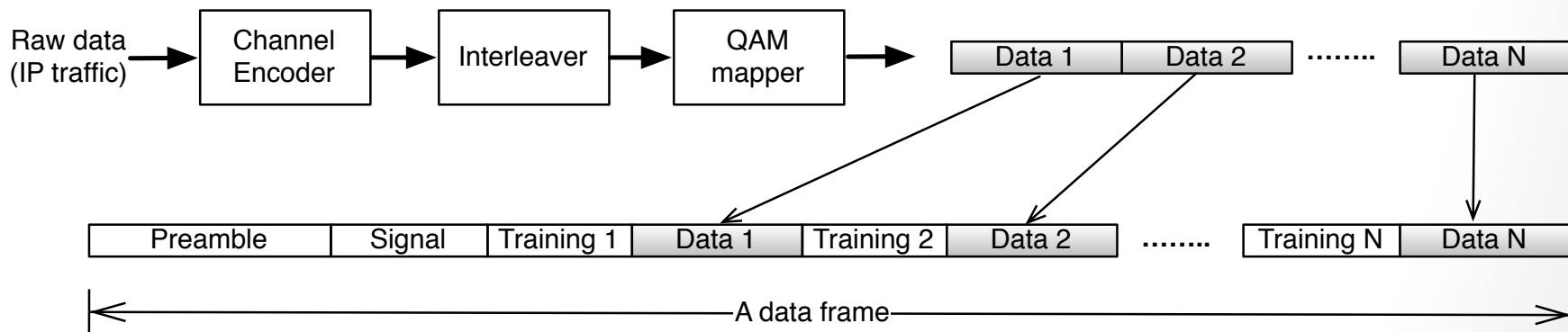
MoDem component

- A typical acoustic modem
  - QAM modulation

- Reliable transmission
  - Turbo codes
  - Use Preambles

```
Raw data          Channel           QAM
(IP traffic)  →   Encoder   →  Interleaver  →  mapper  →     [ Data 1 | Data 2 ] ···· [ Data N ]
```

| Preamble | Signal | Training 1 | Data 1 | Training 2 | Data 2 | .... | Training N | Data N |

←——————————————————————— A data frame ———————————————————————→

Evaluations

| Client location	MoDem parameters			Data rate	Packet drop rate
	Q	$1/T$	R_C		
Berlin, Germany	4	8 kHz	0.5	16000 bps	0
Frankfurt, Germany	4	8 kHz	0.5	16000 bps	0
Paris, France	4	8 kHz	0.5	16000 bps	0
Maidenhead, UK	4	8 kHz	0.5	16000 bps	0
Manchester, UK	4	8 kHz	0.5	16000 bps	0
Lodz, Poland	4	8 kHz	0.5	16000 bps	0.06
Chicago, IL	4	9.6 kHz	0.5	19200 bps	0.01
San Diego, CA	4	9.6 kHz	0.469	18000 bps	0

FreeWave's unobservability

- Comprehensive unobservability at the protocol level

- Traffic analysis (packet rates and sizes)
- ➢ Fixed rate codecs (e.g., G.7 series)
  - Not an issue ☺
- ➢ Variable bit-rates (e.g., Skype's SILK)
  - Simple analysis

Pattern	FreeWave over Skype	Skype-Speak	Skype-Silent
Average packet rate (pps)	49.91	50.31	49.57
Average packet size	148.64	146.50	103.97
Minimum packet size	64	64	64
Maximum packet size	175	171	133

  - Superimpose with recoded conversation

Server obfuscation

Client

Google

FreeWave
Server

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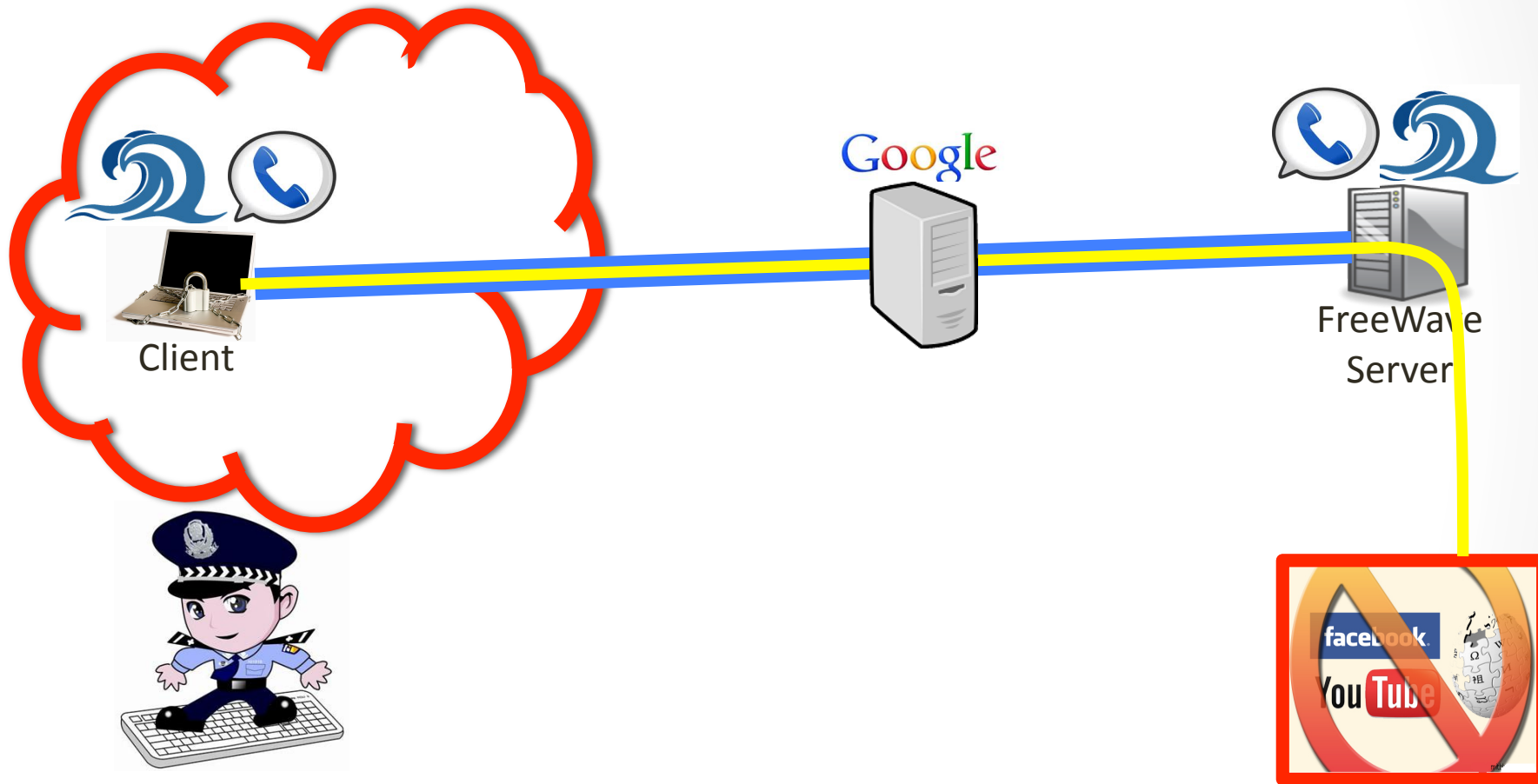
Future directions

… IP over Voice over IP over Voice-over-IP

- Embed into Video of VoIP

- Find other protocol to tunnel
  - Look for better **efficiency**

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Questions!

Deployment scenarios

- Personal deployment

- Central VoIP-center

- Central Phone-center

- Distributed service