NAT and Firewall Traversal with STUN / TURN / ICE

Simon Perreault

Viagénie

{mailto|sip}:Simon.Perreault@viagenie.ca

http://www.viagenie.ca

Credentials

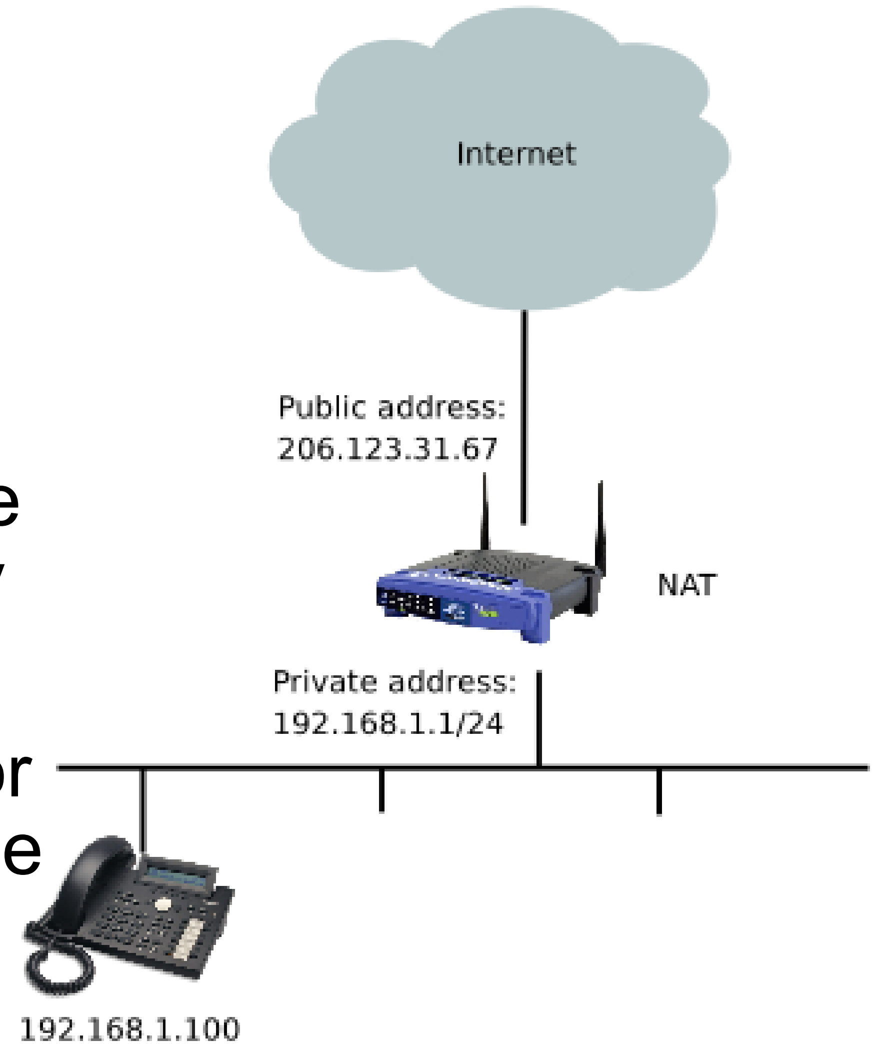
- Consultant in IP networking and VoIP at Viagénie.
- Developed Numb, a STUN / TURN server.
- Ported FreeSWITCH to IPv6.
- Co-ported Asterisk to IPv6.
- Developed many custom VoIP applications.

Plan

- The problem of NAT and firewalls in VoIP
- How STUN, TURN, and ICE solve it
- Asterisk specifics
- Wireshark traces

The Problem of NAT and Firewalls in VoIP

- Network address translators (NATs) are common devices that “hide” private networks behind public IP addresses.
- Connections can be initiated from the private network to the Internet, but not the other way around.
- Having separate addresses for signaling and media makes the situation worse.



Server-Reflexive Address

- A NAT device works by associating a public address and port with a private destination address and port.

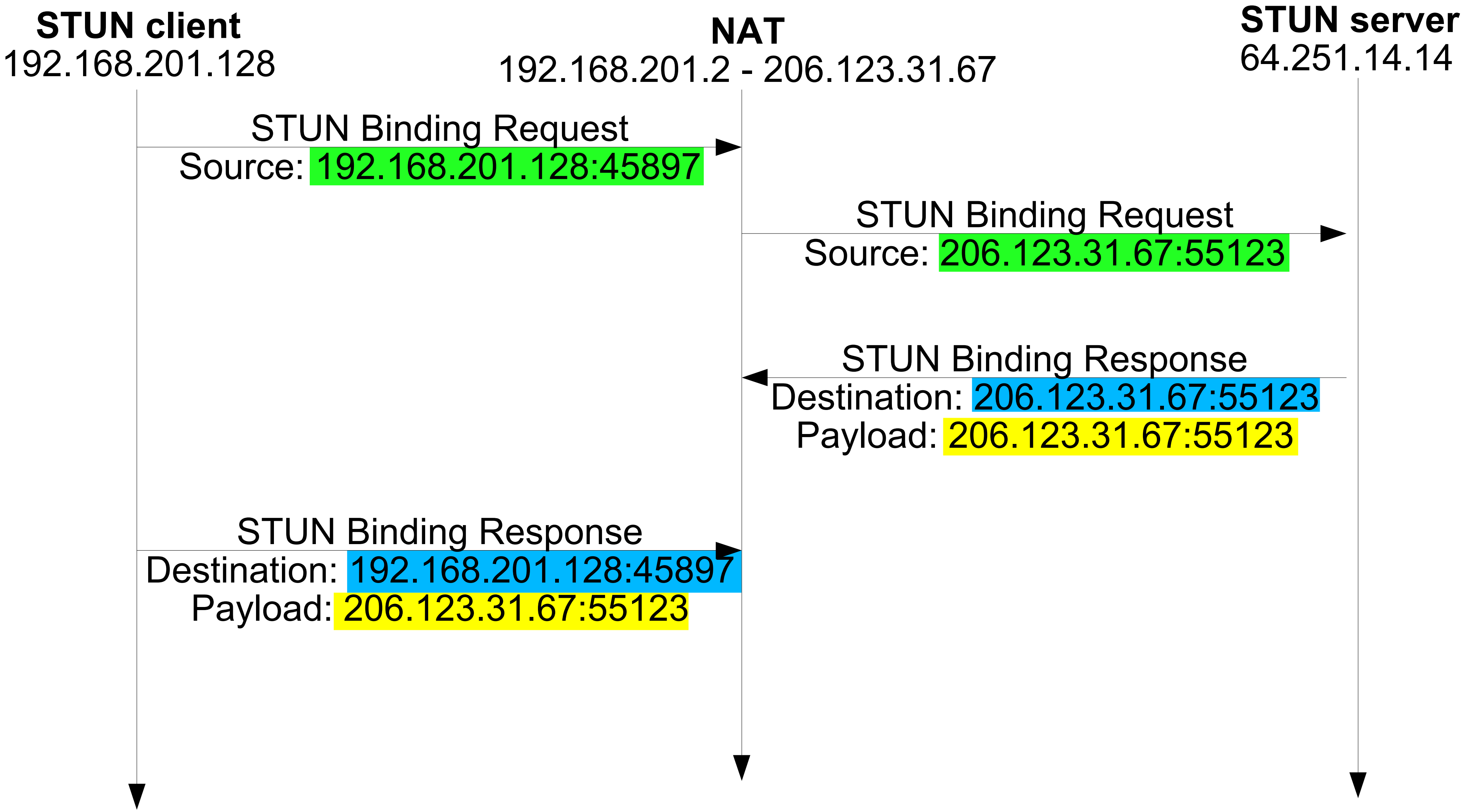
Public		**Private**
206.123.31.67 : 55123	↔	192.168.1.2 : 5060

- Valid for duration of flow
  - Meaning of “flow” for UDP?
  - Must be kept alive.
- Useful to discover this address.

STUN

- Session Traversal Utilities for NAT (STUN): simple protocol for discovering the server-reflexive address.
  - Client: Where do you see me at?
  - Server: I see you at 206.123.31.67:55123.
- A STUN server is located in the public Internet or in an ISP's network when offered as a service.
  - Double NATs pose an interesting problem...

STUN Flow Diagram



STUN

- It turns out that some NAT devices try to be clever by inspecting the payloads and changing all references to the server-reflexive address into the private address.
- STUN2 obfuscates the address by XORing it with a known value.
- TCP and UDP are supported over IPv4 and IPv6.

Server-Reflexive Address

- A client who knows its server-reflexive address could use it in place of its private address in the SIP headers.
  - Not the intended usage. See *sip-outbound* IETF draft.
- Intended usage: RTP ports.
- RTP port ⇒ NAT binding ⇒ STUN request

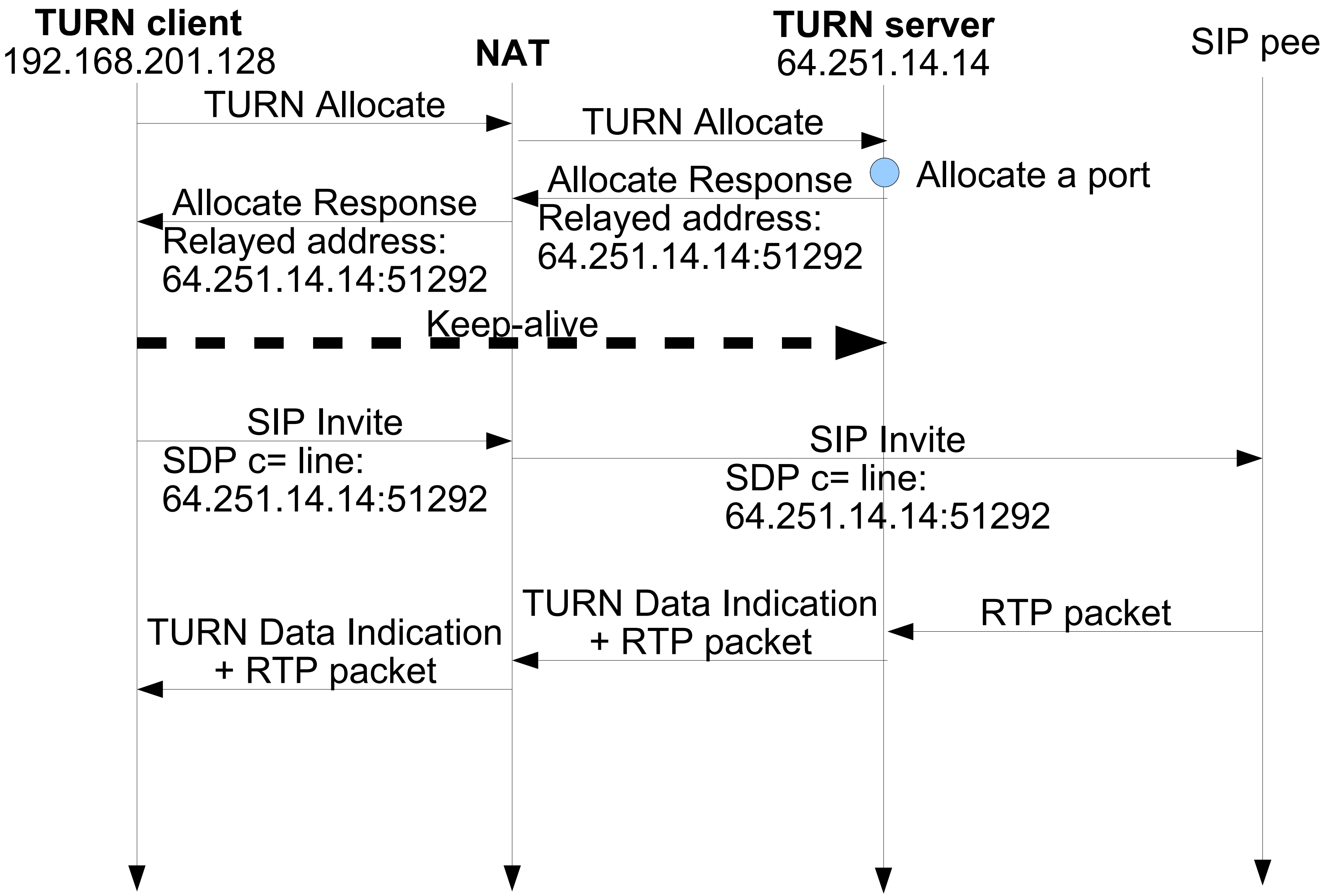
Symmetric NATs

- Some NAT devices only allow packets from the remote peer to reach the NATed peer.
  - Address dependent
  - Port dependent
  - Both
  - Implication: knowing server-reflexive address is useless.
- These NAT devices are called *symmetric NATs*.
  - Often “enterprise” NATs $\Rightarrow$ many devices.
  - Significant presence, must be worked around.

TURN

- Makes devices behind symmetric NATs reachable.
  - Device initiates and maintains connection to relay.
- Traversal Using Relays around NAT (TURN)
  - Protocol between NATed device and relay.
  - Built on top of STUN.
- TURN server is located outside the NAT.
  - On the public Internet
  - or in an ISP's network when offered as a service by the ISP.

TURN Flow Diagram



Relayed Address

- The address allocated by the TURN server is called the *relayed address*.
  - TURN server communicates it to TURN client.
  - TURN client communicates it to SIP peer.
- The TURN client may use it in the SIP headers.
- Intended usage: RTP ports.
- RTP port ⇒ NAT binding ⇒ TURN allocation
- TURN **guarantees** communication in all NAT cases unless there is an explicit firewall policy to prohibit its use.

Disadvantages of TURN

- TURN server is in forwarding path.
  - Requires a lot of bandwidth.
  - Server must remain available for the whole duration of the allocation.
  - Triangle routing results in longer path.
- Encapsulation.
  - Lowers MTU (not so much a problem for VoIP packets).
  - Additional headers consume a bit more bandwidth.
  - Firewall must inspect payload to discover real sender.
- Allocation must be kept alive.

Disadvantages of TURN

- ICMP not relayed.
  - No path MTU discovery.
- TTL not properly decremented.
  - Possibility of loops.
- DiffServ (DS) field not relayed.
- As of now only IPv4 and UDP.

Mitigating Mechanisms

- Availability and scalability provided by anycast.
  - Only used for discovery, server must remain up for the duration of the allocation.
- Channel mechanism for minimizing header size.
  - 4 bytes only.
- Permission mechanism enforced by TURN server.
  - Only peers previously contacted by client may send data to relayed address.
  - Firewall may “trust” the TURN server, no payload inspection.
- Keep TURN server close to NAT device.
  - Offered as a service by ISPs.

IPv4 and IPv6 Interoperability

- TURN will also be used to relay packets between IPv4 and IPv6.
- Alleviates load from the B2BUA.
  - Designed for relaying performance.
  - Anycast ensures scalability and reliability.
- TURNv6 draft still in progress.

Numb

- Numb is a STUN and TURN server developed by Viagénie.
  - Supports IPv4 and IPv6 in mixed scenarios.
  - Supports anycast.
- Free access at http://numb.viagenie.ca
- To install it in your own network, contact us: info@viagenie.ca

Connectivity Establishment

- Many addresses may be available:
  - Host addresses.
  - Server-reflexive address.
  - Relayed address.
  - Each in IPv4 and IPv6 flavour!
  - Each in UDP and TCP flavour!
- Which one to choose?
- Need for an automatic *connectivity establishment* mechanism.

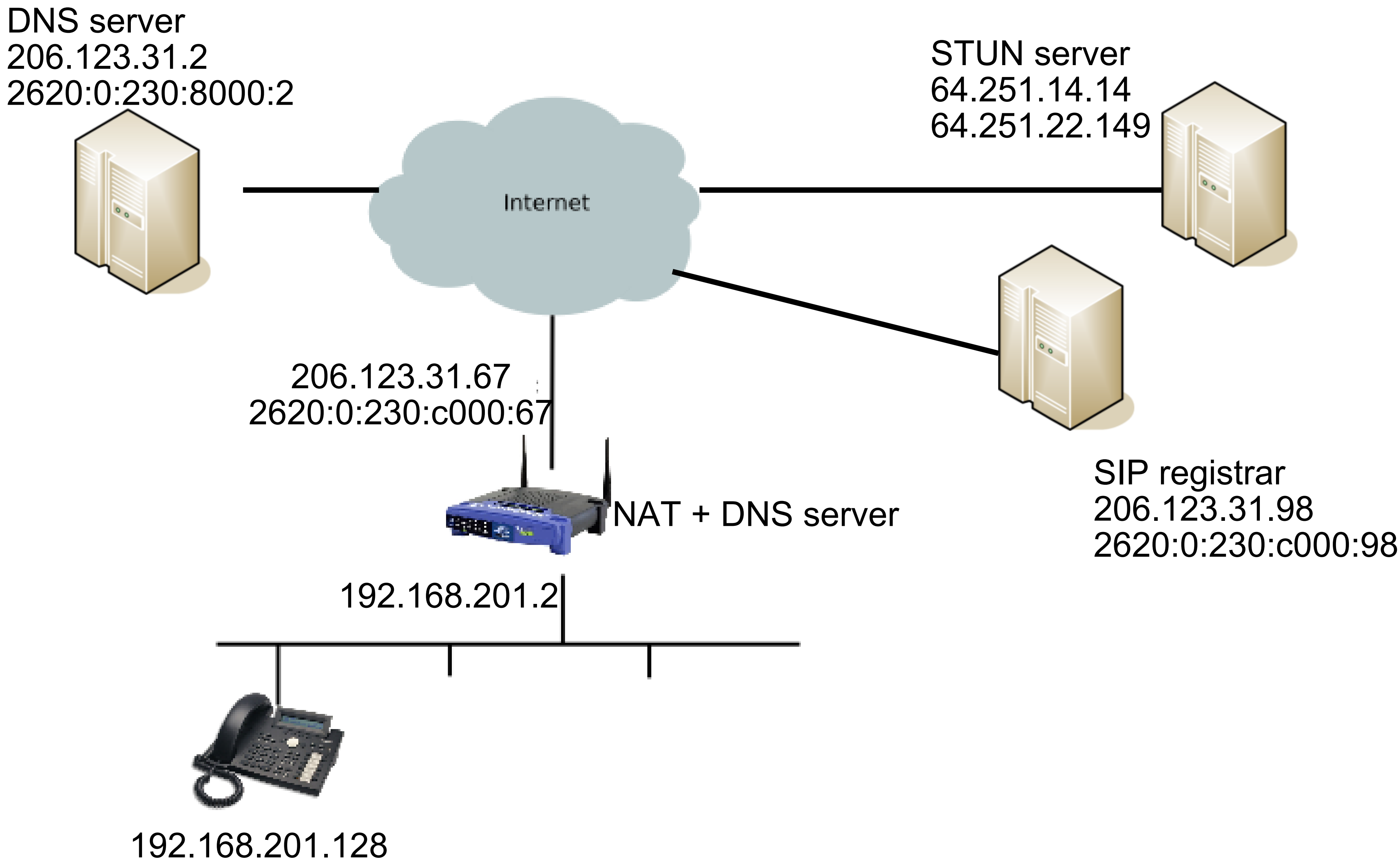
Interactive Connectivity Establishment (ICE)

- Conceptually simple.
  - Gather all *candidates* (using STUN/TURN).
  - Order them by priority.
  - Communicate them to the callee in the SDP.
  - Do connectivity checks.
  - Stop when connectivity is established.
- Gnarly details:
  - Keep candidates alive.
  - Agree on priority.
  - Reduce delays and limit packets.

Peer-Reflexive Address

- Remember: Server-reflexive address useless with symmetric NAT.
- Address as seen from peer (instead of STUN server) is *peer-reflexive address.*
  - Works even with a symmetric NAT.
    - ...but not two of them (TURN still necessary).
- During ICE connectivity checks, peer-reflexive candidates are gathered and prepended to check list.
- Information reuse between ICE instances.

Examples


DNS server
206.123.31.2
2620:0:230:8000:2
Internet
STUN server
64.251.14.14
64.251.22.149
206.123.31.67
2620:0:230:c000:67
NAT + DNS server
SIP registrar
206.123.31.98
2620:0:230:c000:98
192.168.201.2
192.168.201.128

Asterisk Specifics

- NAT traversal in 1.6 was greatly enhanced
  - Can define internal NATed network (*localnet*)
  - Can determine external address either...
    - directly (*externip*)
    - via dynamic DNS (*externhost*)
    - with a **STUN client** (*stunaddr*)
- RFC 3581 rport mechanism (*nat = yes*)
- Don't re-INVITE internal ↔ external calls (*canreinvite = nonat*)

Deployment

- ISPs are deploying STUN / TURN servers within their network.
- TURN a part of the IPv6 migration.
- SIP client vendors are implementing ICE.
- B2BUAs also should implement ICE.

Conclusion

- Discussed
  - The problem of NAT and firewalls in VoIP
  - How STUN, TURN, and ICE solve it
    - Obtaining a server reflexive address via STUN
    - Obtaining a relayed address via TURN
    - Telling the other party about these addresses via ICE
    - Making connectivity checks
    - Obtaining peer reflexive addresses
- STUN / TURN / ICE stack too thick? Use IPv6!

Questions?

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Simon.Perreault@viagenie.ca

This presentation: http://www.viagenie.ca/publications/

STUN / TURN server: http://numb.viagenie.ca

References:

STUNv1 RFC: http://tools.ietf.org/html/rfc3489

STUNv2 draft: http://tools.ietf.org/html/draft-ietf-behave-rfc3489bis

TURN draft: http://tools.ietf.org/html/draft-ietf-behave-turn

ICE draft: http://tools.ietf.org/html/draft-ietf-mmusic-ice