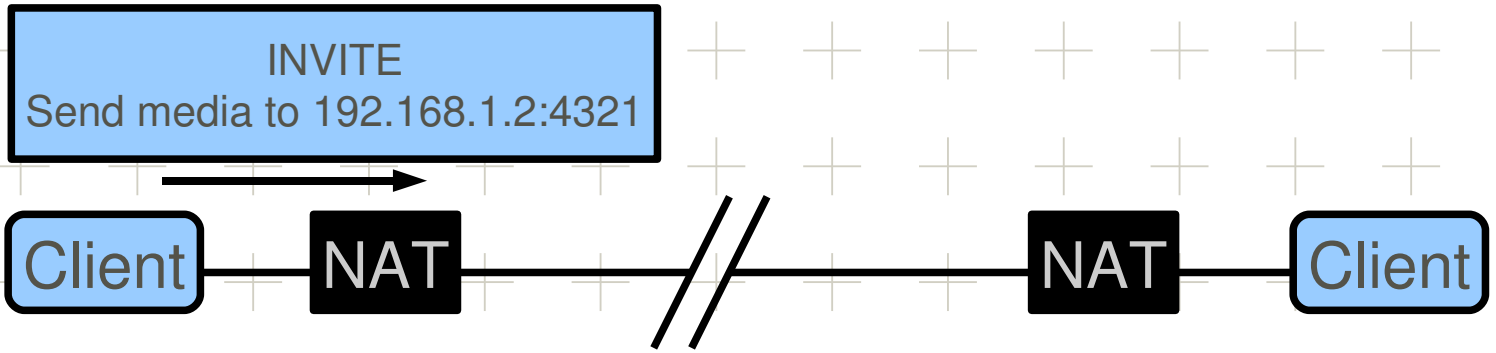
ICE, TURN and STUN

Stephen Strowes

31/Oct/2008

NOKIA

NATs



- NAT Terminology
  - Full cone
  - Restricted cone
  - Port-restricted cone
  - Symmetric
- Guarantees…
- Packet rewriting (ALGs)…

ICE, Interactive Connectivity Establishment

- ICE is a mechanism to permit media streams to flow between two peers in a NATed environment
- An extension to SIP, it can be used by other signalling mechanisms

ICE, Interactive Connectivity Establishment

- http://tools.ietf.org/html/draft-ietf-mmusic-ice
- Really high-level of how ICE-enabled peers enable comms:
  1. Discover information about network, be pessimistic
  2. Exchange information about network (signalling)
  3. Systematically probe possibilities to find useful connection

ICE, Interactive Connectivity Establishment

- http://tools.ietf.org/html/draft-ietf-mmusic-ice
- Allows hosts in same NAT realm to communicate directly...
  - ... and also ...
- Allows hosts behind symmetric NATs to communicate via a relay
- And variations in-between...

ICE, Terminology

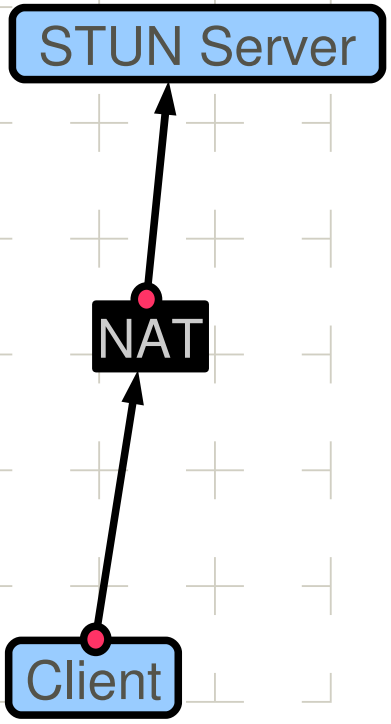
- ICE deals with *components*
  - 1 component per media stream
    - e.g., 1 for RTP, 1 for RTCP
  - Each media stream may nominate multiple candidate addresses
- Candidate: A transport address (ip:port) which may offer reachability for data incoming from an opposing peer

ICE, Sequence of Events

- In a little more detail:
  1. Candidate gathering
     - STUN
     - TURN
  2. Prioritisation
  3. Exchange
  4. Connectivity checks
  5. Coordination
  6. Communication

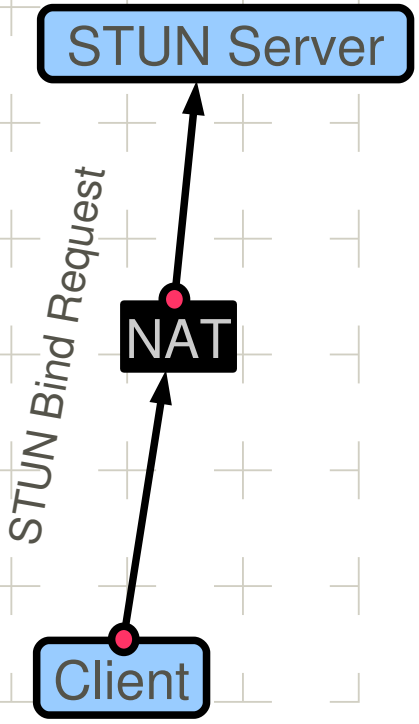
ICE, Candidate Gathering

- Uses STUN & TURN
- Each host possibly has multiple candidates…
  - Host
  - Server reflexive
  - Relay
  - Peer reflexive (later…)



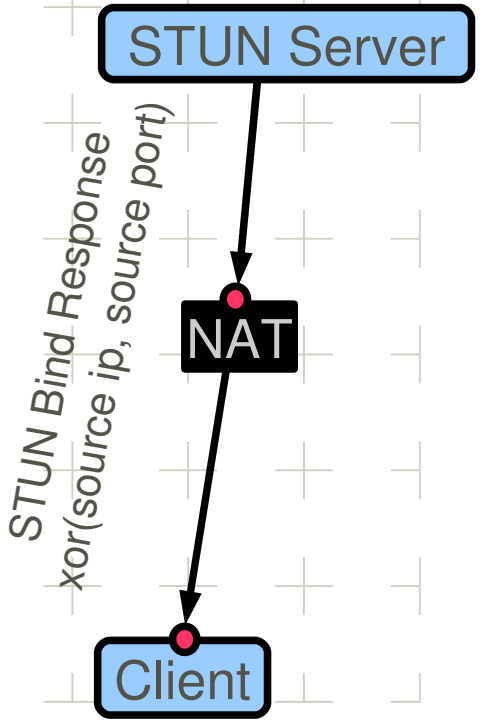
STUN: Session Traversal Utilities for NAT

- http://tools.ietf.org/html/draft-ietf-behave-rfc3489bis
  - Returns the public-side of the binding
  - XOR-mapped address



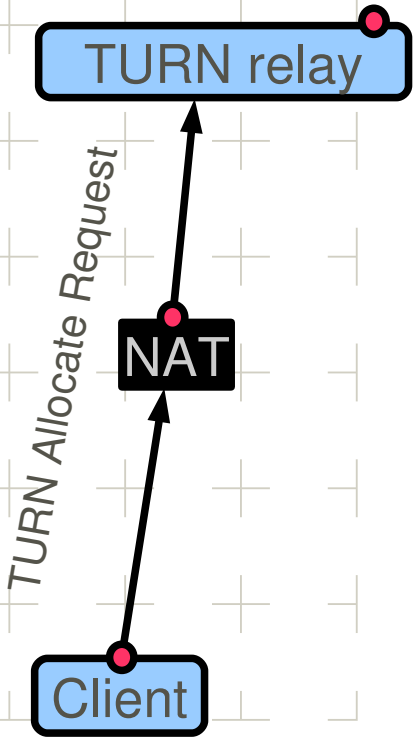
STUN: Session Traversal Utilities for NAT

- http://tools.ietf.org/html/draft-ietf-behave-rfc3489bis
  - Returns the public-side of the binding
  - XOR-mapped address



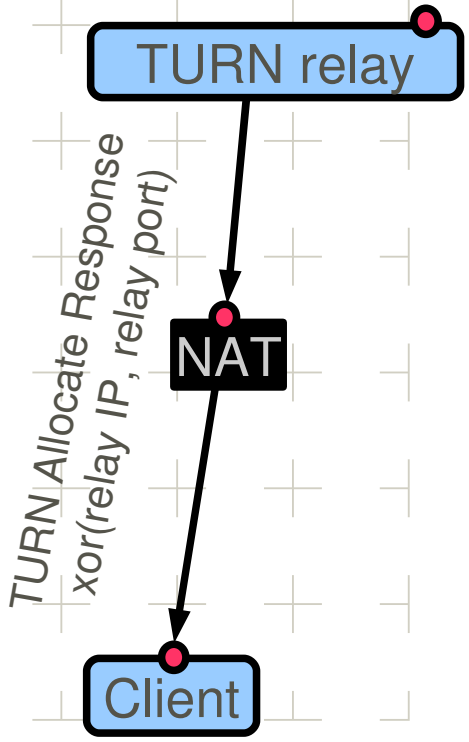
TURN: Traversal Using Relays around NAT

- http://tools.ietf.org/html/draft-ietf-behave-turn
  - Allocations
    - Allocate a socket on the relay…
  - Permissions
    - Inform relay which locations it should accept packets from for relaying back to client



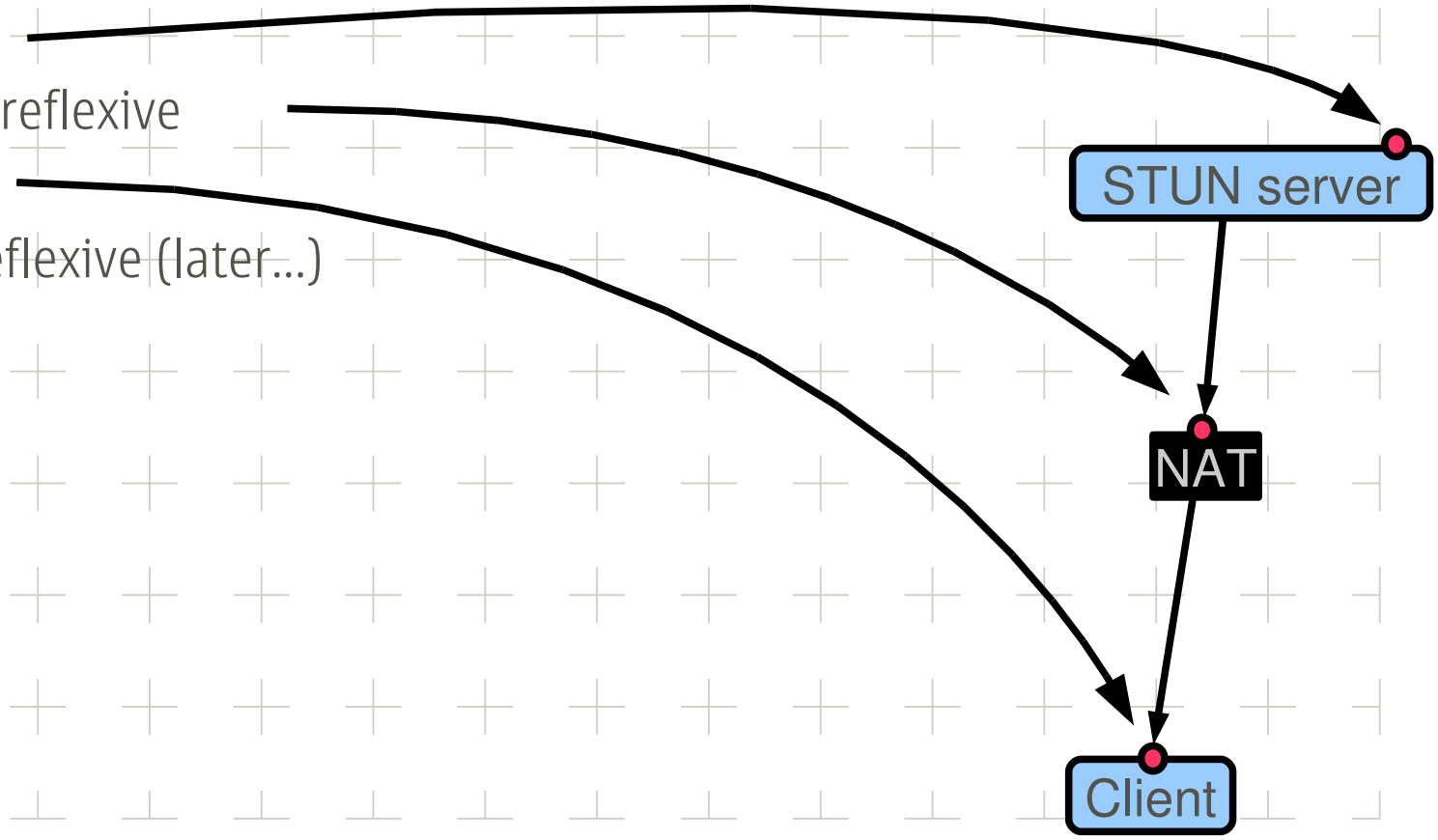
TURN: Traversal Using Relays around NAT

- http://tools.ietf.org/html/draft-ietf-behave-turn
  - Allocations
    - Allocate a socket on the relay…
  - Permissions
    - Inform relay which locations it should accept packets from for relaying back to client



ICE, Candidate Gathering

- Uses STUN & TURN
- Possibly multiple candidates…
  - Relay
  - Server reflexive
  - Host
  - Peer reflexive (later…)

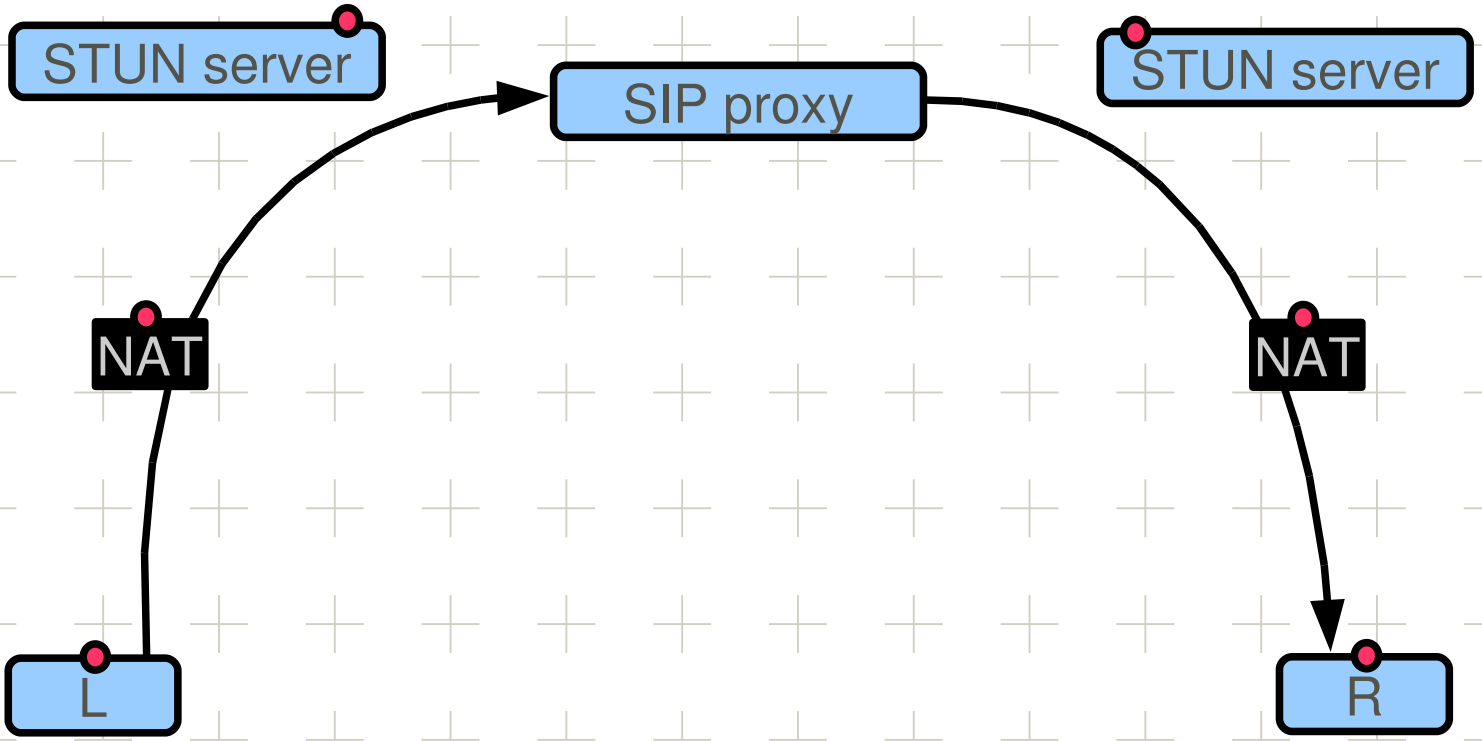


ICE, Prioritisation

- prio = 2^{24}(type_pref) + 2^{8}(local_pref) + (256 – component_ID)
- *Type preference:*
  - 0 Relayed candidates
  - 100 Server reflexive candidates
  - 110 Peer reflexive candidates
  - 126 Host candidates
- *Local preference:*
  - Preference by interface, by STUN server…
- *Component ID:*
  - As described (RTP=1; RTCP=2)

ICE, Candidate Exchange

- Signalling carries the gathered candidates
  - In SIP, INVITE & response
- SDP carries the candidates for ICE usage…



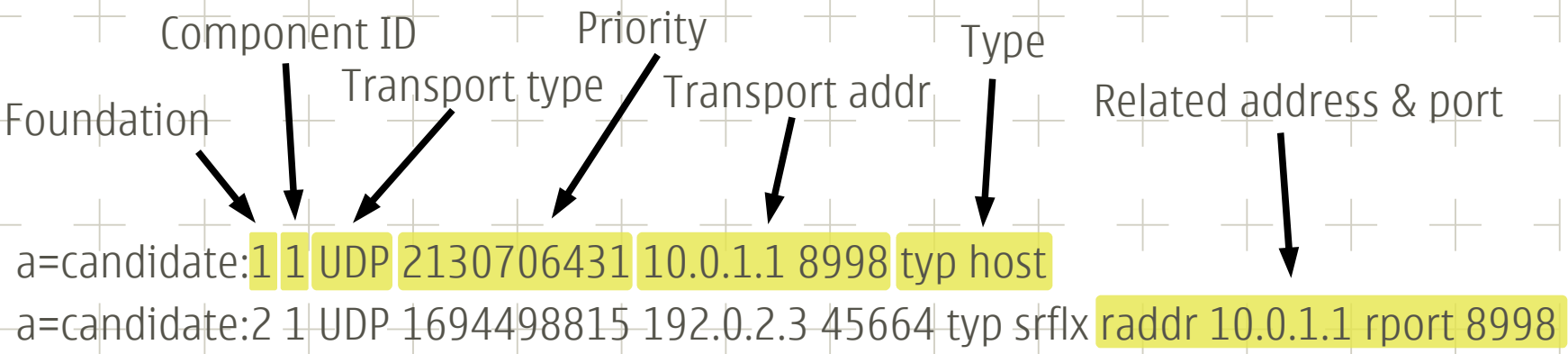
ICE, Candidate Exchange

- Signalling carries the gathered candidates
  - In SIP, INVITE & response
- SDP carries the candidates for ICE usage…

a=candidate:1 1 UDP 2130706431 10.0.1.1 8998 typ host
a=candidate:2 1 UDP 1694498815 192.0.2.3 45664 typ srflx raddr 10.0.1.1 rport 8998

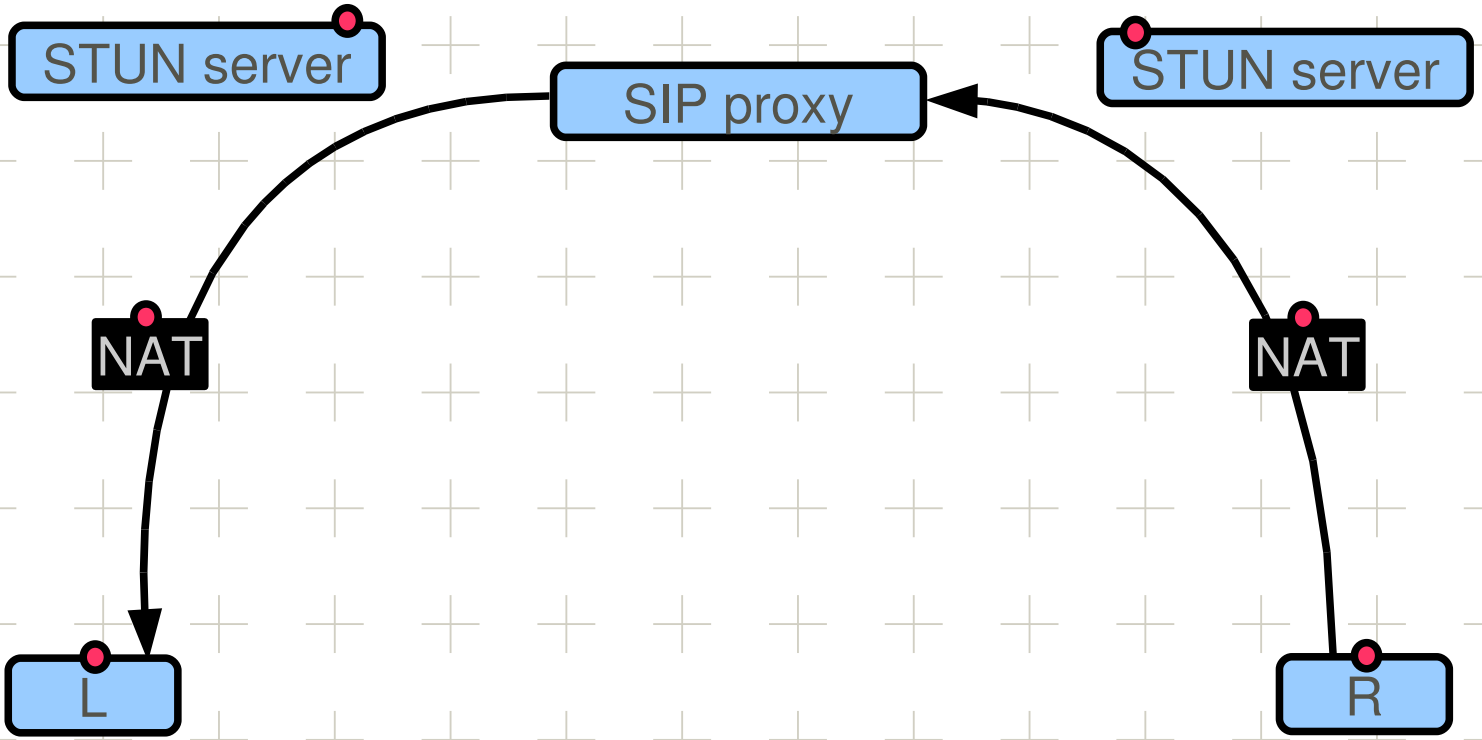
ICE, Candidate Exchange

- Signalling carries the gathered candidates
  - In SIP, INVITE & response
- SDP carries the candidates for ICE usage…



ICE, Candidate Exchange

- Signalling carries the gathered candidates
  - SIP response carrying opposing peer's candidate set



ICE, Connectivity Checks

- Pair the local candidates off against the remote candidates
- Calculate pair priority as:
  - $2^{32}\min(P_L,P_R) + 2\max(P_L,P_R) + (P_L > P_R ? 1:0)$
- Order the list by priority…
- Prune duplicates

ICE, Connectivity Checks

- Pair the local candidates off against the remote candidates

HostL -- HostR
SrflxL -- HostR
RelayL -- HostR
HostL -- SrflxR
SrflxL -- SrflxR
RelayL -- SrflxR
HostL -- RelayR
SrflxL -- RelayR
RelayL -- RelayR

ICE, Connectivity Checks

- Prioritise and order candidates…
  - $2^{32}\min(P_L,P_R) + 2\max(P_L,P_R) + (P_L>P_R?1:0)$

126-126	HostL	--	HostR
100-126	SrflxL	--	HostR
0-126	RelayL	--	HostR
100-126	HostL	--	SrflxR
100-100	SrflxL	--	SrflxR
0-100	RelayL	--	SrflxR
0-126	HostL	--	RelayR
0-100	SrflxL	--	RelayR
0-0	RelayL	--	RelayR

ICE, Connectivity Checks

- Prioritise and order candidates…
  - $2^{32}\min(P_L,P_R) + 2\max(P_L,P_R) + (P_L>P_R?1:0)$

126-126	HostL	--	HostR
100-126	SrflxL	--	HostR
100-126	HostL	--	SrflxR
100-100	SrflxL	--	SrflxR
0-126	RelayL	--	HostR
0-126	HostL	--	RelayR
0-100	RelayL	--	SrflxR
0-100	SrflxL	--	RelayR
0-0	RelayL	--	RelayR

ICE, Connectivity Checks

- Prune duplicates…
  - Replace local candidates with their bases

126-126	HostL	--	HostR
100-126	SrflxL	--	HostR
100-126	HostL	--	SrflxR
100-100	SrflxL	--	SrflxR
0-126	RelayL	--	HostR
0-126	HostL	--	RelayR
0-100	RelayL	--	SrflxR
0-100	SrflxL	--	RelayR
0-0	RelayL	--	RelayR

ICE, Connectivity Checks

- Prune duplicates…
  - Replace local candidates with their bases

126-126	HostL	--	HostR
100-126	HostL	--	HostR
100-126	HostL	--	SrflxR
100-100	HostL	--	SrflxR
0-126	RelayL	--	HostR
0-126	HostL	--	RelayR
0-100	RelayL	--	SrflxR
0-100	HostL	--	RelayR
0-0	RelayL	--	RelayR

ICE, Connectivity Checks

- Prune duplicates…
  - Remove duplicates, retain highest priority duplicate

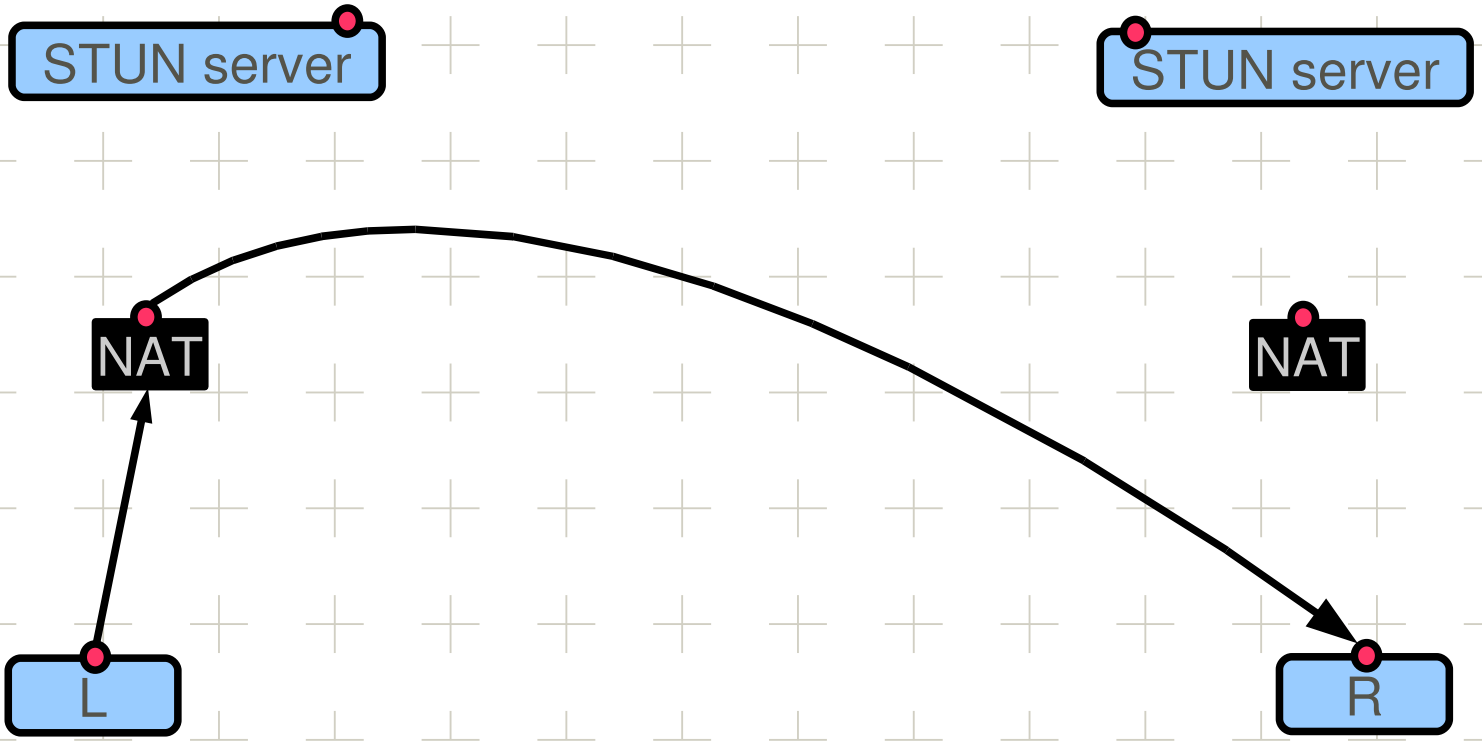
126-126 HostL -- HostR
100-126 HostL -- SrflxR
0-126 RelayL -- HostR
0-126 HostL -- RelayR
0-100 RelayL -- SrflxR
0-0 RelayL -- RelayR

ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs
- Checks are paced
  - 1 every 20 ms
- Frozen Algorithm
- Normal checks (following prioritisation)
- Triggered checks (optimisation)

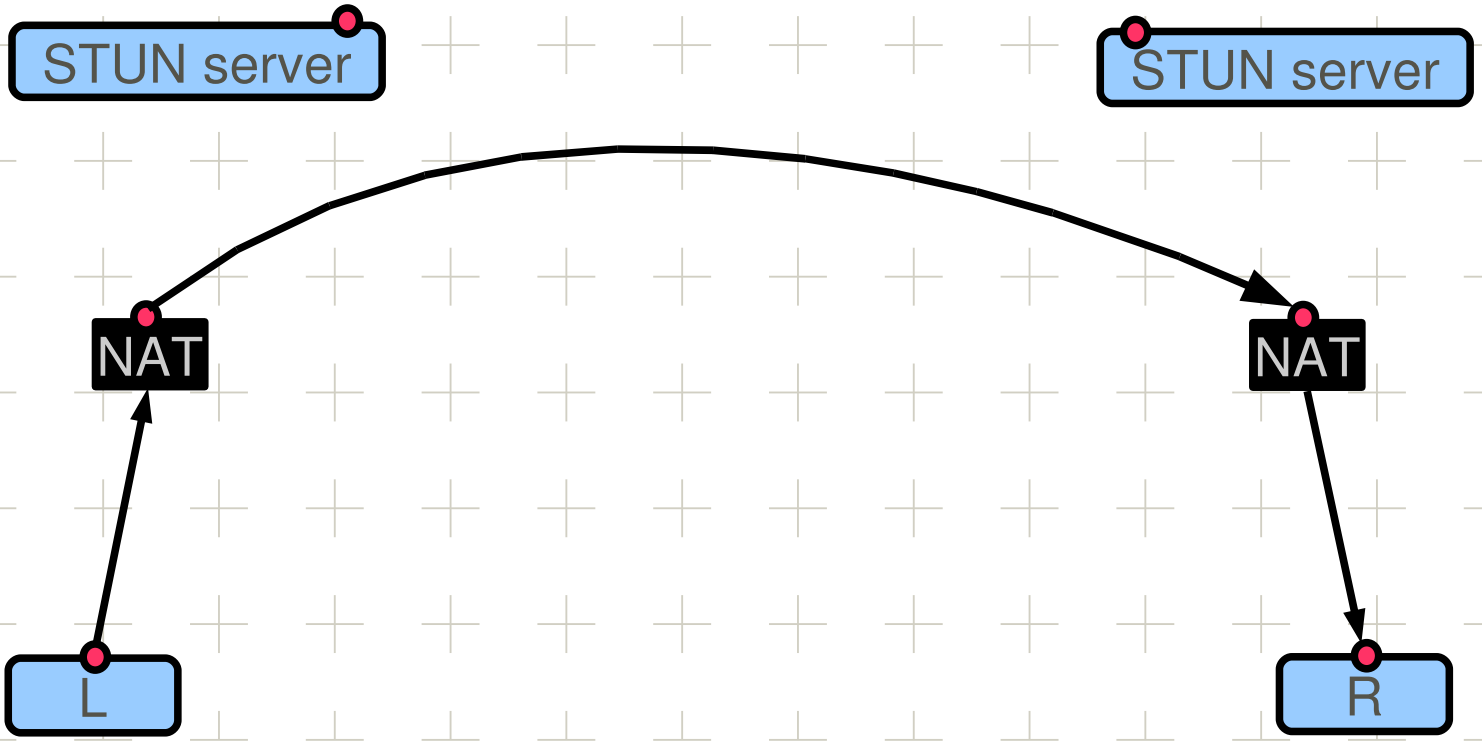
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



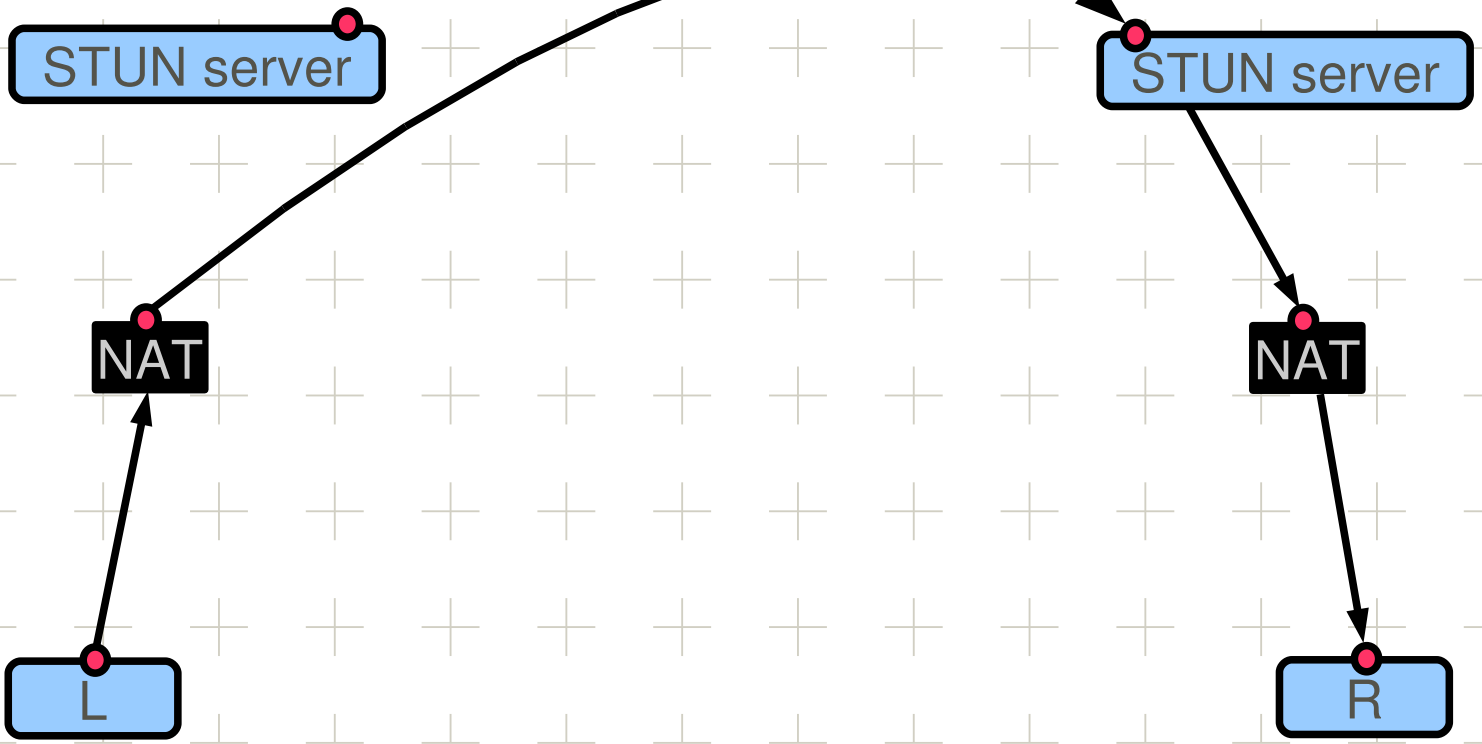
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



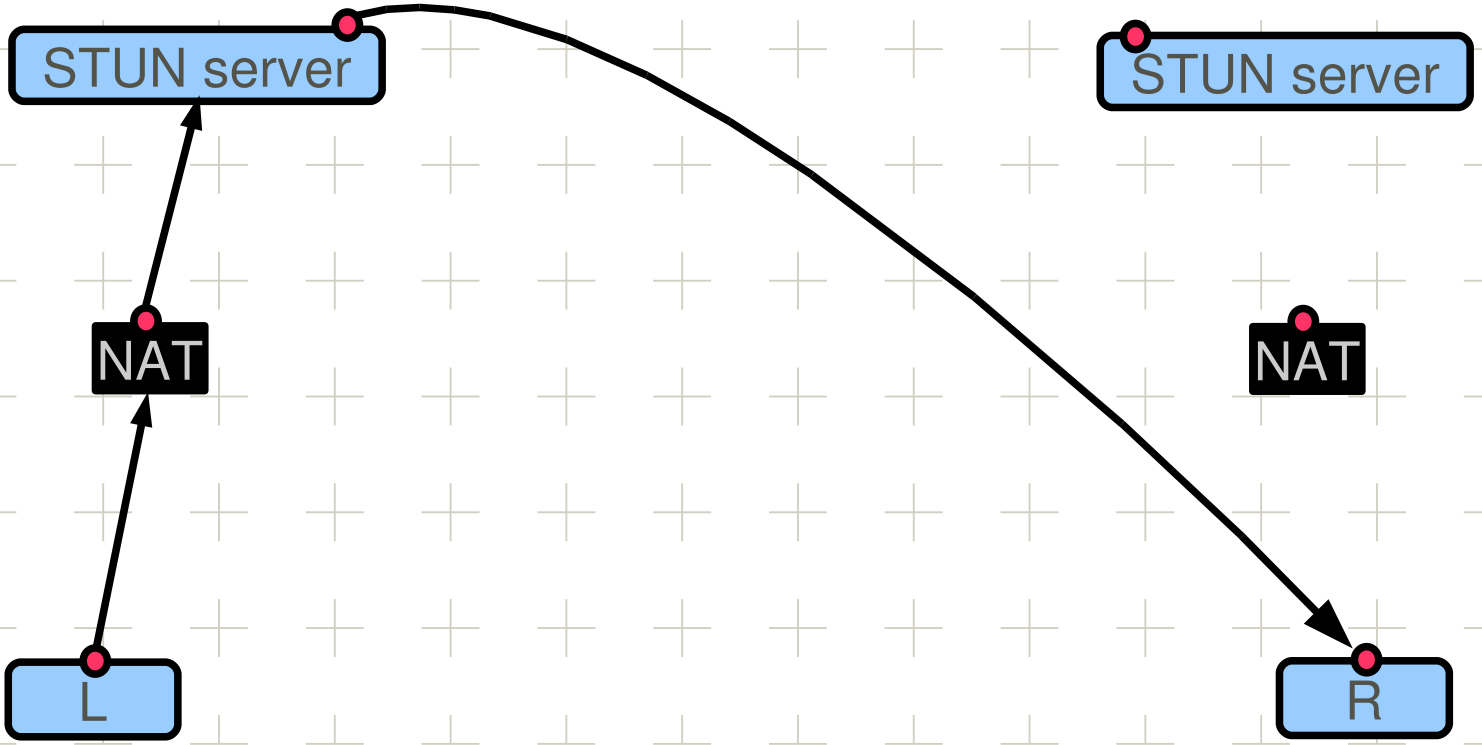
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



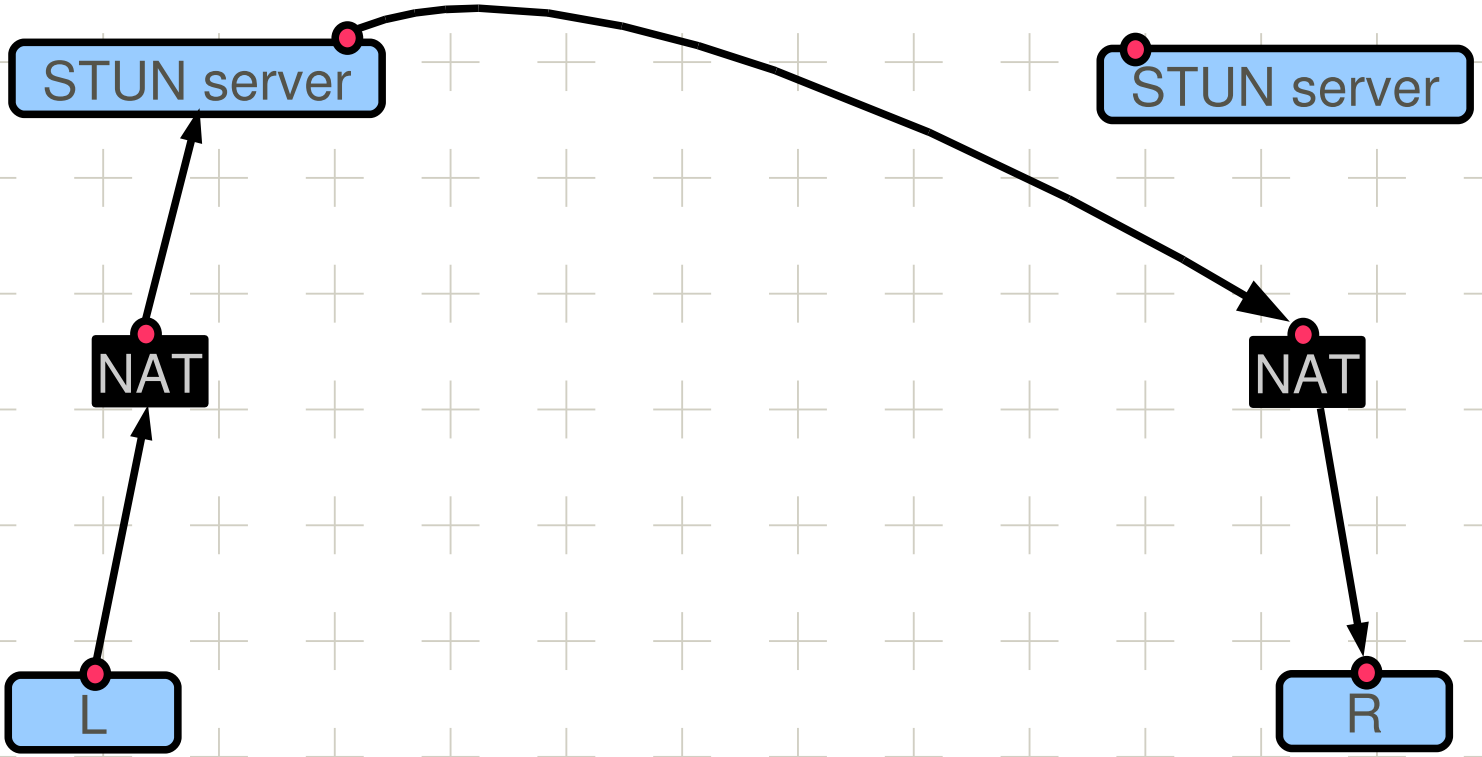
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



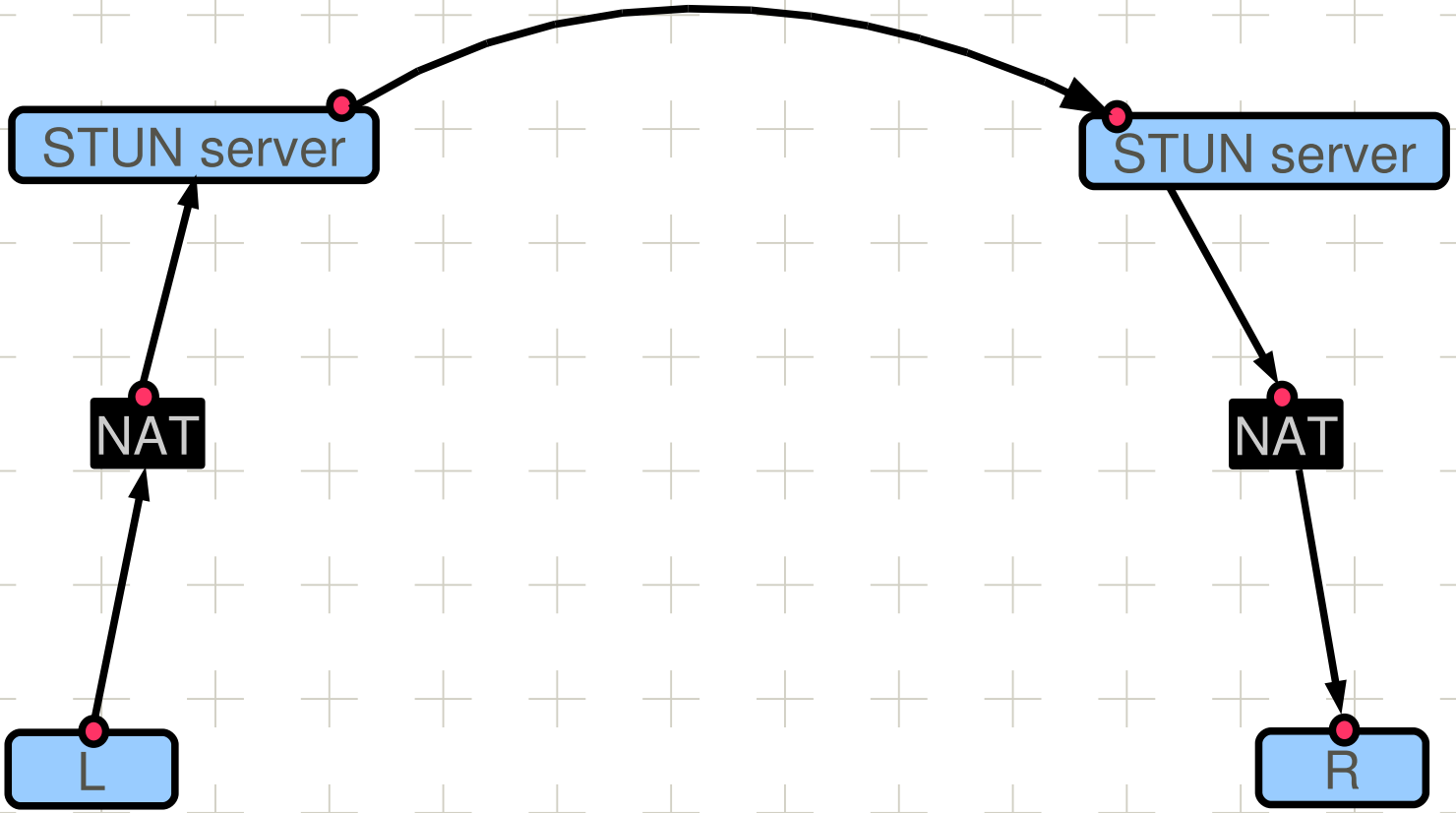
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



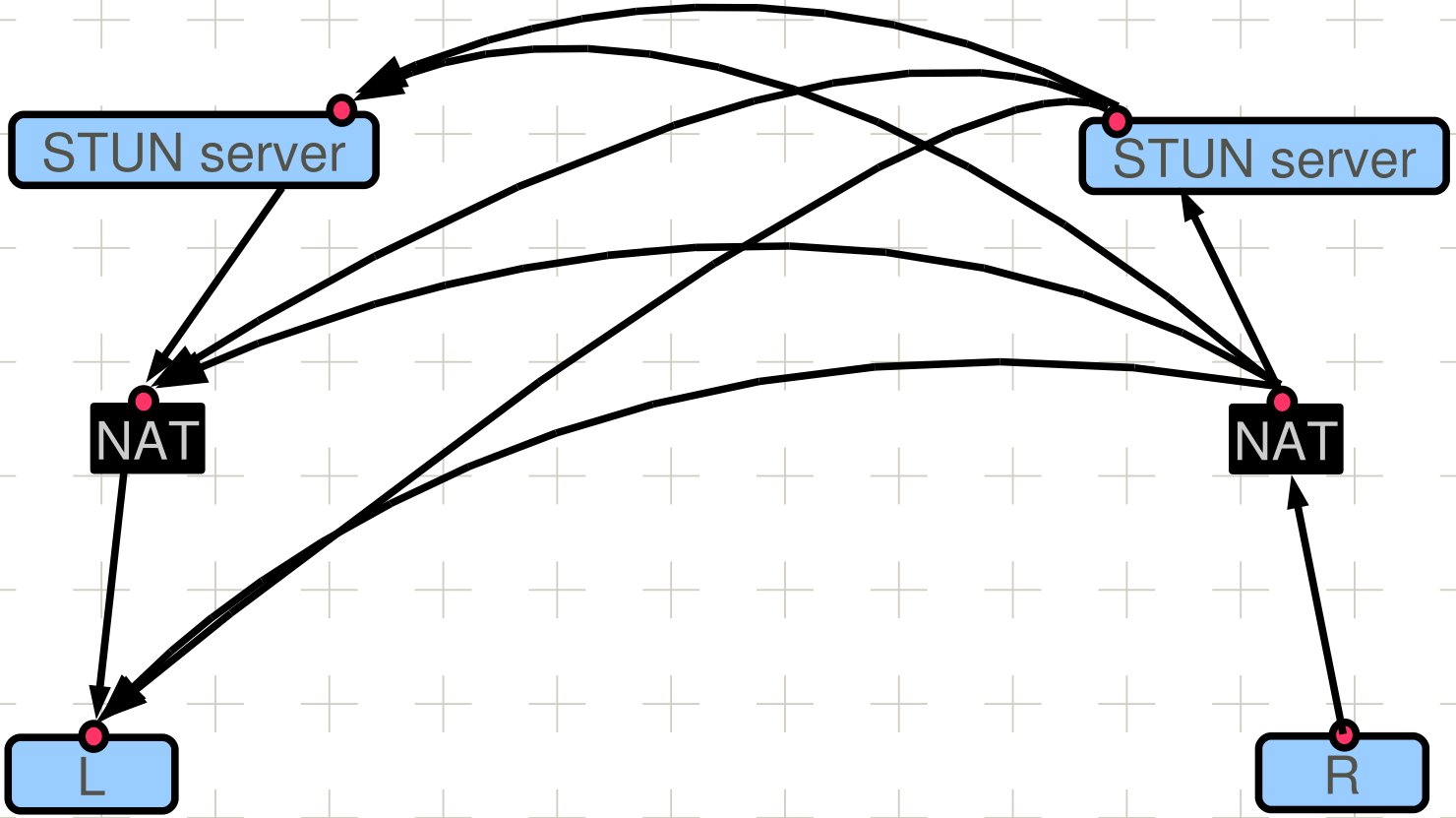
ICE, Connectivity Checks

- Series of STUN *requests* and *responses* between these pairs



ICE, Connectivity Checks

- … and host R does the same …

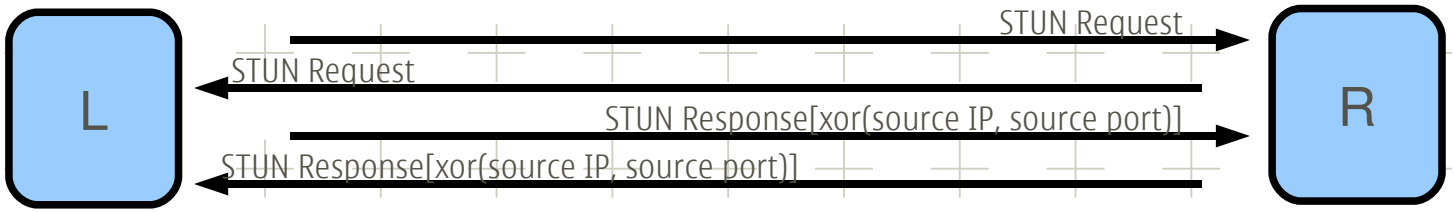


ICE, Frozen Algorithm

- Generally, have multiple components (RTP, RTCP…), each with their own candidate sets
- ICE assumes that similar candidate pairs between components will exhibit similar characteristics
  - Initially all pairs are frozen; highest priority pair "unfrozen" and checked
  - If a STUN request comes in from one of the frozen pairs, unfreeze it such that it's the next check to be dispatched (*triggered check*)

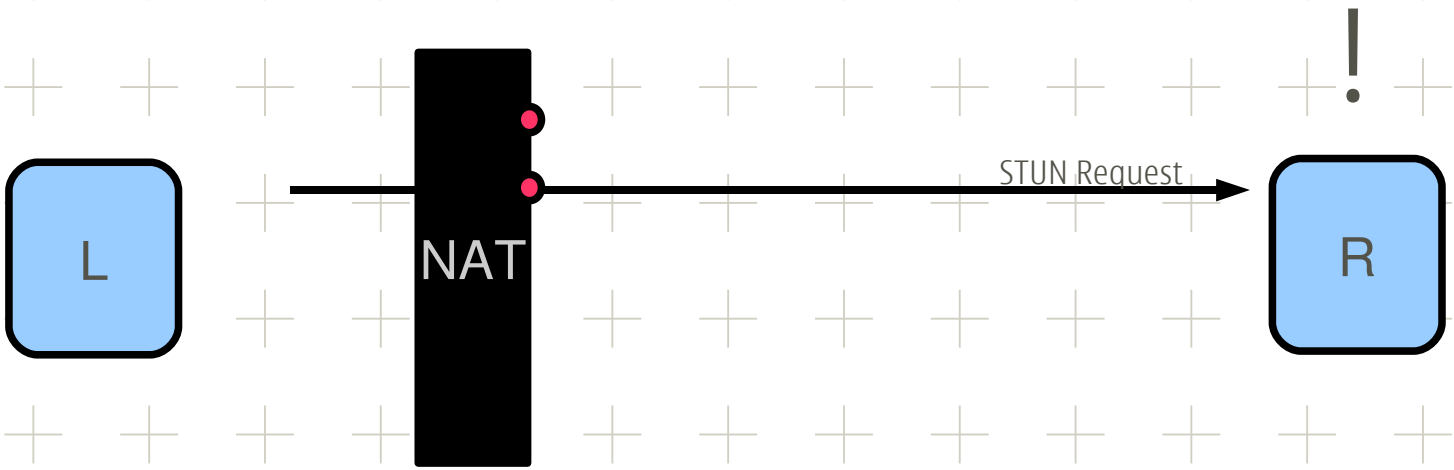
ICE, Connectivity Checks

- 4-way handshake



ICE, Connectivity Checks

- Peer Reflexive candidate discovery:
- A STUN check through a symmetric NAT will reveal to the receiving peer a new candidate address



ICE, Coordination

- Signal completion (achieved directly between peers)
- Regular Nomination by controlling peer
  - Re-send a STUN check, with a flag set
- Aggressive nomination by controlling peer
  - Set flag in all STUN checks, such that the first working candidate is chosen

ICE, Communication

joy

Nokia Research Center

NOKIA

Security Mechanisms

- TURN:
  - Long-term credentials
    - Digest challenge
- Connectivity checks:
  - Short-term credentials
    - Time-limited

MIMP: Mobile Internet Measurement Platform

Nokia Research Center

NOKIA

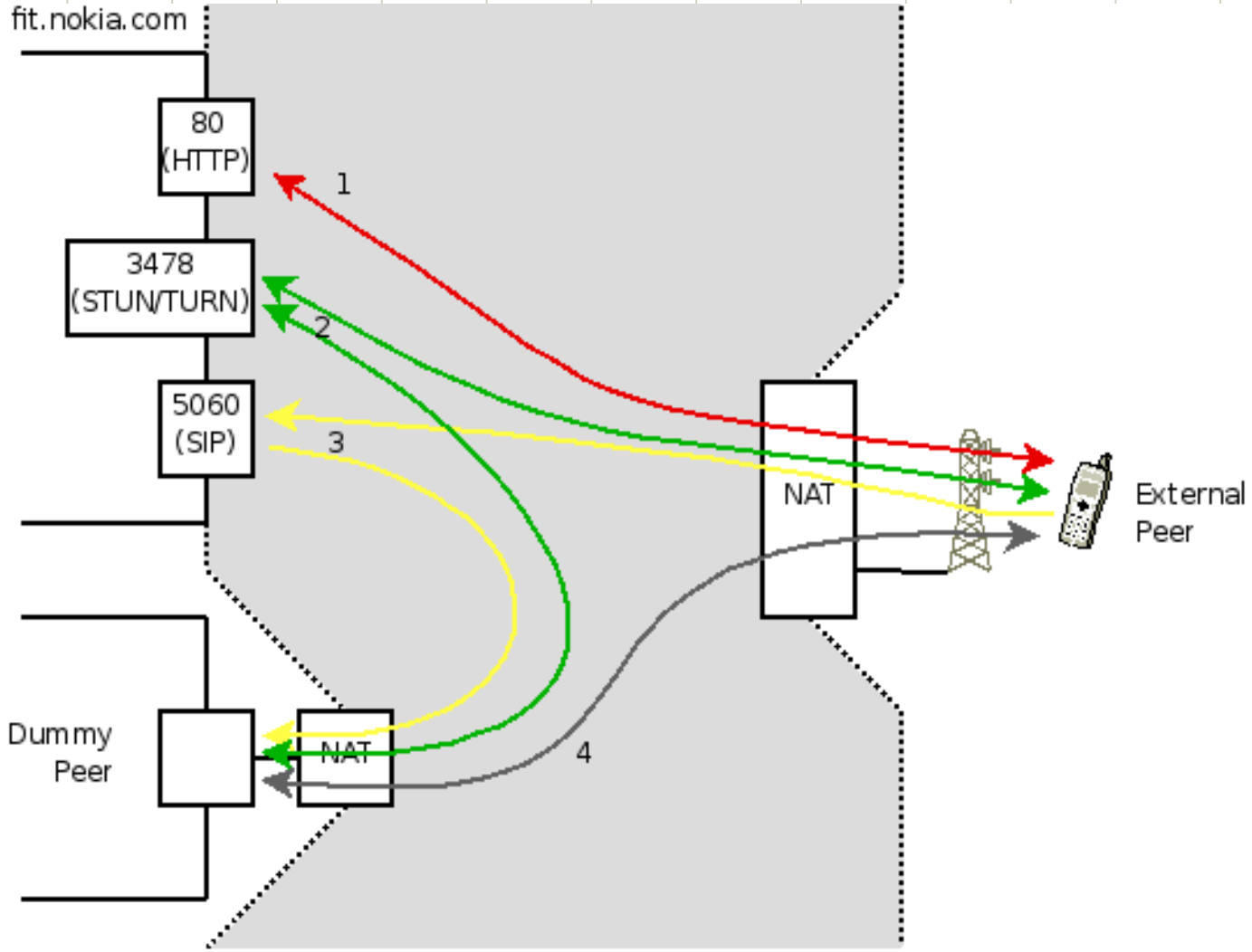
MIMP: Mobile Internet Measurement Platform

- Aim is to support multiple different kinds of tests...
- Collect data from cellphones (etc...) in the real-world
- Server hardware located at Nokia; *fit.nokia.com*

MIMP: Mobile Internet Measurement Platform

- Downloadable client for Symbian
  - Updateable
  - Presents a list of tests to run
- Test-specific configuration via HTTP
- On test completion, submit results over HTTP

MIMP: Mobile Internet Measurement Platform



MIMP: ICE

- SIP server (OpenSER), STUN server/TURN relay (turnserver)
- ICE implementation: pjnath (part of the pjsip project)
  - http://pjsip.org/
- Symbian client grabs test configuration, e.g.,
  - SIP username & password
  - STUN/TURN server
  - SIP agent to contact (located on our machine)
  - Submits logged results to known location over HTTP
- Server side of comms also logs ICE interactions and submits
- Post-processing will take place to generate pretty pictures, graphs, etc

ICE: What don't we know?

- Actual quantifiable data on success rates for ICE
  - These protocols, or the ideas behind them, are being used in the real world, but perhaps they need tweaking
- Performance of connectivity checks
  - Analysis of quality of chosen candidates
- ... and then there's the possibility of collecting information on the type of NATs widely deployed in the Internet

Resources

- ICE: http://tools.ietf.org/html/draft-ietf-mmusic-ice
- STUN: http://tools.ietf.org/html/draft-ietf-behave-rfc3489bis
- TURN: http://tools.ietf.org/html/draft-ietf-behave-turn

Questions?
stephen.strowes@nokia.com

Nokia Research Center

NOKIA