OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG | INF

Communication and Networked Systems

Bachelor/Master Thesis
NAT Traversal for CoAP

Motivation

A wide range of solutions exist for connecting devices in the Internet of Things (IoT). For example, ZigBee & Z-Wave exist for the world of home automation and smart buildings, and LoRaWAN & 6LoWPAN with protocols like the Constrained Application Protocol (CoAP) [1] exist for distributed sensor networks in industrial or agricultural applications. While other technologies usually introduce entirely new network stacks and require specialized hardware transcievers or at least the drivers for it, CoAP works on well-known and widely adopted Internet Protocol (IP)-based infrastructure and already deployed hardware. This makes it the perfect cost-efficient and ready-to-use candidate for most IoT use cases, in theory also for home automation, smart homes, smart cities and alike.

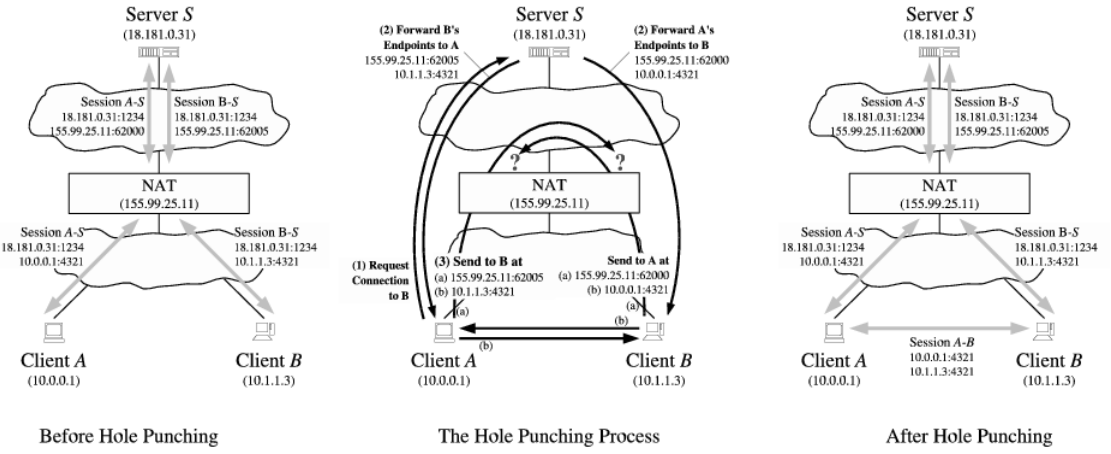

Figure 1. Process of UDP Hole Punching [2].

CoAP is intended to run on IP networks and thus is suitable for direct communication (without any tunnelling or conversion) over the Internet. However communication is usually hindered by Network Address Translation (NAT) and/or firewalls, especially for applications running over legacy Internet Protocol Version 4 (IPv4) networks but also on Internet Protocol Version 6 (IPv6) devices behind firewalls. To traverse those NATs and/or firewalls, several well-known techniques like Session Traversal Utilities for NAT (STUN) [3] and Traversal Using Relays around NAT (TURN) [4] exist. STUN can be used to get knowledge about public IP addresses corresponding to private NAT-ed addresses, and TURN can be used as a last resort to relay information if there is no direct path of communication. Interactive Connectivity Establishment (ICE) [5] combines STUN and TURN to find the best possible solution, and adds NAT hole punching to establish connections without port forwarding, as visualized in Figure 1 [2].

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For the world of web browsers and more powerful machines, the Web Real-Time Communication (WebRTC) protocol stack exists that implements STUN and TURN behaviour [6]. Another notable example is libp2p [7], primarily a framework for building Peer-to-Peer (P2P) networks that also implements NAT traversal, but its complexity and the used transport protocols are not suitable for IoT use cases. RELOAD [8] was already tested with CoAP successfully, but similar to libp2p its scope expands well beyond NAT traversal.

Goal

The goal of this thesis is to develop, implement and evaluate approaches to establish connections between the NAT-ed and/or firewalled peers over the Internet that communicate via CoAP, in the context of IoT.

Depending on the type of the module, the scope can be adjusted accordingly. One could, for example, just implement and evaluate a CoAP-based STUN server and client on RIOT OS, or implement a small protocol suite for multiple tasks.

Tasks

- research current technologies that exist for IoT/CoAP but also for other architectures in general (WebRTC, STUN, TURN, RELOAD, libp2p)
- design and implement approach(es) to establish connections through NAT-ed and/or firewalled networks for CoAP
  - implementation of libraries for embedded applications (in C, e.g. for RIOT OS)
  - testing on real microcontrollers
  - extend/convert STUN and/or TURN, or design own approach(es)
- evaluate the approach(es) on the Magdeburg Internet of Things Laboratory (MIoT-Lab) [9]
  - setup realistic scenarios to test your approaches
  - compare your solution(s) with existing ones, e.g. CoAP over WebRTC [10], Thin-ICE [11]
  - run experiments on tens or hundreds of embedded nodes to stress test your implementation(s)
- write a thesis about it

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