Ubiquitous overlay

Universal connectivity using imperfect hardware

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by

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Preface

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6.1. Analysis and Puncturing of Carrier Grade NAT

According to the report by Statista [2], there were three major mobile phone operators providing services in the Netherlands in Q4 2018. They are listed in Table 6.1. In total, these represent up to 85 % of the market share. The rest of the market is shared by Mobile Virtual Network Operators who sell services over existing networks of those three operators.

Operator	Market share
KPN	35%
Vodafone	25%
Mobile Virtual Network Operators	25%
T-Mobile	20%

Table 6.1: Market share of mobile network operators in the Netherlands in Q4 2018. The shares do not sum up to 100% as they are rounded up within five percent ranges in the original report. [2]

We have purchased pre-paid SIM cards for all three major mobile network operators to investigate whether they are suitable for peer-to-peer communication. First, we tried to infer the characteristics of their Carrier Grade NAT deployments.

We used the STUN protocol and NAT behavior discovery mechanisms described in [1]. They have shown that all networks appear to use *Endpoint-Independent Mapping (EIM)* and *Address and Port-Dependent Filtering* (also known as *port-restricted cone NAT*). EIM is a sufficient condition for our NAT traversal mechanism to be successful, so this would make all these NATs suitable for P2P communication.

However, as NAT behavior can change over time, we performed some more tests to verify that the behavior is consistent over time. We attempted to connect to 50 different peers over the interval of 5 minutes. We verified that KPN and T-Mobile networks are consistent with EIM behavior. However, the Vodafone network changes the mapped port for new connections approximately every 60 seconds, even when connecting to the same IP address and a different port. This behavior can be described as *Address and Port-Dependent Mapping*, which is characteristic for a *symmetric NAT*.

The mapped ports seem to be assigned at random from the range of 10,000 ports, which makes it infeasible to use any known symmetric NAT traversal techniques such as port prediction or multiple hole punching [4][3].

6.2. Performance Evaluation

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7.1. Future Work

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