DOTS
Internet-Draft
Intended status: Informational
Expires: January 4, 2018

R. Dobbins
Arbor Networks
D. Migault
Ericsson
S. Fouant

R. Moskowitz
HTT Consulting
N. Teague
Verisign
L. Xia
Huawei
K. Nishizuka
NTT Communications
July 03, 2017

Use cases for DDoS Open Threat Signaling
draft-ietf-dots-use-cases-06

Abstract

The DDoS Open Threat Signaling (DOTS) effort is intended to provide a protocol that facilitates interoperability between multivendor solutions/services. This document presents use cases to evaluate the interactions expected between the DOTS components as well as DOTS messaging exchanges. The purpose of describing use cases is to identify the interacting DOTS components, how they collaborate and what are the types of information to be exchanged.

Status of This Memo

Table of Contents

1. Introduction

Currently, distributed denial-of-service (DDoS) attack mitigation solutions/services are largely based upon siloed, proprietary communications paradigms which result in vendor/service lock-in. As a side-effect, this makes the configuration, provisioning, operation, and activation of these solutions a highly manual and often time-consuming process. Additionally, coordination of multiple DDoS mitigation solutions/services simultaneously engaged in defending the same organization against DDoS attacks is fraught with both technical and process-related hurdles. This greatly increase operational complexity and often results in suboptimal DDoS attack mitigation efficacy.

The DDoS Open Threat Signaling (DOTS) effort is intended to provide a protocol that facilitates interoperability between multivendor DDoS mitigation solutions/services. As DDoS solutions/services are broadly heterogeneous among different vendors, the primary goal for DOTS is to provide a high level interaction with these DDoS solutions/services such as initiating or terminating DDoS mitigation assistance.

It should be noted that DOTS is not in and of itself intended to perform orchestration functions duplicative of the functionality being developed by the [I2NSF] WG; rather, DOTS is intended to allow devices, services, and applications to request DDoS attack mitigation assistance and receive mitigation status updates from systems of this nature.

The use cases presented in the document are intended to provide examples of communications interactions DOTS-enabled nodes in both inter- and intra-organizational DDoS mitigation scenarios. These use cases are expected to provide inputs for the design of the DOTS protocol(s).

2. Terminology and Acronyms

2.1. Requirements Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2.2. Acronyms

This document makes use of the same terminology and definitions as [I-D.ietf-dots-requirements], except where noted.

2.3. Terms

Inter-organizational: a DOTS communications relationship between distinct organizations with separate spans of administrative control. Typical inter-organizational DOTS communication relationships would be between a DDoS mitigation service provider and an end-customer organizational which requires DDoS mitigation assistance; between multiple DDoS mitigation service providers coordinating mutual defense of a mutual end-customer; or between DDoS mitigation service providers which are requesting additional DDoS mitigation assistance in for attacks which exceed their inherent DDoS mitigation capacities and/or capabilities.

Intra-organizational: a DOTS communications relationship between various elements within a single span of administrative control. A typical intra-organizational DOTS communications relationship would be between DOTS clients, DOTS gateways, and DOTS servers within the same organization.

3. Use Cases Scenarios

This section provides a high-level description of scenarios addressed by DOTS. In both sections, the scenarios are provided in order to illustrate the use of DOTS in typical DDoS attack scenarios. They are not definitive, and other use cases are expected to emerge with widespread DOTS deployment.

All scenarios present a coordination between the targeted organization, the DDoS attack telemetry and the mitigator. The coordination and communication between these entity depends, for example on the characteristic or functionality of the equipment, the reliability of the information provided by DDoS attack telemetry, and the business relationship between the DDoS target domain and the mitigator.

More explicitly, in some cases, the DDoS attack telemetry may simply activate a DDoS mitigation, whereas in other cases, it may collaborate by providing some information about an attack. In some cases, the DDoS mitigation may be orchestrated, which includes selecting a specific appliance as well as starting/ending a mitigation.

3.1. Inter-domain Use Cases

3.1.1. End-customer with a single upstream transit provider offering DDoS mitigation services

In this scenario, an enterprise network with self-hosted Internet-facing properties such as Web servers, authoritative DNS servers, and VoIP PBXes has an intelligent DDoS mitigation system (IDMS) deployed to protect those servers and applications from DDoS attacks. In addition to their on-premise DDoS defense capability, they have contracted with their Internet transit provider for DDoS mitigation services which threaten to overwhelm their transit link bandwidth.

The IDMS is configured such that if the incoming Internet traffic volume exceeds 50% of the provisioned upstream Internet transit link capacity, the IDMS will request DDoS mitigation assistance from the upstream transit provider.

The requests to trigger, manage, and finalize a DDoS mitigation between the enterprise IDMS and the transit provider is performed using DOTS. The enterprise IDMS implements a DOTS client while the transit provider implements a DOTS server which is integrated with their DDoS mitigation orchestration system.

When the IDMS detects an inbound DDoS attack targeting the enterprise servers and applications, it immediately begins mitigating the attack.

During the course of the attack, the inbound traffic volume exceeds the 50% threshold; the IDMS DOTS client signals the DOTS server on the upstream transit provider network to initiate DDoS mitigation. The DOTS server signals the DOTS client that it can service this request, and mitigation is initiated on the transit provider network.

Over the course of the attack, the DOTS server on the transit provider network periodically signals the DOTS client on the enterprise IDMS in order to provide mitigation status information, statistics related to DDoS attack traffic mitigation, and related information. Once the DDoS attack has ended, the DOTS server signals the enterprise IDMS DOTS client that the attack has subsided.

The enterprise IDMS then requests that DDoS mitigation services on the upstream transit provider network be terminated. The DOTS server on the transit provider network receives this request, communicates with the transit provider orchestration system controlling its DDoS mitigation system to terminate attack mitigation, and once the mitigation has ended, confirms the end of upstream DDoS mitigation service to the enterprise IDMS DOTS client.

Note that communications between the enterprise DOTS client and the upstream transit provider DOTS server may take place in-band within the main Internet transit link between the enterprise and the transit provider; out-of-band via a separate, dedicated wireline network link utilized solely for DOTS signaling; or out-of-band via some other form of network connectivity such as a third-party wireless 4G network link.

3.1.2. End-customer with multiple upstream transit providers offering DDoS mitigation services

This scenario shares many characteristics with the above, but with the key difference that the enterprise in question is multi-homed, i.e., has two or more upstream transit providers, and that they all provide DDoS mitigation services.

In most cases, the communications model for a multi-homed model would be the same as in the single-homed model, merely duplicated in parallel. However, if two or more of the upstream transit providers have entered into a mutual DDoS mitigation agreement and have established DOTS peering between the participants, DDoS mitigation status messages may exchanged between the DOTS servers of the participants in order to provide a more complete picture of the DDoS attack scope, and allow for either automated or operator-assisted programmatic cooperative DDoS mitigation activities on the part of the transit providers.

3.1.3. End-customer with multiple upstream transit providers, but only a single upstream transit provider offering DDoS mitigation services

This scenario is similar to the multi-homed scenario referenced above; however, only one of the upstream transit providers in question offers DDoS mitigation services. In this situation, the enterprise would cease advertising the relevant network prefixes via the transit providers which do not provide DDoS mitigation services - or, in the case where the enterprise does not control its own routing, request that the upstream transit providers which do not offer DDoS mitigation services stop advertising the relevant network prefixes on their behalf.

Once it has been determined that the DDoS attack has ceased, the enterprise once again announces the relevant routes to the upstream transit providers which do not offer DDoS mitigation services, or requests that they resume announcing the relevant routes on behalf of the enterprise.

Note that falling back to a single transit provider has the effect of reducing available inbound transit bandwidth during a DDoS attack. Without proper planning and sufficient provisioning of both the link capacity and DDoS mitigation capacity of the sole transit provider offering DDoS mitigation services, this reduction of available bandwidth could lead to network link congestion caused by legitimate inbound network traffic. Therefore, careful planning and provisioning of both upstream transit bandwidth as well as DDoS mitigation capacity is required in scenarios of this nature.

The withdrawal and announcement of routing prefixes described in this use-case falls outside the scope of DOTS, although they could conceivably be triggered as a result of provider-specific orchestration triggered by the receipt of specific DOTS messages from the enterprise in question.

3.1.4. End-customer with an overlay DDoS mitigation managed security service provider (MSSP)

This use case details an enterprise that has a local DDoS detection and classification capability and may or may not have an on-premise mitigation capability. The enterprise is contracted with an overlay DDoS mitigation MSSP, topologically distant from the enterprise network (i.e., not a direct upstream transit provider), which can redirect (divert) traffic away from the enterprise, provide DDoS mitigation services services, and then forward (re-inject) legitimate traffic to the enterprise on an on-demand basis. In this scenario, diversion of Internet traffic destined for the enterprise network into the overlay DDoS mitigation MSSP network is typically accomplished via eBGP announcements of the relevant enterprise network CIDR blocks, or via authoritative DNS subdomain-based mechanisms (other mechanisms are not precluded, these are merely the most common ones in use today).

The enterprise determines thresholds at which a request for mitigation is triggered indicating to the MSSP that inbound network traffic should be diverted into the MSSP network and that DDoS mitigation should be initiated. The enterprise may also elect to manually request diversion and mitigation via the MSSP network as desired.

The communications required to initiate, manage, and terminate active DDoS mitigation by the MSSP is performed using DOTS. The enterprise DDoS detection/classification system implements a DOTS client, while the MSSP implements a DOTS server integrated with its DDoS mitigation orchestration system. One or more out-of-band methods for initiating a mitigation request, such as a Web portal, a smartphone app, or voice support hotline, may also be made available by the MSSP.

When an attack is detected, an automated or manual DOTS mitigation request is be generated by the enterprise and sent to the MSSP. The enterprise DOTS mitigation request is processed by the MSSP DOTS server, which validates the origin of the request and passes it to the MSSP DDoS mitigation orchestration system, which then initiates active DDoS mitigation. This action will usually involve the diversion of all network traffic destined for the targeted enterprise into the MSSP DDoS mitigation network, where it will be subjected to further scrutiny, with DDoS attack traffic filtered by the MSSP. Successful mitigation of the DDoS attack will not only result preserving the availability of services and applications resident on the enterprise network, but will also prevent DDoS attack traffic from ingressing the networks of the enterprise upstream transit providers/peers.

The MSSP should signal via DOTS to the enterprise that a mitigation request has been received and acted upon, and should also include an update of the mitigation status. The MSSP may respond periodically with additional updates on the mitigation status to in order to enable the enterprise to make an informed decision on whether to maintain or terminate the mitigation. An alternative approach would be for the DOTS client mitigation request to include a time to live (TTL) for the mitigation, which may also be extended by the client should the attack still be ongoing as the TTL reaches expiration.

A variation of this use case may be that the enterprise is providing a DDoS monitoring and analysis service to customers whose networks may be protected by any one of a number of third-party providers. The enterprise in question may integrate with these third-party providers using DOTS and signal accordingly when a customer is attacked - the MSSP may then manage the life-cycle of the attack mitigation on behalf of the enterprise.

3.1.5. End-customer operating an application or service with an integrated DOTS client

In this scenario, a Web server has a built-in mechanism to detect and classify DDoS attacks, which also incorporates a DOTS client. When an attack is detected, the self-defense mechanism is activated, and local DDoS mitigation is initiated.

The DOTS client built into the Web server has been configured to request DDoS mitigation services from an upstream transit provider or overlay MSSP once specific attack traffic thresholds have been reached, or certain network traffic conditions prevail. Once the specified conditions have been met, the DOTS communications dialogue and subsequent DDoS mitigation initiation and termination actions described above take place.

3.1.6. End-customer operating a CPE network infrastructure device with an integrated DOTS client

Similar to the above use-case featuring applications or services with built-in DDoS attack detection/classification and DOTS client capabilities, in this scenario, an end-customer network infrastructure CPE device such as a router, layer-3 switch, firewall, or load-balance incorporates both the functionality required to detect and classify incoming DDoS attacks as well as DOTS client functionality.

The subsequent DOTS communications dialogue and resultant DDoS mitigation initiation and termination activities take place in the same manner as the use-cases described above.

3.1.7. End-customer with an out-of-band smartphone application featuring DOTS client capabilities

This scenario would typically apply in a small office/home office (SOHO) setting, where the end-customer does not have CPE equipment or software capable of detecting/classifying/mitigating DDoS attack, yet still has a requirement for on-demand DDoS mitigation services. A smartphone application containing a DOTS client would be provided by the upstream transit mitigation provider or overlay DDoS MSSP to the SOHO end-customer; this application would allow a manual 'panic-button' to request the initiation and termination of DDoS mitigation services.

The DOTS communications dialogue and resultant DDoS mitigation initiation/status reporting/termination actions would then take place as in the other use-cases described above, with the end-customer DOTS client serving to display received status information while DDoS mitigation activities are taking place.

3.1.8. MSSP as an end-customer requesting overflow DDoS mitigation assistance from other MSSPs

This is a more complex use-case involving multiple DDoS MSSPs, whether transit operators, overlay MSSPs, or both. In this scenario, an MSSP has entered into a pre-arranged DDoS mitigation assistance agreement with one or more other DDoS MSSPs in order to ensure that sufficient DDoS mitigation capacity and/or capabilities may be activated in the event that a given DDoS attack threatens to overwhelm the ability of a given DDoS MSSP to mitigate the attack on its own.

BGP-based diversion (including relevant Letters of Authorization, or LoAs), DNS-based diversion (including relevant LoAs), traffic re-

injection mechanisms such as Generic Routing Encapsulation (GRE) tunnels, provisioning of DDoS orchestration systems, et. al. must be arranged in advance between the DDoS MSSPs which are parties to the agreement. They should also be tested on a regular basis.

When a DDoS MSSP which is party to the agreement is nearing its capacity or ability to mitigate a given DDoS attack traffic, the DOTS client integrated with the MSSP DDoS mitigation orchestration system signals partner MSSPs to initiate network traffic diversion and DDoS mitigation activities. Ongoing attack and mitigation status messages may be passed between the DDoS MSSPs, and between the requesting MSSP and the ultimate end-customer of the attack.

The DOTS dialogues and resultant DDoS mitigation-related activities in this scenario progress as described in the other use-cases detailed above. Once the requesting DDoS MSSP is confident that the DDoS attack has either ceased or has fallen to levels of traffic/ complexity which they can handle on their own, the requesting DDoS MSSP DOTS client sends mitigation termination requests to the participating overflow DDoS MSSPs.

3.2. Intra-domain Use Cases

3.2.1. Suppression of outbound DDoS traffic originating from a consumer broadband access network

While most DDoS defenses concentrate on inbound DDoS attacks ingressing from direct peering links or upstream transit providers, the DDoS attack traffic in question originates from one or more Internet-connected networks. In some cases, compromised devices residing on the local networks of broadband access customers are used to directly generate this DDoS attack traffic; in others, misconfigured devices residing on said local customer networks are exploited by attackers to launch reflection/amplification DDoS attacks. In either scenario, the outbound DDoS traffic emanating from these devices can be just as disruptive as an inbound DDoS attack, and can cause disruption for substantial proportions of the broadband access network operator's customer base.

Some broadband access network operators provide CPE devices (DSL modems/routers, cablemodems, FTTH routers, etc.) to their end-customers. Others allow end-customers to provide their own CPE devices. Many will either provide CPE devices or allow end-customers to supply their own.

Broadband access network operators typically have mechanisms to detect and classify both inbound and outbound DDoS attacks, utilizing flow telemetry exported from their peering/transit and customer

aggregation routers. In the event of an outbound DDoS attack, they may make use of internally-developed systems which leverage their subscriber-management systems to de-provision end-customers who are sourcing outbound DDoS traffic; in some cases, they may have implemented quarantine systems to block all outbound traffic sourced from the offending end-customers. In either case, the perceived disruption of the end-customer's Internet access often prompts a help-desk call, which erodes the margins of the broadband access provider and can cause end-customer dissatisfaction.

Increasingly, CPE devices themselves are targeted by attackers who exploit security flaws in these devices in order to compromise them and subsume them into botnets, and then leverage them to launch outbound DDoS attacks. In all of the described scenarios, the end-customers are unaware that their computers and/or CPE devices have been compromised and are being used to launch outbound DDoS attacks - however, they may notice a degradation of their Internet connectivity as a result of outbound bandwidth consumption or other disruption.

By deploying DOTS-enabled telemetry systems and CPE devices (and possibly requiring DOTS functionality in customer-provided CPE devices), broadband access providers can utilize a standards-based mechanism to suppress outbound DDoS attack traffic while optionally allowing legitimate end-customer traffic to proceed unmolested.

In order to achieve this capability, the telemetry analysis system utilized by the broadband access provider must have DOTS client functionality, and the end-customer CPE devices must have DOTS server functionality. When the telemetry analysis system detects and classifies an outbound DDoS attack sourced from one or more end-customer networks/devices, the DOTS client of the telemetry analysis system sends a DOTS request to the DOTS server implemented on the CPE devices, requesting local mitigation assistance in suppressing either the identified outbound DDoS traffic, or all outbound traffic sourced from the end-customer networks/devices. The DOTS server residing within the CPE device(s) would then perform predefined actions such as implementing on-board access-control lists (ACLs) to suppress the outbound traffic in question and prevent it from leaving the local end-customer network(s).

Broadband access network operators may choose to implement a quarantine of all or selected network traffic originating from end-customer networks/devices which are sourcing outbound DDoS traffic, redirecting traffic from interactive applications such as Web browsers to an internal portal which informs the end-customer of the quarantine action, and providing instructions for self-remediation and/or helpdesk contact information.

Quarantine systems for broadband access networks are typically custom-developed and -maintained, and are generally deployed only by a relatively small number of broadband access providers with considerable internal software development and support capabilities. By requiring the manufacturers of operator-supplied CPE devices to implement DOTS server functionality, and requiring customer-provided CPE devices to feature DOTS server functionality, broadband access network operators who previously could not afford the development expense of creating custom quarantine systems to integrate DOTS-enabled network telemetry systems to act as DOTS clients and perform effective quarantine of end-customer networks and devices until such time as they have been remediated.

3.2.2. DDoS Orchestration

In this use case, one or multiple telemetry systems or monitoring devices like a flow collector monitor a network -- typically an ISP network. Upon detection of a DDoS attack, these telemetry systems alert an orchestrator in charge of coordinating the various DDoS mitigation systems within the domain. The telemetry systems may be configured to provide some necessary or useful pieces of informations, such as a preliminary analysis of the observation to the orchestrator.

The orchestrator analyses the various information it receives from specialized equipements, and elaborates one or multiple DDoS mitigation strategies. In some case, a manual confirmation may also be required to chose a proposed strategy or to start the DDoS mitigation. The DDoS mitigation may consists in multiple steps such as configuring the network, the various hardware or already instantiated DDoS mitigation functions. In some cases, some specific virtual DDoS mitigation functions need to be instantiated and properly chained between each other. Eventually, the coordination of the mitigation may involved external DDoS resources such as a transit provider (Section 3.1.1) or an MSSP (Section 3.1.4).

The communication to trigger a DDoS mitigation between the telemetry and monitoring systems and the orchestrator is performed using DOTS. The telemetry systems implements a DOTS client while the Orchestrator implements a DOTS server.

The communication between to select a DDoS strategy by a network administrator and the orchestrator is also performed using DOTS. The network administrator via its web interfaces implements a DOTS client while the Orchestrator implements a DOTS server.

The communication between the Orchestrator and the DDoS mitigation systems is performed using DOTS. The Orchestrator implements a DOTS client while the DDoS mitigation systems implement a DOTS server.

The configuration aspects of each DDoS mitigation systems, as well as the instantiations of DDoS mitigation functions or network configuration is not part of DOTS. Similarly the discovery of the available DDoS mitigation functions is not part of DOTS.

```
+----------+
| network  |C
| adminis  |<-+
| trator   |  |
+----------+  |
              |                        (internal)
+----------+  | S+--------------+     +-----------+
|telemetry/|  +->|              |C   S| DDoS      |+
|monitoring|<--->| Orchestrator |<--->| mitigation||
|systems   |C   S|              |<-+  | systems   ||
+----------+     +--------------+C |  +-----------+|
                                   |    +----------+
                                   |
                                   |  (external)
                                   |  +-----------+
                                   | S| DDoS      |
                                   +->| mitigation|
                                      | systems   |
                                      +-----------+
* C is for DOTS client functionality
* S is for DOTS server functionality
```

Figure 1: DDoS Orchestration

The telemetry systems monitor various traffic network and perform their measurement tasks. They are configured so that when an event or some measurements reach a predefined level to report a DOTS mitigation request to the Orchestrator. The DOTS mitigation request may be associated with some element such as specific reporting.

Upon receipt of the DOTS mitigation request from the telemetry system, the orchestrator responds with an acknowledgement, to avoid retransmission of the request for mitigation. The status of the DDoS mitigation indicates the orchestrator is in an analysing phase. The orchestrator begins collecting various informations from various telemetry systems on the network in order to correlate the measurements and provide an analyse of the event. Eventually, the

orchestrator may ask additional informations to the telemetry system that just sent the DOTS request, however, the collection of these information is performed outside DOTS.

The orchestrator may be configured to start a DDoS mitigation upon approval from a network administrator. The analysis from the orchestrator is reported to the network administrator via a web interface. If the network administrator decides to start the mitigation, she order through her web interface a DOTS client to send a request for DDoS mitigation. This request is expected to be associated with a context that identifies the DDoS mitigation selected.

Upon receiving the DOTS request for DDoS mitigation from the network administrator, the orchestrator orchestrates the DDoS mitigation according to the specified strategy. It status first indicates the DDoS mitigation is starting while not effective.

Orchestration of the DDoS mitigation systems works similarly as described in Section 3.1.1 or Section 3.1.4. The orchestrator indicates with its status the DDoS Mitigation is effective.

When the DDoS mitigation is finished on the DDoS mitigation systems, the orchestrator indicates to the Telemetry systems as well as to the network administrator the DDoS mitigation is finished.

4. Security Considerations

DOTS is at risk from three primary attacks: DOTS agent impersonation, traffic injection, and signaling blocking. The DOTS protocol MUST be designed for minimal data transfer to address the blocking risk.

Impersonation and traffic injection mitigation can be managed through current secure communications best practices. DOTS is not subject to anything new in this area. One consideration could be to minimize the security technologies in use at any one time. The more needed, the greater the risk of failures coming from assumptions on one technology providing protection that it does not in the presence of another technology.

Additional details of DOTS security requirements may be found in [I-D.ietf-dots-requirements].

5. IANA Considerations

No IANA considerations exist for this document at this time.

6. Acknowledgments

TBD

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

7.2. Informative References

[APACHE] "Apache mod_security", n.d., <https://www.modsecurity.org>.

[I-D.ietf-dots-requirements] Mortensen, A., Moskowitz, R., and T. Reddy, "Distributed Denial of Service (DDoS) Open Threat Signaling Requirements", draft-ietf-dots-requirements-05 (work in progress), June 2017.

[RFC6335] Cotton, M., Eggert, L., Touch, J., Westerlund, M., and S. Cheshire, "Internet Assigned Numbers Authority (IANA) Procedures for the Management of the Service Name and Transport Protocol Port Number Registry", BCP 165, RFC 6335, DOI 10.17487/RFC6335, August 2011, <http://www.rfc-editor.org/info/rfc6335>.

[RFC7368] Chown, T., Ed., Arkko, J., Brandt, A., Troan, O., and J. Weil, "IPv6 Home Networking Architecture Principles", RFC 7368, DOI 10.17487/RFC7368, October 2014, <http://www.rfc-editor.org/info/rfc7368>.

[RRL] "BIND RRL", August 2014, <https://deepthought.isc.org/article/AA-00994/0/Using-the-Response-Rate-Limiting-Feature-in-BIND-9.10.html>.

Authors' Addresses

Roland Dobbins
Arbor Networks
Singapore

EMail: rdobbins@arbor.net

Daniel Migault
Ericsson
8400 boulevard Decarie
Montreal, QC H4P 2N2
Canada

EMail: daniel.migault@ericsson.com

Stefan Fouant
USA

EMail: stefan.fouant@copperriverit.com

Robert Moskowitz
HTT Consulting
Oak Park, MI 48237
USA

EMail: rgm@labs.htt-consult.com

Nik Teague
Verisign
12061 Bluemont Way
Reston, VA 20190

EMail: nteague@verisign.com

Liang Xia
Huawei
No. 101, Software Avenue, Yuhuatai District
Nanjing
China

EMail: Frank.xialiang@huawei.com

Kaname Nishizuka
NTT Communications
GranPark 16F 3-4-1 Shibaura, Minato-ku
Tokyo 108-8118
Japan

EMail: kaname@nttv6.jp