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Use cases for DDoS Open Threat Signaling
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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 the DOTS exchanges. The purpose of the use cases is to identify the interacting DOTS component, how they collaborate and what are the types of information to be exchanged.

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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. These scenarios are described in more detail in Appendix A. 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 telemetry attack 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. Elementary Intra-organizational DDoS Mitigation

The most elementary scenario considers equipment such as a CPE that when overloaded sends an alert to specific equipment located upstream. In many cases, these very basic devices are unlikely to diagnose whether an DDoS attack is ongoing or not and detection as well as potential mitigation is left to the upstream equipment.

In many deployments, the upstream equipment belongs to the same organization as the CPE. In such cases, it is not expected that a specific commercial contract is established between the CPE and the DDoS mitigation service. The CPE and concerned traffic is likely to be identified by the source of the alert, which also imply the mitigator is aware of the nature of the equipment as well as the architecture of the organization.

For example, the DDoS mitigation service may be equipment that is located on path or a controller that will configure the network to the traffic to be analyzed and mitigated is redirected to a dedicated vendor specific equipment or solution. The DDoS mitigation service may be activated only for the traffic associated to the CPE sending the alert or instead to the traffic associated to all CPE. Such decisions are not part of DOTS, but instead depend on the policies of the network administrator.

The DDoS mitigation service is expected to acknowledge the reception of the alert in order to avoid retransmission. This may become an issue if an ISP receives alerts from all CPEs multiple times. However, it is unlikely that in such cases the CPE will follow the status of the mitigation. Instead, as the DDoS mitigation service and the CPE belongs to the same administrative domain, it is expected that the decision of mitigating or not, as well as the decision to end an ongoing mitigation will be left to DDoS mitigation service without notice to the CPEs.

There are several merits of using DOTS signaling in an intra-organizational manner:

1. It will facilitate interoperability between DDoS solutions/ services by providing a standards-based, programmatic communications mechanism

2. It will reduce time to initiate DDoS mitigation services

The required data exchange between DOTS client and DOTS server may be equivalent to or a subset of information set of inter-organizational use cases.

3.2. Advanced/Extended Intra-Organizational DDoS Mitigation

This section considers that more specialized equipment is generating DDoS alerts. These devices are likely to provide reliable information about the ongoing attack.

Such equipment could typically be a telemetry system, or a specific targeted service such as a web server, or another type application detecting application-specific attacks.

Typically, a telemetry system may indicate classifiers of DDoS attack traffic as well indicators or qualification of the detected attack.

As the telemetry system is expected to monitor multiple aspects of the traffic, similarly when an attack is detected by the target service.

The destination of the alert is likely to receive alerts from multiple different services (DNS, HTTP, TCP, UDP, application layer specific...). Such information is likely to be trusted and considered by the mitigator to apply to the appropriated security appliance.

Note that within a single domain it is likely that the service or the telemetry system is the most accurate equipment to qualify the attack.

As a result, not providing the information is likely to re-do the analysis phase. Providing the information while sending the alert avoid re-processing the analysis. Instead the mitigator directly uses the information to redirect the traffic to the appropriated specialized appliance.

For the same reasons as the CPE, as mitigation of the DDoS Service is performed in a single administrative domain, the source of the alert may not manage the end of the mitigation service and leave such decision to the administrator of domain or the DDoS mitigation service.

3.3. Orchestrated Intra-Organizational DDoS Mitigation

This section presents a generalization of the Service/System intra-organizational scenario. Orchestration goes one step further and considers that the information carried by the alert could have some management purpose. This includes explicitly starting/ending mitigation as well as selecting a specific DDoS mitigation service. This differs from the previous case in that the source of the alert

does not leave the decision on how to mitigate the attack by the mitigator. Instead the mitigator is orchestrated.

Typical example of orchestrators could be a network administrator that monitors the traffic and manually initiates a DDoS mitigation from its web portal. Orchestration may also applied automatically by an orchestrator.

3.4. Inter-Organizational DDoS Mitigation

In the case of inter-organizational mitigation, it is expected that a DDoS mitigation service provider can provide DDoS mitigation service to the targeted organization. The relationship between the two organizations is generally expected to be described into a pre-agreed contract, although ad-hoc mitigation scenarios without a pre-existing business relationship are also quite common, and DOTS is intended to work in either scenario, once the appropriate DOTS communications relationships are configured by the involved parties.

Mutual authentication between all elements in the DOTS communications chain is required in both intra- and inter-organizational scenarios.

DDoS attacks are often sourced from multiple independent networks on the Internet. The targeted organization may request DDoS mitigation services from multiple peered DOTS organizations with cooperation contract in order to mitigate a given attack.

The coordination relationship among the DOTS organizations will often be bilateral, which represents a direct peer to peer communication between each DOTS organization without the existence of a broker or orchestrator. The other case is a broker or orchestrator facilitating DDOS mitigation coordination among multiple DOTS-enabled organizations.

4. Use Cases Taxonomy

DOTS communication is a communication between a DOTS Client and a DOTS Server. A DOTS Client or DOTS Server can be hosted on different nodes which are associated to different functionalities, and thus leading to different expectations from DOTS. This section provides a classification of the DOTS Client, DOTS Servers as well as the different examples of DOTS message exchanges.

Appendix A provides more details of anticipated DOTS communications relationships, message flow, and message type examples.

4.1. DOTS Client Taxonomy

DOTS clients initiate DOTS communications in order to request DDoS mitigation assistance. This includes initiation/termination ofDDoS mitigation service as well as requesting and reporting the status and efficacy of an ongoing DDoS mitigation.

Note that this section only considers DOTS Client that are actually initiating an exchange with a DOTS Server, and nodes that simply relay DOTS messages are not considered here.

Here are the categories of DOTS Client envisioned in this document:

(a) DOTS Client alerting a DDoS attack is ongoing

  i) hosted on the target attack

  ii) hosted on a monitoring service/system

(b) DOTS Client coordinating an DDoS attack mitigation

  i) hosted on an orchestrator

  ii) hosted on administrative GUI

When an alert is raised by the node under attack, very little information is expected to be provided by DOTS Client to the DDoS mitigation service/system. More particularly telemetric information or characteristics of the attack are likely to be unreliable as the host is already overloaded, and may not have sophisticated DDoS detection/classification capabilities.

When the DOTS Client is hosted on a more sophisticated attack monitoring system, the monitoring system may raise an alert an attack is ongoing. Unlike the host under attack, the monitoring system is expected to have sufficient resource so it is not itself overload and impacted by the ongoing attack. As a result, the DOTS Client is more likely to provide additional information associated to the alert, as this information is expected to be reliable. The type of information associated may be associated to the asset to protect and eventually some information qualifying the attack. The information associated also depends on what has been agreed with DDoS mitigation service/ system. In most cases, when a DDoS attack is detected all the traffic is redirected to the DDoS mitigation procedure that has been agreed between the DDoS mitigation service/system and the entity hosting the monitoring service. In such cases, very little information is needed.

When the DOTS Client is hosted on an orchestrator, the DOTS Client contacts the DDoS mitigation service/system to initiates a DDoS mitigation. The orchestrator is responsible for setting the network to redirect the traffic to the DDoS mitigation service/system. If the DDoS mitigation service/system is not available, the orchestrator is responsible for finding an alternative. Again the orchestrator is likely to provide additional information to the DDoS mitigation service/system. For example, typical information may be the asset to protect, as well as the specific mitigation function requested.

The service is usually expected to be associated with the mitigation service, and so may not be explicitly specified. In addition, the DOTS Client is also expected to control how the DDoS mitigation is performed. More specifically, it is expected that the DOTS Client can terminate the DDoS mitigation. The DOTS Client should have sufficient information to decide how to operate next. For example, it should be able to check if the mitigation is ongoing as well as the efficiency of the mitigation.

When the DOTS client is hosted on an administrative system, the DOTS Client may be triggered by the network administrator to initiate a DDoS mitigation. In this case, the DOTS Server is likely to be an orchestrator, and all necessary information may be provided so the DDoS mitigation can be initiated. This includes, the asset to be protected, the action expected to be performed by the orchestrator, the DDoS mitigation service/system to contact...

Note that information included by DOTS Client in a request for mitigation is not limited to simple mitigation assistance requests; it can be more detailed. However, as DDoS mitigation systems are highly heterogeneous, if there is a need to provide interoperability between the vendors and DDoS mitigation services/systems, the actions provided by a DOTS Clients remains small and accepted by all services/systems. As a result here are the envisioned optional information provided by the DOTS Client.

(a) recommended asset to protect (e.g. IP, port number, DNS record, URI, et. all.). This information specifies the expected action from the DDoS mitigation service/system.

(b) optional DDoS Mitigation Contract ID: which references the contract agreed out-of-band. This information specifies the expected action from the DDoS mitigation service/system.

(c) optional Requested Service: which designates the function or service associated to the DDoS mitigation service/system. This information specifies the expected action from the DDoS mitigation service/system.

(d) optional DDoS attack information (e.g. suspected attack, telemetry): This information is expected to help the mitigation service/system to diagnose the ongoing attack.

In both cases, the DOTS Client sends a request for DDoS mitigation to the DOTS Server, and expects the DDoS mitigation service/system to mitigate the DDoS attack. The difference between sending a request for DDoS mitigation as an alert or for coordinating an DDoS mitigation is that an alert is a request to completely outsource the mitigation, whereas the coordination requires additional control over the DDoS mitigation. An alert may be acknowledged by the DOTS Server to acknowledge the reception whereas during the coordination, the DOTS server may acknowledge the initiation of the DDoS mitigation.

4.2. DOTS Server Taxonomy

DOTS Servers terminate DOTS communications. The DOTS Server is typically hosted on a DDoS mitigation service/system or an intermediary node such as an orchestrator.

The DOTS Server is expected to be the entry point of a DDoS mitigation service/system. Some DOTS Clients do not expect any further interaction from the DOTS Server, once a DDoS mitigation has been requested. This is especially true for DOTS Clients hosted on the attack target. Other DOTS Clients hosted on orchestrators or DDoS mitigation service/systems are likely to expect from the DOTS Server a confirmation the system accepts the DDoS mitigation task.

These DOTS Client are also likely to expect a confirmation when DDoS mitigation service termination has been requested.

In addition, DOTS Servers are also expected to provide information related to the mitigation status when requested by the DOTS Client.

It is also expected that the DOTS Server could provide some status report of the DDoS mitigation on a push basis.

4.3. DOTS Message Taxonomy

The core essential messages to coordination a heterogeneous set of DDoS mitigation services/system needs to be small and enable future options. Here are the different exchanges envisioned in this document between a DOTS Client and a DOTS Server.

(a) DOTS MITIGATION CONTROL messages are used by the DOTS Client to initiate or terminate a DDoS mitigation. The initiator the termination can be specified by the action type START or STOP. These messages can carry some additional options that specify

information such as the asset under attack. These DOTS MITIGATION CONTROL messages are expected to be ACKed by the DOTS Server, in order to indicate the DOTS Server will perform the requested action. In any other case an error is expected to be returned. In the case of a DOTS Client sends an alert, ACK is recommended so the DOTS Client stop sending the alert.

(b) DOTS MITIGATION INFORMATIONAL message are left for any additional interaction between a DOTS Client and DOTS Server regarding an ongoing request. An INFORMATIONAL message can be ignored by the receiver if it does not understand the requested information or options. In the current document an informational message can be the status of the ongoing mitigation.

(c) DOTS ERROR contains the errors associated to a request.

(d) DOTS OPTIONS: options can be used to indicate some optional information. The option is expected to specify whether the DOTS Server can ignore it or must return an error if it is not understood. Options are not messages, but part of the message.

5. 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].

6. IANA Considerations

No IANA considerations exist for this document at this time.

7. Acknowledgments

TBD

8. References

8.1. 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>.

8.2. Informative References

[APACHE] "Apache mod_security", <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-03 (work in progress), October 2016.

[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>.

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

Appendix A. Use Cases

This section provides a high-level overview of likely use cases and deployment scenarios for DOTS-enabled DDoS mitigation services. It should be noted that DOTS servers may be standalone entities which, upon receiving a DOTS mitigation service request from a DOTS client, proceed to initiate DDoS mitigation service by communicating directly or indirectly with DDoS mitigators, and likewise terminate the service upon receipt of a DOTS service termination request; conversely, the DDoS mitigators themselves may incorporate DOTS servers and/or DOTS clients. The mechanisms by which DOTS servers initiate and terminate DDoS mitigation service with DDoS mitigators is beyond the scope of this document.

All of the primary use cases described in this section are derived from current, real-world DDoS mitigation functionality, capabilities, and operational models.

The posited ancillary use cases described in this section are reasonable and highly desirable extrapolations of the functionality of baseline DOTS capabilities, and are readily attainable in the near term.

Each of the primary and ancillary use cases described in this section may be read as involving one or more DDoS mitigation service providers; DOTS makes multi-provider coordinated DDoS defenses much more effective and practical due to abstraction of the particulars of a given DDoS mitigation service/solution set.

Both the primary and ancillary use cases may be facilitated by direct DOTS client - DOTS server communications or via DOTS relays deployed in order to aggregate DOTS mitigation service requests/responses, to mediate between stateless and stateful underlying transport protocols, to aggregate multiple DOTS requests and/or responses, to filter DOTS requests and/or responses via configured policy mechanisms, or some combination of these functions.

All DOTS messages exchanged between the DOTS clients and DOTS servers in these use cases may be communicated directly between DOTS clients and servers, or mediated by one or more DOTS relays residing on the network of the originating network, the network where upstream DDoS mitigation service takes place, an intervening network or networks, or some combination of the above.

DOTS is intended to apply to both inter- and Intra-organizational DDoS attack mitigation scenarios. The technical and operational requirements for inter- and Intra-organizational DOTS communications are identical. The main difference is administrative in nature; although it should be noted that provisioning challenges which are typically associated with inter-organizational DOTS communications relationships may also apply in intra-organizational deployment scenarios, based upon organizational factors. All of the same complexities surrounding authentication and authorization can apply in both contexts, including considerations such as network access policies to allow DOTS communications; DOTS transport selection (including considerations of the implications of link congestion if a stateful DOTS transport option is selected), etc. Registration of well-known ports for DOTS transports per [RFC6335] should be considered in light of these challenges.

It should also be noted that DOTS does not directly ameliorate the various administrative challenges required for successful DDoS attack mitigation. Letters of authorization, RADB updates, DNS zone delegations, alteration of network access policies, technical configurations required to facilitate network traffic diversion and re-injection, etc., are all outside the scope of DOTS. DOTS may,

however, prove useful in automating the registration of DOTS clients with DOTS servers, as well as in the automatic provisioning of situationally-appropriate DDoS defenses and countermeasures. This ancillary DOTS functionality is described in Appendix A.2.

Many of the 'external' administrative challenges associated with establishing workable DDoS attack mitigation service may be addressed by work currently in progress in the I2RS and I2NSF WGs. Interested parties may wish to consider tracking those efforts, and coordination with both I2RS and I2NSF is highly desirable.

Note that all the use-cases in this document are universal in nature. They apply equally to endpoint networks, transit backbone providers, cloud providers, broadband access providers, ASPs, CDNs, etc. They are not specific to particular business models, topological models, or application types, and are deliberately generalizable. Both networks targeted for attack as well as any adjacent or topologically distant networks involved in a given scenario may be either single- or multi-homed. In the accompanying vector illustrations incorporated into draft-ietf-dots-use-cases-01.pdf, specific business and topological models are described in order to provide context.

Likewise, both DOTS itself and the use cases described in this document are completely independent of technologies utilized for the detection, classification, traceback, and mitigation of DDoS attacks.

Flow telemetry such as NetFlow and IPFIX, direct full-packet analysis, log-file analysis, indirection manual observation, etc. can and will be enablers for detection, classification and traceback.

Intelligent DDoS mitigation systems (IDMSes), flowspec, S/RTBH, ACLs, and other network traffic manipulation tools and techniques may be used for DDoS attack mitigation. BGP, flowspec, DNS, inline deployment, and various 'NFV' technologies may be used for network traffic diversion into mitigation centers or devices in applicable scenarios; GRE, MPLS, 'NFV', inline deployment and other techniques may be utilized for 'cleaned' traffic re-injection to its intended destination.

The scope, format, and content of all DOTS message types cited in this document must be codified by the DOTS WG.

The following use cases are intended to inform the DOTS requirements described in [I-D.ietf-dots-requirements].

A.1. Primary Use Cases

A.1.1. Automatic or Operator-Assisted DOTS Clients Request Upstream DDoS Mitigation Services

DOTS client can be supported on different devices or systems, like:

- CPE or PE mitigators: CPE or PE mitigators can mitigate the DDoS attack by itself, but also with DOTS client capabilities may be configured to signal to one or more DOTS servers in order to request upstream DDoS mitigation service initiation during an attack when DDoS attack volumes and/or attack characteristics exceed the capabilities of such CPE mitigators;

- CPE or PE network infrastructure elements: Refer to the network elements like routers, switches, load-balancers, firewalls, 'IPSes', etc, which have the capability to detect and classify DDoS attacks. These network elements involved are not engaged in mitigating DDoS attack traffic, instead have DOTS client capabilities to be configured to signal to one or more DOTS servers in order to request upstream DDoS mitigation service initiation during an attack;

- CPE or PE Attack Telemetry Detection/Classification Systems: These systems having DOTS client capabilities may be configured so that upon detecting and classifying a DDoS attack, they signal one or more DOTS servers in order to request upstream DDoS mitigation service initiation. These systems do not possess any inherent capability to mitigate DDoS attack traffic, and is signaling for upstream mitigation assistance;

- The DDoS targeted service/applications: A service or application which is the target of a DDoS attack and which has the capability to detect and classify DDoS attacks (i.e, Apache mod_security [APACHE], BIND RRL [RRL], etc.) as well as DOTS client functionality may be configured so that upon detecting and classifying a DDoS attack, it signals one or more DOTS servers in order to request upstream DDoS mitigation service initiation. They do not possess any inherent capability to mitigate DDoS attack traffic, and is signaling for upstream mitigation assistance.

Despite the different implementations of DOTS client, the DOTS signaling process of them are very similar. For simplicity, the abstract term 'DOTS client' is used here as a general representation for all kinds of implementation.

One or more DOTS clients may be configured to signal to one or more DOTS servers in order to request upstream DDoS mitigation service initiation during an attack. DDoS mitigation service may be

terminated either automatically or manually via a DOTS mitigation service termination request initiated by the DOTS client when it has been determined that the DDoS attack has ended. The DOTS signaling process listed below applies to both intra- and inter-organizational scenarios:

(a) A DDoS attack is initiated against online properties of an organization with DOTS clients deployed.

(b) DOTS client detects, classifies, and maybe begin mitigating the DDoS attack (if it's implemented as the DDoS mitigator).

(c) DOTS client determine to send a DOTS mitigation service initiation request (for DDoS mitigator, if their capability to mitigate the DDoS attack is insufficient) to one or more DOTS servers residing on one or more upstream transit networks, peer networks, or overlay MSSP networks, either directly or via intermediate DOTS relays residing upon the requesting organization's network, the upstream mitigation provider's network, or both. This DOTS mitigation service initiation request may be automatically initiated by the DOTS clients, or may be manually triggered by personnel of the requesting organization in response to an alert from the DOTS clients (the mechanism by which this process takes place is beyond the scope of this document).

(d) The DOTS servers which receive the DOTS mitigation service initiation requests determine that they have been configured to honor requests from the requesting DOTS clients, and initiate situationally-appropriate DDoS mitigation service on their respective networks (the mechanism by which this process takes place is beyond the scope of this document).

(e) The DOTS servers transmit a DOTS service status message to the requesting DOTS clients indicating that upstream DDoS mitigation service has been initiated.

(f) While DDoS mitigation services are active, the DOTS servers regularly transmit DOTS mitigation status updates to the requesting DOTS clients.

(g) While DDoS mitigation services are active, the DOTS clients may optionally regularly transmit DOTS mitigation efficacy updates to the relevant DOTS servers.

(h) When the upstream DDoS mitigators determine that the DDoS attack has ceased, they indicate this change in status to their

respective DOTS servers (the mechanism by which this process takes place is beyond the scope of this document).

(i) The DOTS servers transmit a DOTS mitigation status update to the DOTS clients indicating that the DDoS attack has ceased.

(j) The DOTS clients transmit a DOTS mitigation service termination request to the DOTS servers. This DOTS mitigation service termination request may be automatically initiated by the DOTS clients, or may be manually triggered by personnel of the requesting organization in response to an alert from the DOTS clients or a management system which monitors them (the mechanism by which this process takes place is beyond the scope of this document).

(k) The DOTS servers terminate DDoS mitigation service on their respective networks (the mechanism by which this process takes place is beyond the scope of this document).

(l) The DOTS servers transmit a DOTS mitigation status update to the DOTS clients indicating that DDoS mitigation services have been terminated.

(m) The DOTS clients transmit a DOTS mitigation termination status acknowledgement to the DOTS servers.

A.1.2. Manual Request to Upstream Mitigator

A Web portal, or application for mobile devices such as smartphones and tablets, which has DOTS client capabilities has been configured in order to allow authorized personnel of organizations which are targeted by DDoS attacks to manually request upstream DDoS mitigation service initiation from a DOTS server. When an organization has reason to believe that it is under active attack, authorized personnel may utilize the Web portal or mobile device application to manually initiate a DOTS client mitigation request to one or more DOTS servers in order to initiate upstream DDoS mitigation services. DDoS mitigation service may be terminated manually via a DOTS mitigation service termination request through the Web portal or mobile device application when it has been determined that the DDoS attack has ended.

In this use-case, the organization targeted for attack does not possess any automated or operator-assisted mechanisms for DDoS attack detection, classification, traceback, or mitigation; the existence of an attack has been inferred manually, and the organization is requesting upstream mitigation assistance. This can theoretically be

an inter- or Intra-organizational use-case, but is more typically an inter-organizational scenario.

(a) A DDoS attack is initiated against online properties of an organization have access to a Web portal or mobile device application which incorporates DOTS client functionality and can generate DOTS mitigation service requests upon demand.

(b) Authorized personnel utilize the Web portal or mobile device application to send a DOTS mitigation service initiation request to one or more upstream transit networks, peer networks, or overlay MSSP networks, either directly or via intermediate DOTS relays residing upon the requesting organization's network, the upstream mitigation provider's network, or both. This DOTS mitigation service initiation request is manually triggered by personnel of the requesting organization when it is judged that the organization is under DDoS attack (the mechanism by which this process takes place is beyond the scope of this document).

(c) The DOTS servers which receive the DOTS mitigation service initiation requests determine that they have been provisioned to honor requests from the Web portal or mobile device application, and initiate situationally-appropriate DDoS mitigation service on their respective networks (the mechanism by which this process takes place is beyond the scope of this document).

(d) The DOTS servers transmit a DOTS service status message to the Web portal or mobile device application indicating that upstream DDoS mitigation service has been initiated.

(e) While DDoS mitigation services are active, the DOTS servers regularly transmit DOTS mitigation status updates to the Web portal or mobile device application.

(f) While DDoS mitigation services are active, the Web portal or mobile device application may optionally regularly transmit manually-triggered DOTS mitigation efficacy updates to the relevant DOTS servers.

(g) When the upstream DDoS mitigators determine that the DDoS attack has ceased, they indicate this change in status to their respective DOTS servers (the mechanism by which this process takes place is beyond the scope of this document).

(h) The DOTS servers transmit a DOTS mitigation status update to the Web portal or mobile device application indicating that the DDoS attack has ceased.

(i) The Web portal or mobile device application transmits a manually-triggered DOTS mitigation service termination request to the DOTS servers (the mechanism by which this process takes place is beyond the scope of this document).

(j) The DOTS servers terminate DDoS mitigation service on their respective networks (the mechanism by which this process takes place is beyond the scope of this document).

(k) The DOTS servers transmit a DOTS mitigation status update to the Web portal or mobile device application indicating that DDoS mitigation services have been terminated.

(l) The Web portal or mobile device application transmits a DOTS mitigation termination status acknowledgement to the DOTS servers.

A.1.3. **Unsuccessful Automatic or Operator-Assisted DOTS Clients Request** Upstream DDoS Mitigation Services

One or more DOTS clients may be configured to signal to one or more DOTS servers in order to request upstream DDoS mitigation service initiation during an attack (for DDoS mitigators, when DDoS attack volumes and/or attack characteristics exceed the capabilities of such mitigators). DDoS mitigation service may be terminated either automatically or manually via a DOTS mitigation service termination request initiated by the DOTS client when it has been determined that the DDoS attack has ended.

This can theoretically be an inter- or Intra-organizational use-case, but is more typically an inter-organizational scenario.

(a) A DDoS attack is initiated against online properties of an organization with DOTS clients deployed.

(b) DOTS client detects, classifies, and begins mitigating the DDoS attack (if it's implemented as the DDoS mitigator).

(c) DOTS clients determine to send a DOTS mitigation service initiation request (for DDoS mitigator, if their capability to mitigate the DDoS attack is insufficient) to one or more DOTS servers residing on one or more upstream transit networks, peer networks, or overlay MSSP networks, either directly or via intermediate DOTS relays residing upon the requesting organization's network, the upstream mitigation provider's network, or both. This DOTS mitigation service initiation request may be automatically initiated by the DOTS clients, or may be manually triggered by personnel of the requesting

organization in response to an alert from the DOTS clients (the mechanism by which this process takes place is beyond the scope of this document).

(d) The DOTS servers which receive the DOTS mitigation service initiation requests determine that they have been configured to honor requests from the requesting DOTS clients, and attempt to initiate situationally-appropriate DDoS mitigation service on their respective networks (the mechanism by which this process takes place is beyond the scope of this document).

(e) The DDoS mitigators on the upstream network report back to the DOTS servers that they are unable to initiate DDoS mitigation service for the requesting organization due to mitigation capacity constraints, bandwidth constraints, functionality constraints, hardware casualties, or other impediments (the mechanism by which this process takes place is beyond the scope of this document).

(f) The DOTS servers transmit a DOTS service status message to the requesting DOTS clients indicating that upstream DDoS mitigation service cannot be initiated as requested.

(g) The DOTS clients may optionally regularly re-transmit DOTS mitigation status request messages to the relevant DOTS servers until acknowledgement that mitigation services have been initiated.

(h) The DOTS clients may optionally transmit a DOTS mitigation service initiation request to DOTS servers associated with a configured fallback upstream DDoS mitigation service. Multiple fallback DDoS mitigation services may optionally be configured.

(i) The process describe above cyclically continues until the DDoS mitigation service request is fulfilled; the DOTS clients determine that the DDoS attack volume has decreased to a level and/or complexity which they themselves can successfully mitigate; the DDoS attack has ceased; or manual intervention by personnel of the requesting organization has taken place.

A.2. Ancillary Use Cases

A.2.1. Auto-registration of DOTS clients with DOTS servers

An additional benefit of DOTS is that by utilizing agreed-upon authentication mechanisms, DOTS clients can automatically register for DDoS mitigation service with one or more upstream DOTS servers.

The details of such registration are beyond the scope of this document.

A.2.2. Auto-provisioning of DDoS countermeasures

The largely manual tasks associated with provisioning effective, situationally-appropriate DDoS countermeasures is a significant barrier to providing/obtaining DDoS mitigation services for both mitigation providers and mitigation recipients. Due to the 'self-descriptive' nature of DOTS registration messages and mitigation requests, the implementation and deployment of DOTS has the potential to automate countermeasure selection and configuration for DDoS mitigators. The details of such provisioning are beyond the scope of this document.

This can theoretically be an inter- or Intra-organizational use-case, but is more typically an inter-organizational scenario.

A.2.3. Informational DDoS attack notification to interested and authorized third parties

In addition to its primary role of providing a standardized, programmatic approach to the automated and/or operator-assisted request of DDoS mitigation services and providing status updates of those mitigations to requesters, DOTS may be utilized to notify security researchers, law enforcement agencies, regulatory bodies, etc. of DDoS attacks against attack targets, assuming that organizations making use of DOTS choose to share such third-party notifications, in keeping with all applicable laws, regulations, privacy and confidentiality considerations, and contractual agreements between DOTS users and said third parties.

This is an inter-organizational scenario.

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