Cybersecurity Framework DDoS Profile

Executive Summary

The Framework for Improving Critical Infrastructure Cybersecurity (Cybersecurity Framework) version 1.0, developed by the National Institute of Standards and Technology (NIST), with extensive private sector input, provides a risk-based and flexible approach to managing cybersecurity risk that incorporates industry standards and best practices. The Cybersecurity Framework is by design crafted to allow individual organizations to determine their own unique risks, tolerances, threats and vulnerabilities, so that they may prioritize their resources to maximize effectiveness.

The Framework is general in nature to allow for broad applicability to a variety of industries, organizations, risk tolerances and regulatory environments. A Framework Profile is the application of Framework components to a specific situation. A Profile may be customized to suit specific implementation scenarios by applying the Framework Category and Sub-Categories appropriate to the situation. Profiles should be constructed to take into account the organization's:

- Business/mission objectives
- Regulatory requirements
- Operating environment

Organizations can use Profiles to define a desired state for their Cybersecurity posture based on their business objectives, and use it to measure progress towards achieving this state. It provides organizations with the ability to analyze cost, effort and risk for a particular objective. Profiles may also be used by industry sectors to document best practices for protection against specific threats.

The below Cybersecurity Framework Profile focuses on Distributed Denial of Service (DDoS). DDoS attacks are increasing in complexity, size, and frequency, and the range of targets and methods (e.g., from using individual PCs to using connected Internet of Things (IoT) devices) has also broadened. This threat profile emphasizes how the Cybersecurity Framework can address DDoS attacks, which NIST has acknowledged is a growing risk.

To develop the threat profile, we have reviewed all the Cybersecurity Framework Categories and Subcategories and determined those most important to combat the DDoS threat. The Categories and Sub-Categories were then labeled into different priorities as follows:

P1 – Minimum actions required to protect network and services against DDoS attacks

P2 – Highly recommended actions to protect network and services against DDoS attacks

P3 – Recommended actions to protect network and services against DDoS attacks.

The DDoS threat mitigation profile represents a Target Profile focused on the desired state of organizational cybersecurity to mitigate DDoS attacks. It may be used to assist in identifying opportunities for improving DDoS threat mitigation and aiding in cybersecurity prioritization by comparing current state with this desired Target state.

In the development of this profile we did not identify the need for any additions or changes at the Category or Subcategory level. Instead, the comments provided as part of the profile give the necessary guidance to refine the understanding of the Subcategory as it applies to DDoS threat mitigation.

Overview of the DDoS Threat

A DDoS attack attempts to overwhelm a network, service or application with traffic from multiple sources. There are many methods for carrying out DDoS attacks. These can include

- Low bandwidth connection oriented attacks designed to initiate and keep many connections open on the victim exhausting its available resources.
- High bandwidth volumetric attacks that exhaust available network or resource bandwidth.
- Protocol oriented attacks that take advantages of stateful network protocols such as TCP.
- Application layer attacks designed to overwhelm some aspect of an application or service.

Although each of these methods can be highly effective, in recent years, there has been considerable attention given to volumetric attacks as the result of several high-profile incidents.

One prominent example of a volumetric DDoS attack vector is reflection amplification. This is a type of DDoS attack in which the attacker fakes the attack target's IP address and launches queries from this address to open services on the Internet to solicit a response. The services used in this methodology are typically selected such that the size of the response to the initial query is many times (x100s) larger than the query itself. The response is returned to the real owner of the faked IP. This attack vector allows attackers to generate huge volumes of attack traffic, while making it difficult for the target to determine the original sources of the attack traffic. Reflection amplification has been responsible for some of the largest DDoS attacks seen on the Internet through the last decade.

Attackers can build out their attack capability in many ways, such as the use of malware to infect Internet connected computers, deploying servers within hosting environments, exploiting program flaws or other vulnerabilities, and by exploiting the use of inadequate access controls on Internet connected devices to create botnets.

Botnets are created when an attacker infects or acquires a network of hosts, then controls these devices to remotely launch an attack at a given target. Increasingly, botnets are incorporating Internet of Things (IoT) devices, which continue to proliferate at a remarkable rate. Botnets allow for a wide variety of attack methods aimed at evading or overwhelming defenses.

DDoS is often referred to as a 'weaponized' threat as technical skills are no longer needed to launch an attack and services to conduct DDoS have proliferated and become easily obtainable for relatively low cost.

Availability is a core information security pillar but the operational responsibility and discipline for assessing and mitigating availability-based threats such as DDoS often falls to network operations or application owners in addition to Risk and Information Security teams. Because of this divided responsibility, fissures in both risk assessment and operational procedures for addressing these threats may occur. The goal of this profile is to ensure the strategic and operational discipline needed to protect and respond to DDoS threats is comprehensively addressed by applying the appropriate recommendations and best practices outlined in the Cybersecurity Framework.

DDoS Threat Mitigation Profile

Function	*Category*	*Sub-Category*	*Priority*	*Framework Comment*
Identify (ID)	**Asset Management (ID.AM)**	**ID.AM-1:** Inventory physical devices and systems within the organization	**P2**	Catalog critical Internet facing services by location and capacity Catalog ISP connectivity by ISP, bandwidth usage, bandwidth available
		ID.AM-2: Inventory software platforms and applications within the organization	**P1**	Determine critical Internet facing services by type of application/service, IP address and hostname

Function	Category	Sub-Category	Priority	Framework Comment
		ID.AM-3: Map organizational communication and data flows	**P2**	Identify key stakeholders in the organization critical to availability of Internet facing services including application owners, security personnel, network operations personnel, executive leadership, legal/risk personnel and ISP or Cloud based DDoS mitigation service providers Maintain network maps showing data flows Create an operational process document detailing communication workflows
		ID.AM-4: Catalogue external information systems	**P3**	Identify applications and services that are run in cloud, SaaS, hosting or other external environments
		ID.AM-5: Resources are prioritized based on their classification, criticality, and business value	**P2**	Determine what Internet facing services will result in the most business impact if they were to become unavailable
	Business Environment (IDE.BE)	**ID.BE-4:** Establish dependencies and critical functions for delivery of critical services	**P2**	Catalog external dependencies for services and applications including DNS, NTP, cloud/hosting provider, partner network connections and Internet availability
		ID.BE-5: Establish resilience requirements to support delivery of critical services	**P3**	Ensure geographical redundancy and high availability of equipment providing services, network infrastructure and Internet connections

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	Risk Assessment (ID.RA)	**ID.RA-1:** Identify and document asset vulnerabilities	P2	Determine network and application bottlenecks including throughput, connection rate and total connections supported
		ID.RA-2: Cyber threat intelligence and vulnerability information is received from information sharing forums and sources	P3	Monitor vulnerabilities lists (CVE, NVD and similar) to check if critical Internet facing services have vulnerabilities that could be used as a condition for Denial of Service.
		ID.RA-3: Identify and document internal and external threats	P3	Continuously gather industry information around DDoS trends, peak attack sizes, frequency, targeted verticals, motivations and attack characteristics
		ID.RA-4: Identify potential business impacts and likelihoods	P2	Create a risk profile that quantifies potential cost of recovery operations per DDoS incident, revenue loss, customer churn, brand damage and impact to business operations
	Governance (ID.GV)	**ID.GV-3:** Legal and regulatory requirements regarding cybersecurity, including privacy and civil liberties obligations, are understood and managed	P1	Put processes in place to ensure all regulatory requirements are met. Train all personnel responsible for DDoS incident response on the relevant legal and regulatory requirements surrounding the data that they may handle. Document regulatory and data privacy policies of DDoS service providers and partners

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Protect (PR)	**Awareness and Training (PR.AT)**	**PR.AT-2:** Privileged users understand roles & responsibilities	P1	Security Operations personnel have been trained on DDoS defense processes, products and services Equip security operations personnel with an operational run book defining what process to follow and who to contact should an incident take place
	Information Protection Processes and Procedures (PR.IP)	**PR.IP-1:** Create and maintain a baseline configuration of information technology/industrial control systems	P1	Create a baseline DDoS protection architecture consisting of best current practices for the network, network based protection capabilities and non-stateful Intelligent DDoS Mitigation capability Implement anti-spoofing and black/white list filtering at network edge Maintain DDoS protection configuration that provides general protection for all services and always on protection for all business-critical assets
		PR.IP-7: Continuously improve protection processes	P2	Conduct a minimum of 2 annual tests of DDoS protection capabilities Perform after-action reviews following all DDoS incidents and DDoS protection tests adjusting DDoS defenses accordingly

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		PR.IP-9: Response plans (Incident Response and Business Continuity) and recovery plans (Incident Recovery and Disaster Recovery) are in place and managed	P3	The organization's Business Continuity and Disaster Recovery plans should have components to address the potential effects of a DDoS attack
		PR.IP-10: Response and recovery plans are tested	P3	The DDoS components of the Business Continuity and Disaster Recovery plans should be tested.
		PR.IP-12: A vulnerability management plan is developed and implemented	P3	Vulnerabilities that can be leveraged for DDoS events should be documented and remediated.
	Protective Technologies (PR.PT)	**PR.PT-4:** Protect communications and control networks	P1	Perform filtering of traffic to control plane network and/or control plane traffic policing
Detect (DE)	**Anomalies and Events (DE.AE)**	**DE.AE-1:** Establish and manage a baseline of network operations and expected data flows for users and systems	P1	Continuously measure traffic to hosts, resources or groups of resources to determine expected traffic over time. Determine traffic baselines for IP protocols such as TCP, UDP, ICMP, GRE and critical applications such as HTTP, DNS, NTP, SSDPand SIP
		DE.AE-2: Analyze detected events to understand attack targets and methods	P1	Determine source and destination traffic characteristics when anomalous traffic is

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				detected that is indicative of DDoS
		DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors	P2	Aggregate data for detected DDoS events from multiple network sources contributing to the attack.
		DE.AE-4: Impact of events is determined	P2	Total traffic rates for DDoS events can be measured across all contributing network sources Performance and availability of services can be measured before, during and after events
		DE.AE-5: Incident alert thresholds are established	P1	Configure notifications to security monitoring personnel and appropriate stakeholders when traffic exceeds measured or configured thresholds
	Security Continuous Monitoring (DE.CM)	**DE.CM-1:** Monitor network to detect potential cybersecurity events	P1	Continuously measure traffic intoall network ingress points and between transit points on the internal network for traffic anomalies To the extent possible and/or practical from a business perspective, continually measure outbound traffic for detection of traffic anomalies that could represent sources contributing to outbound or cross-bound DDoS attacks.

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		DE.CM-8: Vulnerability scans are performed	P1	Scan Internet facing services to identify vulnerabilities that can be exploited for participation in DDoS events.
	Detection Processes (DE.DP)	**DE.DP-3:** Test detection processes	P2	Conduct regular testing of DDoS defense capabilities including occasional unannounced tests performed with no prior warning to assess the DDoS defense strategies and processes Conduct DDoS simulation wargames as part of security staff onboarding and periodically for the security response team
		DE.DP-5: Continuously improve detection processes	P2	Perform after-action review on any defense testing or DDoS events after all operations are successfully restored to identify and improve DDoS detection capabilities Identify and maintain key security metrics around detection, identification and escalation effectiveness.
Respond (RS)	**Response Planning (RS.RP)**	**RS.RP-1:** Execute response plan during or after an event	P1	Follow DDoS response run book during any detected DDoS events
	Communications (RS.CO)	**RS.CO-1:** Ensure personnel know their roles and order of operations when a response is needed	P1	Define personnel responsible for detection, mitigation, coordination and communication during DDoS incidents

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		RS.CO-4: Coordinate with stakeholders consistently with response plans	P1	Document operational run book that includes roles, responsibilities and escalation process for all parties responsible for DDoS incident response including internal personnel and external consultants or services
		RS.CO-5: Engage in voluntary information sharing with external stakeholders to achieve broader cybersecurity situational awareness	P3	Share and receive DDoS attack trends with consultants, service companies and/or threat intel companies to keep abreast of attack scale, frequency, motivations and evolving attack vectors
	Analysis (RS.AN)	**RS.AN-1:** Investigate notifications from detection systems	P1	Add DDoS alert notifications to monitoring and response systems including security and network operations management systems.
		RS.AN-2: Understand the impact of the incident	P2	Compare DDoS traffic rates, connection rates and total connections against documented system and network limits Identify actual and potential impact to business services, customers, employees and other stakeholders.
		RS.AN-3: Forensics are performed	P3	Save raw anomaly details in available form (logs, packet captures, flow telemetry data) to investigate parties involved in the incident and, where appropriate, to share incident details

Function	Category	Sub-Category	Priority	Framework Comment
				with the operational security community.
	Mitigation (RS.MI)	**RS.MI-2:** Mitigate incidents	P1	Mitigate DDoS attacks using any or all of the following: - Network capabilities such as ACLs, anti-spoofing, remote triggered blackhole and/or flow spec - Using intelligent DDoS mitigation systems on premise - Contracting a DDoS mitigation service Critical resources should be protected by always on mitigation capabilities - Contract or coordinate with upstream bandwidth provider for defense against high-magnitude attacks. Implement a notification system to detect when on premise bandwidth is reaching saturation then alert and/or automate movement of traffic to an upstream DDoS mitigation service Identify and maintain key security metrics around mitigation and escalation effectiveness.

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	Improvements (RS.IM)	**RS.IM-1:** Incorporate lessons learned into response plans	P2	Adjust mitigation processes, capacity, technology and partnerships based on DDoS attack trends, DDoS response testing and results of DDoS after-action reviews Maintain key security metrics around the DDoS program to demonstrate program improvement and effectiveness.
Recover (RC)	**Recovery Planning (RC.RP)**	**RC.RP-1:** Execute recovery plan during or after an event	P2	Establish an internal and external communication plan as part of the DDoS run book that is used every time there is a DDoS incident
	Communications (RC.CO)	**RC.CO-1:** Manage public relations	P2	Ensure impacted applications are restored and availability communicated to relevant stakeholders Manage external communications based on visibility and impact of the DDoS attack on customers, partners or public