

Temporal Session Race Conditions (TSRC) Sept 2011 Presentation

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Temporal Session Race Conditions (TSRC) Sept 2011 Presentation

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Temporal Session Race Conditions Shay Chen Senior Manager, CTO Hacktics ASC, Ernst & Young
15 th September 2011

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TSRC – From theory to practice Overview – Race Conditions and Latency The Challenge Initial Background Sessions and Session Puzzling The solution Intentional Latency Increment Race Conditions and Layer Targeted ADoS Sample TSRC Attack Vectors Analyzing source code vulnerable to TSRC Demonstration and Overview Agenda

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Temporal Session Race Conditions From Theory to Practice

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“A race condition occurs when a pair of routine programming calls in an application do not perform in the sequential manner that was intended per business rules.” (The definition of RC in the OWASP Vulnerability List). Race Conditions Balance Verification Withdraw Transaction 1 2 3 4

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The detection and exploitation of race conditions is very efficient when the vulnerable module has inherent latency Database transactions SOA multiphase operations Backend operations Etc. Race Conditions With Inherent Latency

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Detecting and exploiting race conditions without inherent latency is something entirely different: The detection will be less consistent and harder to reproduce Detecting these instances in black box tests using the standard testing approach is very difficult, sometimes even theoretical Race conditions in session validations fall into the second category, and therefore are rarely reported. Race Conditions in Session Operations

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The Challenge Abusing Temporary Server Side Variables

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The Session Puzzling attack vector was introduced in May 2011, in a local chapter meeting of OWASP. Session Puzzles can be used to perform a variety of attacks by abusing the existence of common session variables. However, the attack was only effective for abusing session variables with a consistent lifespan, and was not effective for exploiting session variables with an extremely limited lifespan (milliseconds)... Until Now. The Challenge

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But if latency is the key, can it be artificially created? Recent research proves that by combining the effects of several different attacks, it is possible to abuse session variables with an extremely limited lifespan. But before we demonstrate this attack, let's first understand the basics...

Temporal Session Race Conditions

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Background Sessions and Session Puzzling

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The Session Mechanism

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The Session Mechanism The process of session identifier generation and association Web Server Session Memory Session ID Abcd123 Cbcr321 Memory Allocation 0xAA... 0xBB... Set-cookie: SID=abcd123 Cookie: SID=abcd123 Domain Cookie SID=Abcd123 Initial Access to the Domain

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The Session Lifespan in Web Applications When the application server is initially accessed by a browser, a new, unique session identifier is generated and associated to a server side memory allocation. The session identifier is returned to the browser, usually in a “set-cookie” response header.

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The Session Lifespan in Web Applications The browser stores the identifier in a domain-specific cookie, and since the content of domain-specific cookies is sent to the domain in every request, so does the session identifier. The server uses the session identifier to “associate” the browser instance with the memory allocation, which can store flags, identities, and browser instance specific data.

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Session Puzzles

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Session Puzzles – What’s That? Session Puzzles are application-level vulnerabilities that could enable attackers to perform a variety of malicious actions, by abusing the existence of session variables: Bypass the authentication and authorization enforcement Elevate privileges and Impersonate legitimate users Bypass restrictions in multiphase processes Execute “traditional attacks” (such as injections) in locations that were previously considered safe Affect content delivery destination Etc.

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Session Puzzling – How Does It Work? Session Puzzles might be caused due to one or more of the following conditions: Premature “population” of session objects in publically accessible entry points. Unnecessary storage of values in the session memory. Identical session variables used by multiple processes. Consistent usage of session flags in legitimate features. Lack of validation to “trusted” session originating values which are used by the application. Inefficient or Incomplete authentication and authorization enforcement mechanisms. Erroneous scenarios that populate or prevent the deletion of session variables.

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Session Puzzling – A Simple Example Authentication Bypass via the password recovery module:

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Session Puzzling – Demonstration Movies Authentication Bypass via the password recovery module: <http://www.youtube.com/watch?v=-DackF8HsIE> User Impersonation via session puzzling: <http://www.youtube.com/watch?v=iklyInm0wAg> Bypassing restrictions in multiphase processes: <http://www.youtube.com/watch?v=HeP54b52leQ>

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The Solution

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The Lifespan of Session “Leftovers” The lifespan of session variables might vary in the context of a module: The content of the session might be initialized in the beginning of the module, a typical behavior in the following: Logout modules Login modules The content of the session might be initialized at the end or the middle of the module: Logout modules The code sections of security mechanisms that deal with failures (including login failures, security events, etc.) The entire session

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The Lifespan of Session “Leftovers” Furthermore, in addition to the previously described scenarios, the lifespan of specific session variables might be limited in additional ways: The content of a session variable might be initialized in certain phases of a multiphase process: State flags Variables used for calculation, identity storage, etc. The content of a session variable might be initialized if a certain criteria is met (the process failed or successfully completed, exceptions did not occur, etc.).

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TSRC Exploitation Definition: a combination of attacks meant to enhance the consistency of exploiting session-level race conditions. In order to make the exploitation consistent, we will need to artificially create that which is missing... Latency. Abusing the session variables will still require the exploitation request to be sent immediately after the request/s meant to populate the session and cause the latency.

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Intentional Latency Increment The solution to exploiting session race conditions with consistency lies in extending the productive latency, artificially increasing the odds for the session manipulation success. Productive Latency

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Intentional Latency Increment, Cont. An increment in the length of the session variable lifespan will directly increase the chances of abusing it... But how can we cause an increment in the execution latency of specific lines of code? ++ ?

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Layer Targeted ADoS

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Layer Targeted Denial Of Service Different lines of code might access different digital layers, such as: Databases Web Services External Servers File Operations. Furthermore, malicious payloads can be used to increase the latency of code sections: Regular Expressions Loops Search Criteria.

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Productive Latency Rules The ADoS attack must affect the lines of code between the session population and the session invalidation more then it affects the rest of the code. For example, a denial of service attack that targets the web server is inefficient (since all the code is affected) while a denial of service attack that targets the database (and thus, the database access code) might be. Database Code Session Variables

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Temporal Session Race Conditions Productive Latency 2 1 3 4 The unnecessary / premature session variable must be granted a lifespan long enough for bypassing the session-level validation.

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RegEx DoS Send Regular Expression DoS payloads to the target module, in order to increase the latency of validations that follow the session value population. http://www.youtube.com/watch?v=3k_ej1bcCro Connection Pool Consumption / Occupation Intentionally "consume" all the available connections in the connection pool, in order to delay database operations in a target entry point. <http://www.youtube.com/watch?v=woWECWwrsSk> Initial Samples of Layer Targeted ADoS

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RegEx Dos Payloads can increase the latency of validation and search mechanisms. For example: RegEx: ([a-zA-Z0-9]+)* Input: Admin, aaaaaaaaaaaaaaaaaaaaaaaaaaaaaa! Increasing Latency with RegEx DoS

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Use an automated script that consistently accesses modules, which use connections from a size-restricted connection pool for querying the database. The script must use a number of threads equal or higher to the maximum connections in the pool. In order to continue occupying connections, each thread should re-access the module again, immediately after getting a response. The script should use less threads then the amount supported by the server. The script should not affect the availability of the server, or any other layer (but the target layer). Occupying Connections to Increase Latency

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Occupying connections will guarantee that code, which requires a database connection, will experience some latency. Occupying Connections to Increase Latency Delayed until a connection is released

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Occupying Connections to Increase Latency "Session KeepAlive" – a sample tool that can exhaust the connection pool:

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Intentional Execution of Complex Queries Access entry points that execute resource-consuming queries, in order to delay the database responses. Shared Backend DoS Perform ADoS on a web site that consumes services from a backend server shared by the target web site, effectively increasing the response time of the shared backend server. Additional Samples of Layer Targeted ADoS

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Intentional Execution of Complex Queries 2 3 4 5 Productive Latency Login Module Internal Module 1 Query Module

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Black-box Becomes possible upon the detection of an ADoS exposure, which affects specific lines of code (database access, input validation, web service access, etc.). Attempt to perform session puzzling while executing the ADoS in a manner that will cause a sufficient latency in a page that might temporarily populate session variables (login, registration, etc.). Code Review Any premature or unnecessary creation of a session variable, which is followed by code that can be targeted by layer specific DoS (DB access, validation, etc.), prior to the invalidation of the session content / variable. Detecting TSRC

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The mitigation of temporal session race conditions is very similar to the mitigations required for session puzzles: Avoid storing unnecessary values in the session. Avoid using session variables with identical names in different modules, multiphase processes, and particularly in public vs. private entry points. Store objects in the session instead of variables. The name of the objects should include the process / module they should serve. Don't rely on the session as a temporary container for values that should not be stored in the context of the module. Perform validations on session originating values before using the in the application code. TSRC Mitigation

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DoS is mainly used to do exactly what the initials stand for - denial of service... but when the focus of DoS becomes certain lines of code, it can do a lot more than just affect the availability of applications and servers Help exploit race conditions. ALL race conditions. Cause specific information to be disclosed. Enable the exploitation of various logical attacks, not just session puzzling. Who knows what more? Additional Uses for Layer Targeted DoS

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And Finally...

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Additional Resources Session Puzzling – Indirect Application Attack Vectors Original Paper Digital Whisper Translation (Simplified - Heb) Puzzlemall Homepage <http://code.google.com/p/puzzlemall/> A vulnerable training application for practicing session puzzling (Derby & MySql version) and temporal session race conditions (MySql version) A collection of movies demonstrating the attacks RegEx DoS (Adar Weidman, Checkmarx) https://www.owasp.org/images/3/38/20091210_VAC-REGEX_DOS-Adar_Weidman.pdf

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Additional Resources, Cont. Race Conditions https://www.owasp.org/index.php/Race_Conditions Application DoS https://www.owasp.org/images/d/da/OWASP_IL_7_Application_DOS.pdf <http://www.slideshare.net/robertosl81/defending-against-application-dos-attacks>

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