***Implementasi Pembangkitan Bilangan Acak Untuk Menghasilkan Salt Menggunakan Henon Map***

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Keywords—component; formatting; style; styling; insert (key words)

# Pendahuluan

Pada penyimpanan data sensitif seperti *password*, umumnya *password* disimpan di basis data dalam bentuk *hash* dari *password* tersebut untuk mencegah penyalahgunaan *password* jika terjadi *data breach*. Namun, fungsi *hash* bersifat deterministik sehingga jika terdapat dua buat masukan yang sama, nilai *hash* dari kedua masukan akan sama. Hal ini memungkinkan penyerang membuat tabel berisi *password* dan nilai *hash* *password* tersebut. Penyerang dapat memanfaatkan tabel tersebut untuk mengakses akun lain yang memiliki nilai *hash* *password* yang sama. Hal ini akan mengancam keamanan pengguna.

Salah satu metode yang umum digunakan untuk mencegah serangan tersebut adalah menambahkan *salt* saat proses *hashing*. *Salt* adalah sebuah *string* yang dibangkitkan secara acak untuk ditambahkan ke *password* pada saat *hashing*. *Salt* bersifat unik untuk setiap *password* sehingga dua buah *password* yang sama akan memiliki nilai *hash* yang berbeda. Hal ini akan menyulitkan penyerang membuat tabel *hash* *password*.

Berdasarkan *guidelines* OWASP[1], *salt* harus *cryptographically strong*. *Cryptographically strong* didefinsiikan sebagai sistem kriptografi yang sangat tahan terhadap kriptoanalisis. Kriptoanalisis adalah upaya untuk men-*decipher* pola rahasia sebuah sistem. Untuk menghasilkan nilai yang *cryptographically strong*, umumnya digunakan *cryptographically secure pseudorandom number generator*(CSPRNG) atau mengumpulkan masukan acak dari sumber yang tidak bisa diamati, seperti API *Random Generator* di sistem operasi.

Dari kedua metode tersebut, membangkitkan nilai menggunakan API *Random Generator* dari sistem operasi, seperti **/dev/random** di Linux, menghasilkan nilai yang benar-benar acak. Hal ini dikarenakan API *Random Generator* mengumpulkan keacakan sistem untuk membangkitkan nilai acak. Namun, hal ini berarti bila keacakan sistem belum cukup untuk membangkitkan nilai, program harus menunggu sampai keacakan sistem sudah cukup untuk mendapatlan nilai acak. Hal ini dapat menyebabkan masalah *availability* jika terdapat banyak *request* dalam waktu singkat yang membutuhkan bilangan acak untuk membangkitkan *salt*. Oleh karena itu, pembangkitan *salt* menggunakan CSPRNG menjadi alternatif yang bagus untuk membangkitkan *salt* dalam jumlah banyak dan waktu yang singkat.

Salah satu metode untuk mengimpementasikan CSPRNG adalah menggunakan fungsi *chaos*. Fungsi *chaos* adalah fungsi yang peka pada nilai awal. Jika nilai awal berubah sedikit, maka nilai fungsi *chaos* yang dihasilkan bisa berbeda jauh. Salah satu contoh fungsi *chaos* adalah Hanon Map.

Pada makalah ini, penulis akan menjelaskan teori dasar Hanon Map, implementasi Hanon Map untuk membangkitkan *salt*, beserta eksperimen dan analisis eksperimen untuk menunjukkan efektifitas Hanon Map dalam membangkitkan *salt.*

# Dasar teori

## Salt

*Salt* adalah *string* unik yang dibangkitkan secara acak untuk ditambahkan ke setiap *password* pada saat *hashing*. Karena nilai *salt* unik untuk setiap *password*, penyerang harus memecahkan *hash* satu per satu menggunakan *salt* masing-masing *hash*. Hal ini membuat memecahkan *hash* dalam jumlah besar menjadi lebih sulit. Selain itu, *salt* juga melindungi *password* dari *rainbow attack*, yang menggunakan daftar *hash* yang sudah dikomputasi oleh penyerang.

## Bilangan Acak

Bilangan acak adalah bilangan yang tidak dapat diprediksi nilai dan kemunculannya. Bilangan acak bisa berupa *integer*, bilangan riil antara 0-1, atau *string* biner. Dalam dunia kriptografi, bilangan acak memegang peranan penting. Beberapa diantaranya adalah:

1. Pembangkitan nilai-nilai parameter kunci dalam algoritma kriptografi kunci publik.
2. Pembangkitan nilai acak k dalam algoritma enkripsi ElGamal.
3. Pembangkitan *initialization vector* (IV) dalam *block cipher.*
4. Pembangkitan *string* di dalam mekanisme *challenge and response* untuk otentikasi.
5. Pembangkitan kunci sesi oleh *client* di dalam SSL.

## Pembangkitan Bilangan Acak

Bilangan acak bisa dibangkitkan dengan dua cara, mengumpulkan masukan acak dari sumber yang tidak bisa diamati, seperti API *Random Generator* di sistem operasi, atau dibangkitkan menggunakan komputasi. Namun, tidak ada prosedur komputasi yang menghasilkan deret bilangan acak yang benar-benar sempurna (*true random*). Bilangan acak yang dihasilkan dengan prosedur komputasi adalah bilangan acak semu (*pseudo-random*), karena pembangkitan bilangannya dapat diulang kembali. Pembangkit deret bilangan acak semacam itu disebut *pseudo-random number generator* *(PRNG*). PRNG bersifat deterministik, artinya bilangan acak bisa diulang kembali pembangkitannya asalkan kunci (umpan) yang digunakan sama.

## CSPRNG

C*ryptographically secure pseudorandom number generator*(CSPRNG) adalah pembangkit bilangan acak yang aman secara kriptografi. Agar aman secara kriptografis, PRNG harus memenuhi beberapa syarat berikut:

1. Secara statistik lolos uji keacakan (*randomness test*).
2. Tahan terhadap serangan (*attack*) yang serius. Serangan ini bertujuan untuk memprediksi bilangan acak yang dihasilkan dari nilai-nilai sebelumnya.

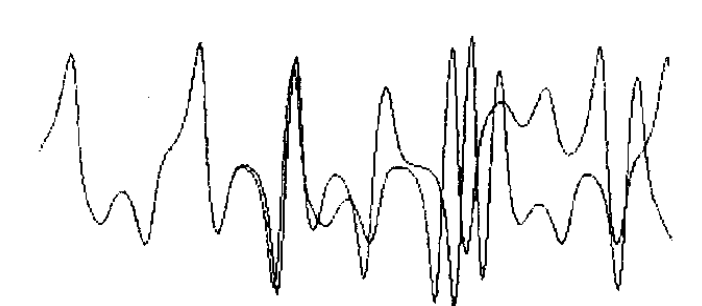
Beberapa persyaratan untuk memastikan bahwa syarat kedua terpenuhi antara lain:

1. Pembangkit bilang acak lulus pengujian *next-bit*. Sebuah pembangkit bit acak dikatakan lulus uji bit berikutnya (next-bit test) jika diberikan barisan k bit, maka tidak dapat diprediksi bit berikutnya 0 atau 1 dengan peluang lebih besar dari ½, sehingga dikatakan *unpredictable*.
2. Pembangkit bilangan acak harus tahan terhadap kompromi perluasan status (*state compromise extensions*). Maksudnya adalah jika penyerangan memperlajari sebagian atau seluruh status sekarang, tidak mungkin bagi penyerang untuk membentuk ulang aliran bilangan acak sebelumnya. Dalam praktiknya, ini berarti CSPRNG harus menggunakan fungsi banyak-ke-satu dalam prosesnya sehingga percobaan untuk membalikkan proses akan menaikkan jumlah kemungkinan aliran secara eksponensial dengan setiap langkah mundur. [5]

## Teori Chaos

Teori *chaos* menggambarkan perilaku sistem dinamis nonlanjar yang menunjukkan fenomena *chaos*. Berdasarkan Wolfram Mathworld [6], suatu sistem disebut menunjukkan fenomena *chaos* apabila memiliki karakterisitik berikut:

1. Memiliki sekumpulan titik yang tebal (*dense collections of points)* dengan orbit periodik.
2. Sensitif terhadap keadaan awal sistem. Jika nilai awal berubah sedikit saja, maka nilai *chaos* yang dihasilkan akan berbeda signifikan. Properti ini kadang-kadang disebut sebagai efek kupu-kupu (*butterfly* effect).
3. Memiliki topologi yang transitif.



**Gambar 1**. Ilustrasi Grafik Nilai Pada Sistem *Chaos*.

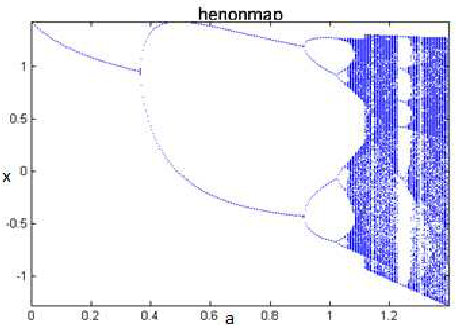
Sumber: <https://informatika.stei.itb.ac.id/~rinaldi.munir/Kriptografi/2023-2024/32-Pembangkit-bilangan-acak-2024.pdf>

## Henon Map

Henon map adalah pemetaan 2 dimesnsi untuk merepresentasikan perilaku *chaotic*, yang merupakan bentuk sederhana dari sistem Lorentz. Henon Map dapat diformulasikan dalam persamaan (1) dan (2).

Nilai xi dan yimerepresentasikan kordinat awal. Nilai xi+1 dan yi+1 merepresentasikan kordinat setelah transformasi. Nilai a dan b merepresentasikan nilai parameter Hanon Map. Jika persamaan Henon Map direduksi menjadi 1 dimensi, maka persamaan Henon Map akan menjadi seperti persamaan (3)

Persamaan Hanon yang kanon menggunakan nilai a=1,4 dan b=0,3.



**Gambar 2**. *Bifurcation Diagram* Henon Map.

Sumber: <https://www.researchgate.net/figure/Bifurcation-diagram-for-Henon-map_fig1_224926941>

# Implementasi

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

## Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

## Units

* Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive.”
* Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
* Do not mix complete spellings and abbreviations of units: “Wb/m2” or “webers per square meter,” not “webers/m2.” Spell units when they appear in text: “...a few henries,” not “...a few H.”

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* Use a zero before decimal points: “0.25,” not “.25.” Use “cm3,” not “cc.” (*bullet list*)

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Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

*a**b*    

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1),” not “Eq. (1)” or “equation (1),” except at the beginning of a sentence: “Equation (1) is ...”

## Some Common Mistakes

* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o.”
* In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset,” not an “insert.” The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
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* In your paper title, if the words “that uses” can accurately replace the word using, capitalize the “u”; if not, keep using lower-cased.
* Be aware of the different meanings of the homophones “affect” and “effect,” “complement” and “compliment,” “discreet” and “discrete,” “principal” and “principle.”
* Do not confuse “imply” and “infer.”
* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”
* The abbreviation “i.e.” means “that is,” and the abbreviation “e.g.” means “for example.”

An excellent style manual for science writers is [7].

# Pengujian dan Analisis

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### For author/s of only one affiliation (Heading 3): To change the default, adjust the template as follows.

#### Selection (Heading 4): Highlight all author and affiliation lines.

#### Change number of columns: Select the Columns icon from the MS Word Standard toolbar and then select “1 Column” from the selection palette.

#### Deletion: Delete the author and affiliation lines for the second affiliation.

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### Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1,” even at the beginning of a sentence.

1. Table Styles

| Table Head | Table Column Head | | |
| --- | --- | --- | --- |
| Table column subhead | Subhead | Subhead |
| copy | More table copya |  |  |

1. Sample of a Table footnote. *(Table footnote)*
2. Example of a figure caption. *(figure caption)*

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization,” or “Magnetization, M,” not just “M.” If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization (A ( m(1),” not just “A/m.” Do not label axes with a ratio of quantities and units. For example, write “Temperature (K),” not “Temperature/K.”

##### Video Link at Youtube *(Heading 5)*

Include link of your video on YouTube in this section.

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The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g.” Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

##### Referensi

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first ...”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

1. OWASP. Methods for Enhancing Password Storage. Diakses pada 05 Juni 2024, dari <https://cheatsheetseries.owasp.org/cheatsheets/Password_Storage_Cheat_Sheet.html#methods-for-enhancing-password-storage>
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8. Text Steganography Using Lsb Insertion Method Along With Chaos Theory - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Bifurcation-diagram-for-Henon-map\_fig1\_224926941 [accessed 12 Jun, 2024]

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Bandung, 12 Juni 2024

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