

Applying adaptive technology in data security

Éder José Pelegrini¹ João José Neto¹

¹Escola Politécnica da Universidade de São Paulo

eder.pelegrini@poli.usp.br, joao.jose@poli.usp.br

Abstract

This paper proposes a new approach for data security and reports the application of adaptivity in the design of an adaptive technology-based experimental cipher system. Our goal with this approach is to build a fast and secure cipher system based on two practices: using the cipher key to encode part of the information on the execution algorithm; and hiding another part of that information as controlled dynamic modifications imposed through changes applied to the execution algorithm. Because of the interesting properties of this proposal, authors expect the main ideas present in this paper be used in actual cryptosystems in a near future.

1. Introduction

A common sense in cryptography is that encrypting and decrypting methods are publicly known, so its secrecy lies on the cryptography key. This idea is stated by Kerckhoff principle. The alternative of keeping hidden the description of the algorithm in order to achieve security is considered an ineffective strategy [Tanenbaum, 2003].

A publicly known algorithm allows cryptanalysts to explore its fragile points, i.e., knowledge on the operation of the algorithm allow inferring more efficient ways for breaking the cipher than simply doing exhaustive trials, in order to verify all possible keys. For example:

- The obsolete Caesar cipher accepts any integer number as a key. Its ciphering idea consists of replacing each letter in a text with another one, displaced by a fixed amount in the alphabet sequence [Bishop, 2002][Tanenbaum, 2003]. Actually, there are only twenty-six different valid keys in this scheme, whose exhaustive trial may be easily performed.
- The RSA is an asymmetric cipher [Bishop, 2002][Rivest; Shamir and Adleman, 1978][Tanenbaum, 2003]. Its security relies on the difficulty of the factorization problem for large integers [Rivest; Shamir and Adleman, 1978]. Solving this problem requires breaking the cipher, despite the difficulty of determining prime factors for large integers.

Modern crypto-algorithms use sophisticated sequences of operations in order to avoid such attacks and increase their security. As an example, the AES algorithm [Bishop, 2002][Daemen and Rijmen, 1999][Tanenbaum, 2003] is based on the Galois Field theory and uses multiple rounds. On each round, replacement, transposition and exclusive-or operations are performed.

This paper presents a novel approach to perform data ciphering (and deciphering) through the use of adaptive technology. It proposes a novel way for the design of a cryptosystem-like ciphering system which hides part of the ciphering/deciphering logic in a way that both ensures Kerckhoff's principle and increases the difficulty to identify and explore fragilities. Both the information and the logic changes are based on the chosen secret key.

To make it harder to explore weaknesses, this method allows changing dynamically the hidden logic, driven by the contents of the input text. Adaptive Technology is used to achieve that goal. Our proposal considers hiding part of the algorithm's logic and changing it in order to get a secure and fast ciphering algorithm for data security. Such approach can eventually be used as a

starting point towards the design of a full cryptosystem.

It is important to emphasize that the aim of our proposal is to demonstrate how to use an adaptive formalism to investigate new ways for assuring data security. For illustrating purposes only, a simple ciphering system is proposed below by means of a toy example, in order to communicate ideas and validate concepts.

The remainder of this paper is organized as follows: section 2 tells about motivations and previous works; section 3 describes the formalism used in this paper; section 4 explains the concepts and a way for building a cipher system based on adaptive technology; section 5 presents and demonstrate a first development of a cipher system based on this approach; section 6 discusses about the security of this approach; at last, section 7 concludes this paper, being followed by the references.

2. Previous Work

Neto [2002] defined adaptive automata as self-modifying rule-driven devices based on structured pushdown automata. The adaptation mechanism employed in adaptive automata is modified to develop the adaptive finite-state transducer used in this publication.

Lewis and Papadimitriou [1981] and Neto [1987] describe a finite-state transducer as a formalism similar to finite-state automata, except for the optional output generated by each transition. The approach presented here is based on this formal model.

Bishop [2002], Tanenbaum [2003] present issues concerning modern cryptosystems. In the history of the used algorithm it is possible to identify the gradual increase of complexity imposed to the algorithm in order to maintain security.

3. Adaptive Technology

Adaptive Technology resulted from searching for formulations that be both simple and sufficiently strong to represent and handle complex phenomena [Pistori, 2003]. It deals with formalisms and devices that react to external stimuli by dynamically activating self-modification actions that change their behavior [Pedrazzi; Tchemra and Rocha, 2005].

Several traditional formalisms, such as finite-state automata, grammars, Markov chains, Statecharts, decision tables and decision trees had their power and expressiveness increased when used as subjacent devices for this approach [Pedrazzi; Tchemra and Rocha, 2005].

Adaptive technology has already been successfully used in a wide range of application fields, e.g. robotic navigation, automatic musical composition, computer vision, pattern recognition, natural language processing and compiler construction [Pistori; Neto and Pereira, 2006].

3.1. Finite-State Transducers

A finite-state transducer is a device much similar to the classic finite-state automaton [Lewis and Papadimitriou, 1981]. Apart of its language recognition purpose, a finite-state transducer is also expected to convert its input into an output text [Neto, 1987].

A finite-state transducer may be described [Lewis and Papadimitriou, 1981][Neto, 1987] as a 6-tuple $(Q, \Sigma, \Lambda, \delta, q_0, F)$, where: Q represents a finite, non-empty set of states; Σ represents the input alphabet; Λ represents the output alphabet; q_0 represents the initial state ($q_0 \in Q$); F

represents a finite non-empty set of final states ($F \subseteq Q$); δ represents a transition function ($\delta : Q \times (\Sigma \cup \{\epsilon\}) \rightarrow Q \times \Lambda$). Set F may be suppressed when accepting the input text is not necessary.

Finite-state transducers may be described by means of state transition diagrams, that are directed graph with input and output information associated to their transitions.

The operation of a finite-state transducer consists of cyclically: read an input symbol; use the transition function to change the current state; and write out some corresponding output symbol if necessary.

In order to represent the execution of such machine, the concept of configuration is defined for finite-state automata [Neto, 1987] as a 3-tuple (current state, input string yet to be read, output string generated so far). Let $w_i w_{i+1} \dots w_n$ be the part of the input string yet to be read and $u_0 \dots u_{i-1}$ the already generated output string. The computation step the automaton performs by applying some transition rule $\delta(q, w_i) \rightarrow (q', u_i)$ is represented by the move from its current configuration to the next one: $(q, w_i w_{i+1} \dots w_n, u_0 \dots u_{i-1}) \vdash (q', w_{i+1} \dots w_n, u_0 \dots u_{i-1} u_i)$.

3.1. Adaptive Finite-State Transducers

Adaptive finite-state transducers are self-modifying rule-driven devices based on finite-state transducers. At the start of its operation, an adaptive finite-state transducer T may be viewed as a finite-state transducer T_0 . Whenever a transition is executed, the behavior of that transducer may change. So, in operation, an adaptive finite-state transducer T describes a path $(M_0, w_0, u_0) \Rightarrow (M_1, w_1, u_1) \Rightarrow \dots \Rightarrow (M_n, w_n, u_n)$, where $w_0 w_1 \dots w_n$ ($n \geq 0$) represent the input string, and u_k ($0 \leq k \leq n$) represent the full output string at each step k .

The basic mechanisms that allow adaptive transducers to perform self-modification are called adaptive functions. Adaptive functions may be parametric, and must be declared apart of the topology of the transducer.

A similar formulation, presented in [Neto and Pariente, 2002] for adaptive automata, defines adaptive functions as collections of elementary adaptive actions. There are three different elementary adaptive actions: insertion actions, that joins a specified transition to the set of transitions defining the automaton; elimination actions, which remove a specified transition from that set; and inspection actions, that searches that set for transitions matching some given pattern.

Calls to adaptive functions may be attached to the transducer's transitions. In this case, they are called adaptive actions. Adaptive actions are specified to execute before and after the execution of the corresponding transition [Neto and Pariente, 2002].

In order to represent transitions with optionally attached adaptive functions the following notation is used: $(q, w_i)B \rightarrow (q', u_i)A$, where: $q, q' \in Q$, $w_i \in \Sigma$, $u_i \in \Lambda$. B and A optionally specify names of adaptive functions to be executed before and after the transition is applied, respectively.

Being mere extensions of adaptive finite-state automata, with no changes in any of their properties, it is easy to show they have the same power of Turing Machines, just as adaptive (finite-state and structured pushdown) automata [Rocha and Neto, 2000][Neto and Pariente, 2002].

4. Building a Data Security System with Adaptive Finite-State Transducer

In this section we introduce finite-state transducers as the subjacent abstraction for the implementation of ciphering systems whose desired behavior is being similar to that of a standard cryptosystem: the transducer's underlying finite-state automaton is used as part of the design of

ciphering functions. Afterwards, adaptive actions are added to its transitions in order to obtain the proposed adaptive technology-based ciphering system. The purpose of our ciphering algorithm is to convert some plain text P into a ciphered text C by means of a ciphering algorithm using key K . The main idea of such a ciphering scheme is to associate different ciphering algorithms/cryptosystems to the states of an adaptive finite-state transducer, so that output is generated as part of the ciphered text in a specific state by applying to the input data the algorithm associated to that state.

4.1. A Finite-State Transducer Approach

Let us consider a finite-state transducer $T = (Q, \Sigma, \Lambda, \delta, q_0, F)$, where:

- Q : set of n states q_s , $1 \leq s \leq n$ (in the examples below, $q_s \equiv s$ by natural isomorphism);
- Σ : is the input alphabet and it contains all possible values for w_i . Typically, Σ is the set of all elements in $\{0,1\}^p$, $p > 0$. In this case, p is the bit width of the symbols in the input alphabet;
- Λ : is the output alphabet, and it contains all possible output values. Note that Σ and Λ may even be the same, but only $|\Lambda| = |\Sigma|$ is required;
- q_0 : is the transducer's initial state ($q_0 \in Q$);
- F : is the set of the transducer's final states (F may even be empty, since typically T is not always intended to operate as an acceptor);
- $\delta: Q \times \Sigma \rightarrow Q \times \Lambda$ is the transduction function. Each of its defining transduction rules $(q_s, w_i) \rightarrow (q_j, \lambda_i)$ maps some input symbol $w_i \in \Sigma$ into its corresponding ciphered output $\lambda_i = \Theta_s(w_i, k_s) \in \Lambda$, where Θ_s and k_s are the output parameters associated with the transition origin state q_s , and moves the transducer from its current state q_s to state q_j .

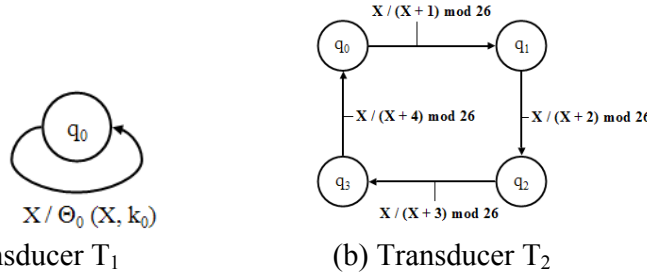


Figure 1: Examples of Finite-state Transducers Token X represents any input symbol

The computation performed on an input string $w = w_1 \dots w_n$ by the finite-state transducer T_1 in Figure 1(a) is $(q_0, w_1 \dots w_n, \epsilon) \vdash^* (q_0, \epsilon, \Theta_0(w_1, k_0) \dots \Theta_0(w_n, k_0))$. Its output is obtained by applying function Θ_0 to each w_i ($1 \leq i \leq n$), with the argument k_0 . If Θ_0 is a ciphering function and k_0 is the ciphering key, then T_1 performs a ciphering computation on w_i . A 4-state transducer T_2 is illustrated in Figure 1(b).

In order to decipher the output of T_1 a finite-state transducer T_1^{-1} is needed, where: (i) Q, F, q_0 are the same as in T_1 ; (ii) The input alphabet of T_1 is the output alphabet of T_1^{-1} and vice-versa; and (iii) for each $(q_s, w_i) \rightarrow (q_j, \lambda_i)$ in T_1 there is some $(q_s, \lambda_i) \rightarrow (q_j, \Theta_s^{-1}(\lambda_i, k_s^{-1}))$ in T_1^{-1} , where $\lambda_i = \Theta_s(w_i, k_s)$ in T_1 , k_s^{-1} is the deciphering key associated to the enciphering key k_s and Θ_s^{-1} is the deciphering function for the Θ_s ciphering function.

The following conditions must hold in order to a finite-state transducer be considered a ciphering system: (i) the ciphering finite-state transducer must be deterministic, otherwise it

would map an input text into different ciphered texts, turning the deciphering operation also non-deterministic; (ii) finite-state transducers must be fully described, otherwise their operation would stop before input text is fully processed; and (iii) the same function and the same key must apply to all transitions emerging from each state (output parameters are associated to the transition's origin state), otherwise the inverse operation will not be deterministic.

4.2. Adaptive Transducer Approach

Adaptive functions allow automatically changing finite-state transducer's behavior. It allows modifying transducer's topology and ciphering parameters (key, function, output mapping).

Adaptive functions used in our proposal must be designed in such a way that the transducer remains both fully described and deterministic. That requires restrictions to be imposed to the allowed adaptive actions, e.g., in order to assure that the transducer remains fully described, the removal of each transition must be complemented by the addition of another one emerging from the same state and consuming the same input symbol. Additionally, for efficiency, it is advisable to restrict the use of adaptive actions only to before- or after- ones, not both.

Choosing adequate adaptive actions requires caution and study. An example of a convenient set of simple adaptive functions is: (i) Modify the destination state of a transition in order to change transducer's topology. The new destination state may be specified as a parameter for the adaptive function; (ii) Modify the adaptive action within a rule by changing the adaptive function invoked by the rule; and (iii) Modify the output symbol in some rule. Such a function must consistently replace the output symbol of all rules departing from the affecting state, in order to ensure that different destination states correspond to different outputs. The idea is to modify ciphering parameters. The output symbol may be changed in two ways: (i) for pre-computed values apply some adequate function (e.g. an exclusive-or operation between the original cipher symbol and some parameter); and (ii) for the function/key method, change the function and/or the key used.

4.3. Adaptive Finite-State Automata in Data Security

Preceding sections propose using (adaptive) finite-state transducers in data security. An adaptive version was used to perform ciphering/deciphering. An adaptive finite-state transducers-based ciphering system is an algorithm that uses by an adaptive finite-state transducer instead of traditional data keys. The strength of this approach is that it radically disguises the algorithm being executed, even allowing it to change dynamically.

Using a finite-state transducer as a key allows performing symmetric stream ciphering (similar to a stream cipher cryptosystem [Bishop, 2002][Tanenbaum, 2003]) in which part of the operation sequence depends on information encoded within the key. The sequence of keys and/or functions executed depends on the current state of the transducer. Each state determines the function and the key to be used, so such execution path may be denoted by a sequence $((\Theta_{q_0}, k_{q_0}), (\Theta_{q_1}, k_{q_1}), \dots, (\Theta_{q_r}, k_{q_r}))$, where q_r denotes the current state before the execution of the n -th step of computation. Consequently, part of the transduction logic became hidden. To illustrate how this hiding operates, let us consider, for analogy, accepting sentences of a language defined by a regular expression. This problem may be solved by using specific finite-state automata [Lewis and Papadimitriou, 1981]. Algorithms that simulate generic finite-state automata are well-known, but the particular one that accepts a specific language defined by some particular regular

expression is encoded in the corresponding transition function. The resulting obscurity in that logic meets the requirements stated by Kerckhoff's principle, provided that the adaptive transducer simulating algorithm be publicly available. It remains hidden the information on what sort of operation is expected to be used at each specific execution step.

However, conventional finite-state transducers may be inferred. Some ciphering key patterns may appear, turning this approach vulnerable to differential attacks. An illustrating example is given in Figure 1(b). Note that the sequence q_0, q_1, q_2, q_3 of states in this automaton corresponds to an execution pattern. Such fragility may be avoided by dynamically modifying the transducer's execution flow.

Such a feature is the essence of adaptive technology. For adaptive finite-state automaton, even topology is not permanent. Adaptive functions allow changing the set of transitions and the associated ciphering parameters. Furthermore, with appropriate adaptive functions it is even possible to change the adaptive actions associated to the transitions.

In brief, this approach has the following features:

- The ciphering key, represented by an adaptive finite-state transducer, holds information on the sequence of computation. The ciphering/deciphering operation depends on that sequence.
- The algorithm does not predefine the number of states, so the key size may be variable. Execution time is constant for each state, so the number of states in the transducer does not affect its speed. However, the larger the number of states, the harder the problem of inferring the transducer (key).
- Adaptive functions related to each executed transition may modify the transducer (key).
- Different input strings can have different computation sequences if the transitions declared do not group every possible input in a unique token. In this case, the ciphering/deciphering operation also depends on the input text.
- The execution algorithm with pre-computed output allows attackers to know only the type of adaptive actions used (no extra functions needs to be declared, except adaptive ones).
- A good key allows a block of input text to be exhaustively ciphered into all possible output ciphers. This is a kind of stream cipher algorithm in which the next key depends on both the input text and the topology of the automaton being used as a key.

Nevertheless, this approach has some limitations: (i) using a transducer as a key often lead to keys that are large compared to the traditional 128- or 256-bit keys used in symmetrical cryptosystems; (ii) execution time depends on the way output symbols are generated: by means of some pre-calculated table or by using function calls. For pre-calculated input, transitions cannot be partitioned, so the number of possible input/output must be limited, otherwise, the transducer becomes too large; (iii) once the transducer triggers its transitions with the input text for ciphering or the ciphered text for deciphering, both transducers must stay synchronized in order to assure correct operation. So, with this approach only two-sided communication is possible; and (iv) With these restrictions only, two or more different keys would return the same cipher text for some given subset of the set plain text. And more, it's possible that two or more different keys execute the same logical operation (to use this ciphering scheme as a basis for a cryptosystem it is necessary to refine the restrictions further in order to avoid such cases).

Security provided by hiding information and by changing the execution flow allows using straightforward operations in the output function, such as the exclusive-or operation, and also uncomplicated adaptive actions such as those previously proposed. Although with limitations, we expect that with some refinements, this ciphering scheme can become the basis for a new kind of

stream cryptosystem.

5. Experiment and Results: The Adapt_Cipher Algorithm

Adapt_Cipher is an illustrative ciphering algorithm developed around the previously presented ideas. It is derived from the obsolete Caesar cipher (by using only that cipher as the Θ function) and is described in Algorithm 1. The aim of this ciphering scheme is to demonstrate the potential of adaptivity in data security and to compare it with a well-known classical cipher (the motivation of choosing Caesar cipher is the ease of understanding). Our main goal of this scheme is to be fast, and although it seems easy to break, it can be significantly hard to predict or infer if the number of states (key length) is sufficiently high (e.g. 50 states).

Algorithm 1 Adapt_Cipher

Require: The key (adaptive finite-state transducer description)

Execute:

```
initialize cipher();
qcurrent = 0;
input = readinput();
while (input != NULL)    {
    qcurrent = executetransition(qcurrent, X);    //performs a transducer transition
    output =  $\Theta_{q_{current}}$  (input, Kqcurrent);    //generates output symbol (ciphered text)
    executeadaptivefunction(qcurrent, X);    //executes adaptive action
    input = readinput();    }    //reads next input symbol
end;
```

This ciphering algorithm accepts an adaptive finite-state transducer with one transition per state (to reduce the key size, the single token X represents all possible input symbols used in the transition). Each transition has an adaptive function associated (indexed by numbers 0 through 4). Let $|Q|$ be the number of states, and DS the destination state in the transition being executed. The adaptive functions used in this ciphering scheme are:

- A₀: Do nothing;
- A₁: Change DS to $(DS+1) \bmod (|Q|)$;
- A₂: Change the $K_{q_{current}}$ to $(K_{q_{current}} + 1) \bmod 26$;
- A₃: Change DS $(DS+1) \bmod (|Q|)$ and change the $K_{q_{current}}$ to $(K_{q_{current}} + 1) \bmod 26$;
- A₄: Change DS to $(DS+2) \bmod (|Q|)$.

The ciphering initialization is a function that reads in the key and converts it to an internal representation. The execution is a loop on the input text symbols (the algorithm keeps running until input is exhausted). The loop body includes: reading a symbol from the input text, performing a transition to the next state of the transducer, generating an output, and executing the required adaptive action.

5.1. Example

This example has been elaborated in order to illustrate some execution details of this method

and its differences to the classical approach. This ciphering scheme is too weak for real uses, since is vulnerable to two simple attacks: testing one of its 26 valid keys or using frequency analysis over the idiom.

This example is based on the finite-state transducer in Figure 1(b). The finite-state approach gives the pattern of key (1234). In order to avoid such patterns, adaptive functions have been inserted, making a key for the adaptive cipher (described in Table 1). The reduced number of states in this example is for easing manual simulation only. Obviously, effective use of this method in actual applications requires a large number of states for the transducer.

Id	Current State	Input String	Destination State	Output String (K_{state})	Adaptive Function
1	0	X	1	$X+1 \text{ mod } 26 (K_0 = 1)$	A_1
2	1	X	2	$X+2 \text{ mod } 26 (K_1 = 2)$	A_2
3	2	X	3	$X+3 \text{ mod } 26 (K_2 = 3)$	A_0
4	3	X	0	$X+4 \text{ mod } 26 (K_3 = 4)$	A_5

Table 1: Adaptive Finite-state Automaton Transitions (Visual key for Adapt Cipher)

A step-by-step evolution of the adaptive finite-state transducer on the word “REDISCOVER” is:

$(M_0, \text{REDISCOVER}, \varepsilon)$	$\vdash_1 (M_1, \text{EDISCOVER}, S)$	$\vdash_2 (M_2, \text{DISCOVER}, SG)$
$\vdash_3 (M_3, \text{ISCOVER}, SGG)$	$\vdash_4 (M_4, \text{SCOVER}, SGGM)$	$\vdash_1 (M_5, \text{COVER}, SGGMT)$
$\vdash_3 (M_6, \text{OVER}, SGGMTF)$	$\vdash_4 (M_7, \text{VER}, SGGMTFS)$	$\vdash_3 (M_8, \text{VE}, SGGMTFSY)$
$\vdash_4 (M_9, \text{R}, SGGMTFSYI)$	$\vdash_1 (M_{10}, \varepsilon, SGGMTFSYIS)$	

The subscript at each computation step indicates the transition applied.

For comparing results, “REDISCOVER” is now ciphered using the Caesar cipher and the finite-state automaton (without adaptive actions). Table 2 compares both approaches.

Input	R	E	D	I	S	C	O	V	E	R
	Caesar cipher									
Keys	3	3	3	3	3	3	3	3	3	3
Output	U	H	G	L	V	F	R	Y	H	U
	Finite-state Automaton in Fig 1 (b)									
Keys	1	2	3	4	1	2	3	4	1	2
Output	S	G	G	M	T	E	R	Z	F	T
	Adaptive Finite-state Automaton (table 1) – Adapt_Cipher									
Keys	1	2	3	4	1	3	4	3	4	1
Output	S	G	G	M	T	F	S	Y	I	S

Table 2: Compared results. “Keys” indicate the Caesar cipher key used for each letter.

Although using so few states is not recommended, one can easily observe how even a simple 4-state adaptive finite-state automaton provides an pseudo-random effect in the sequence of “keys”. Changing “keys” turns this approach less vulnerable to the previously discussed attacks to Caesar cipher. Since the transducer changes dynamically, inference becomes a harder task.

6. Discussion about the results: Overview of Strength against Attacks

The security achieved through this method is fundamentally based on hiding information on the ciphering/deciphering process. In addition, adaptivity modifies the transducer every time an adaptive action takes place, so breaking such system seems to be a hard task. The following text comments on possible attacks and their consequences. The security of this algorithm has not yet been analytically proven. Stream cipher cryptosystems (as well as our cipher system) are often general design or analysis techniques. Estimating or assuring security for this kind of cipher is more complicate than for the block cipher cryptosystem [Schneier, 2000], since the block cipher cryptosystem typically follows some concrete design practice that assures security.

A first possible attack is to build a translation dictionary that maps input text into the corresponding cipher. Using the transducer method, each plain text maps into different ciphered texts, therefore any attack using translation dictionaries becomes rather ineffective.

Another possibility is the differential attack. It studies how variations in the input text reflect in the output text and explores high-probabilities in the occurrence of such differences [Heys, 2001]. Since ciphering functions and keys may vary among states, the state path depends on the input plain text and since adaptive functions may change transducer's parameters, the possibility of simultaneously occurring matching cipher differences in correspondence to identical input text differences seems to be very low. Additionally, it is possible to use functions already proven to be secure against this kind of attack. However, the security of our approach against this attack has not been formally proven yet.

Perhaps the best way to break this ciphering scheme should be to determine its correct key. For doing that one needs to discover the number of states, the set of state transitions and the adaptive functions and corresponding arguments, attached to each transition. Finding such amount of information through brute force is unfeasible, once there exist too many keys (theoretically, infinite keys exist since the number of states is not limited). A more sophisticated technique can combine key inference and differential attack. Our example (adaptive ciphering with 4-state key) is rather easy to break by using a sufficiently large number of input texts together with the respective ciphered texts, and assuming that only Caesar cipher has been used. However, by increasing the number of states, key inference tends to become unfeasible. Certainly more sophisticated attacks will appear with the diffusion of this approach.

Public knowledge of the algorithm provides information that help finding ways to determine the key: (i) the key is encoded as an adaptive finite-state transducer; and (ii) the kind of adaptive functions to be executed. This information seems insufficient to endanger the key's privacy.

7. Conclusions

This work presented some essays toward a novel ciphering method. In our proposal, security is obtained for a ciphering system either: by masking part of the algorithm's logic; by moving some information to the key; by performing adaptive execution.

The security obtained with both transducers and adaptivity allows using simple arithmetic ciphering operations, or even pre-computed values, reducing the ciphering process to simple replacements of input text blocks with corresponding ciphered text blocks obtained by performing the related transduction.

By reducing the complexity of such operations, the ciphering process may turn faster than

with traditional cryptosystem algorithms. With this approach, execution time depends on three factors: (i) the time needed to perform a state transition; (ii) the time needed to obtain an output value; and (iii) the time needed to perform the changes specified by adaptive actions. With fast output algorithms it is possible to achieve better performance in applications that require the encryption of large amounts of data (e.g. ciphering digital video).

The focus of this research is to apply these ideas in near future to design a secure and efficient cryptosystem, with a unique key (the approach developed so far does not guarantee that two different keys do not generate the same output).

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