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Abstract—This document is a model and instructions for $ext{ETEX}$. This and the IEEEtran.cls file define the components of your paper [title, text, heads, etc.]. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.

Index Terms—component, formatting, style, styling, insert

I. INTRODUCTION

Modern operating systems rely on the concept of the trust boundary to keep the system secure. All input that is passed from the user space to the kernel space is considered untrusted. Before the input is used it needs to be validated. Failing to do so can result in the kernel operating on unsafe or malicious data.

Double-fetches occur when the system reads the same data several times from the user space. On a multicore or concurrent system, an adversary can change the values in the user memory. When double-fetches can leave the kernel in an inconsistent state, they result in a double-fetch bug. If these bugs can be exploited they are double-fetch vulnerabilities.

Recent work on double fetches focused on their classification and detection using various static and dynamic, source-level and binary-level techniques. Static analysis techniques such as Wang's have proved successful in detecting double fetches present in the source code. However, they can't detect double fetches introduced by the compiler, or by assigning the address to a different pointer. On the other hand, dynamic techniques such as Bochspwn are successful in detecting these types of bugs, but introduce a significant execution overhead by adding the instrumentation and executing the kernel inside an emulator. They also rely on the hardware being present to fuzz the drivers, which static analysis techniques don't. Recently, progress has been made by SCHWARZ where they use Flush + Reload side-channel attack to detect double-fetches during fuzzing campaigns. However, all of these techniques require

developers to fix the actual bugs after detection. With manufacturers dropping the support for old devices, this simply may not be possible.

The most common variant of double-fetch bugs are TOCTTOU (Time-of-Check-to-Time-of-Use) bugs. They occur when the developer refetches an already copied and validated value. The new data is presumed to be unchanged and it is used instead of the old one. Unfortunately, an adversary could have swapped it for another value bypassing the checks. This can lead to vulnerabilities such as null pointer dereferences and buffer overflows

System call wrappers have been introduced in the early 2000s as a way to filter risky system calls. System call wrappers execute before the system call and analyze the arguments passed. If the call violates a previously established policy, it is terminated. However, while this method works for arguments passed by value, arguments passed by reference (buffers) are prone to the TOCTTOU attack by design. Wrappers such as CentNG for FreeBSD have tried to address this problem by copying buffers to separate, read-only pages and updating the references. Unfortunately, this adds significant overhead to the execution of these calls. Other wrappers have lowered their security guarantees. SecComp doesn't allow any type of pointer dereference. eBPF provides such capabilities, but prevents the developer from influencing the execution of system calls.

Recent systems have adopted Linux Security Module (LSM) hooks to bypass this inherent limitation. LSM hooks are calls to function pointers that should be called before a system resource is accessed. These hooks are triggered after the copying of the arguments has already happened, so they aren't prone to TOCTTOU attacks. Landlock and KPSI (Google) have added the support for eBPF filters in these hooks, enabling loadable filters without the need to change the kernel. Unfortunately, LSM hooks need to be added by the developers by hand and many drivers don't feature them.

Identify applicable funding agency here. If none, delete this.

The contribution of this paper are:

- kTikTok: An extension to the Linux kernel that prevents any changes to the system-call arguments by using the virtual memory protection mechanisms.
- A security analysis of our system and results showing that it is successfull against known double-fetch bugs
- A performance analysis of our system where we show that the performance penalty is comparable to recently merged patches

II. BACKGROUND

In this section we describe the double fetch bugs and user-to-kernel memory interface in the Linux kernel in II-A. Afterward, in the subsection II-B we discuss the memory protection mechanisms that we use for the implementation of our system.

A. Double Fetch Bugs

Double fetch

B. Virtual Memory, Paging and Page Faults

III. EASE OF USE

A. Maintaining the Integrity of the Specifications

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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, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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Number equations consecutively. 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:

$$a + b = \gamma \tag{1}$$

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 . . ."

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Please use "soft" (e.g., \eqref{Eq}) cross references instead of "hard" references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

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- The word "data" is plural, not singular.
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- 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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- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
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- 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].

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Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

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a) 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.

TABLE I TABLE TYPE STYLES

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H	lead	Table column subhead	Subhead	Subhead
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^aSample of a Table footnote.

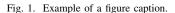


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ACKNOWLEDGMENT

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REFERENCES

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