Eliminating eBPF Tracing Overhead on Untraced Processes

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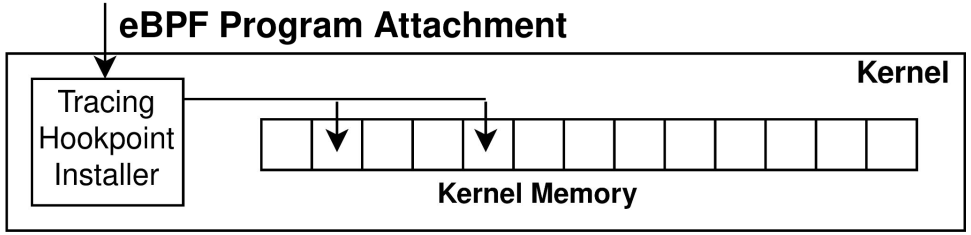
eBPF For Tracing

- eBPF used for dynamic system tracing and observability
- Attach to *Tracing Hookpoints*
  - tracepoints and kprobes
- *Tracing Hookpoint Installer* changes kernel text pages to install the program
  - patching no-op for tracepoint
  - installing trap/interrupt instruction for kprobe



Per-process Tracing with eBPF

- We find current tracing is coarse grained
    - once activated, hookpoint triggers for all processes
- Need for per-process tracing
    - Want to trace a single application or a set of applications
    - Not natively supported

Approaches to Per-process

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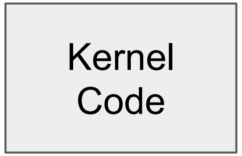

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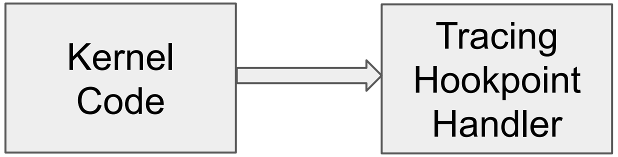

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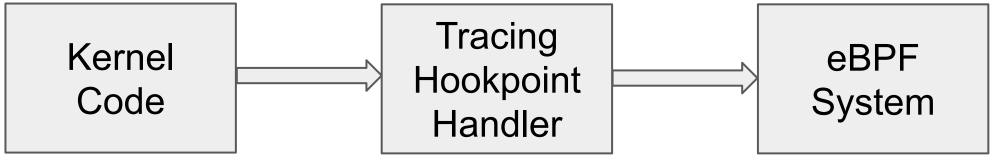

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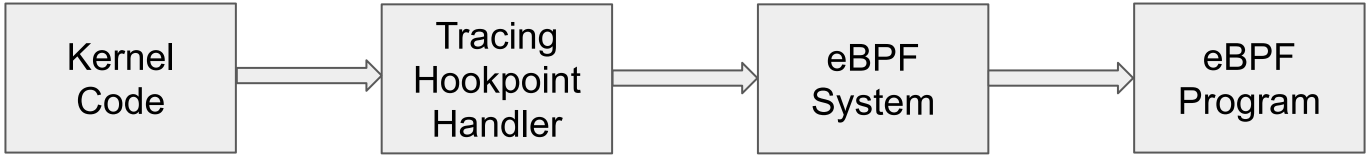

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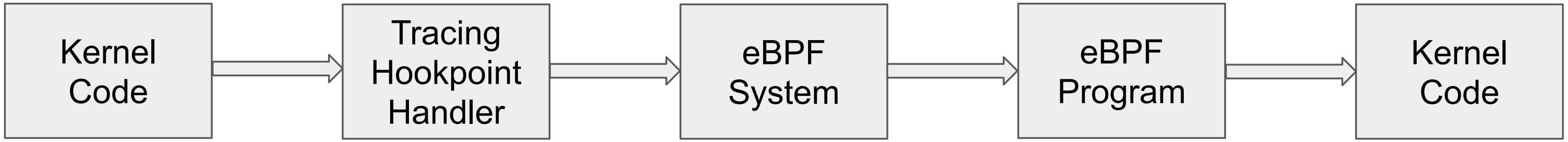

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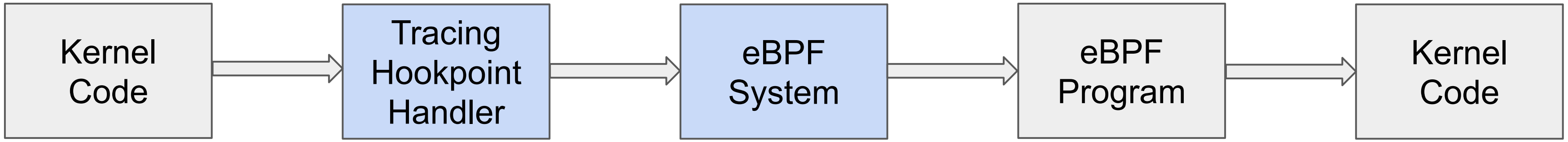

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- Filter for PID before BPF program
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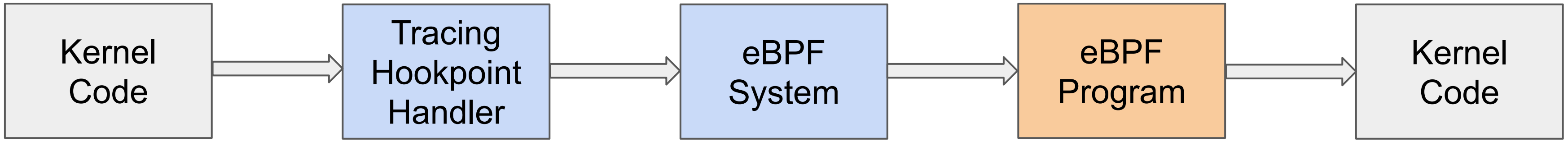

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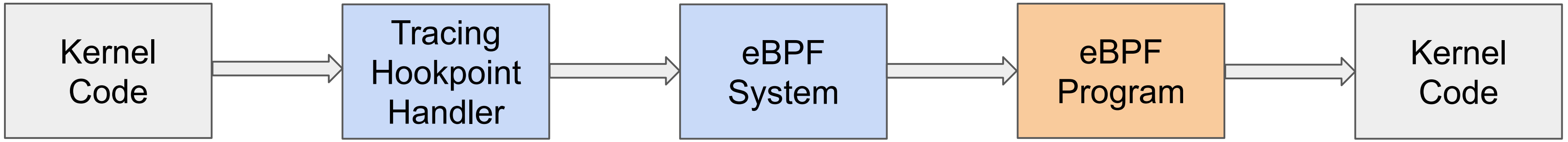

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Post-eBPF

- Filter for PID after data collection
- Intuitively makes sense

Overheads of Per-process Tracing

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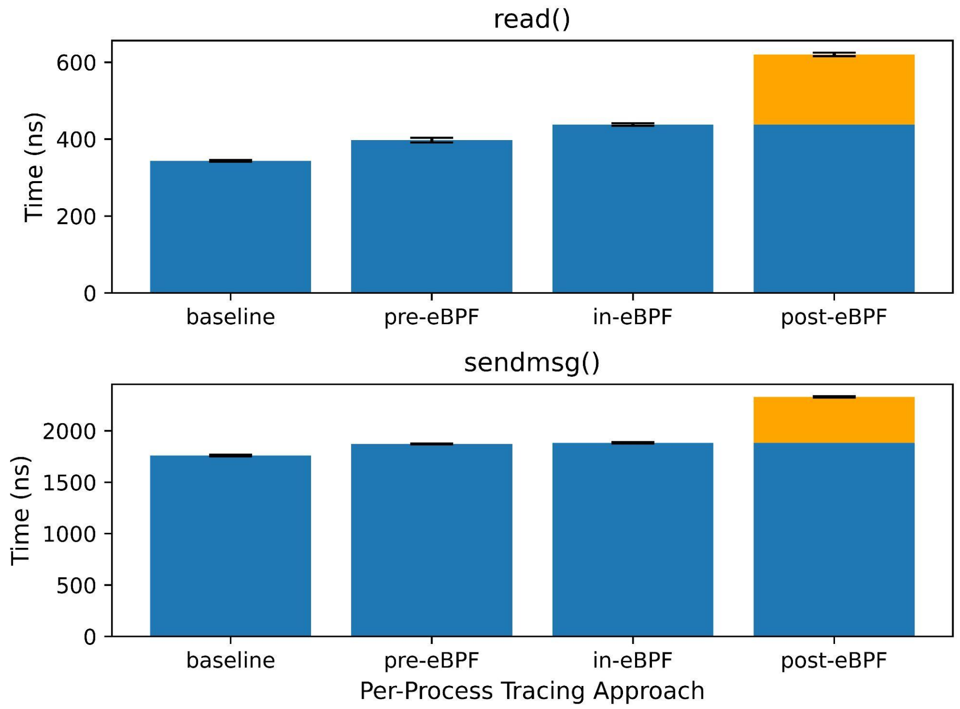

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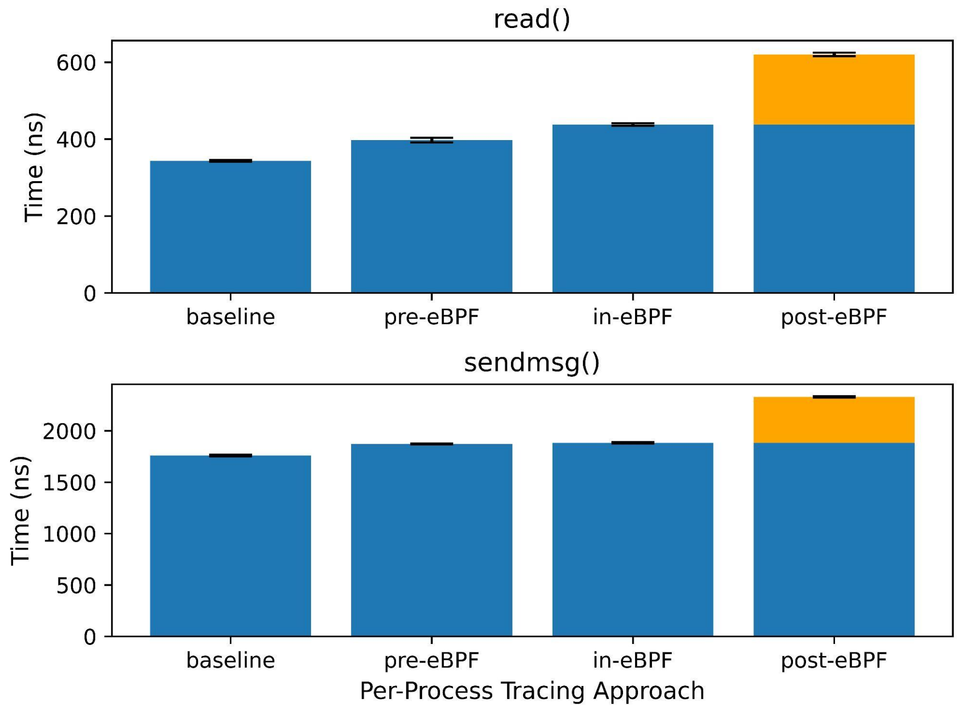

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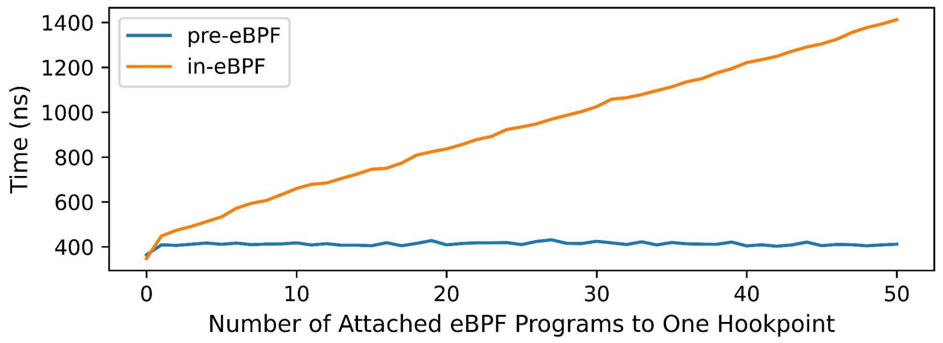
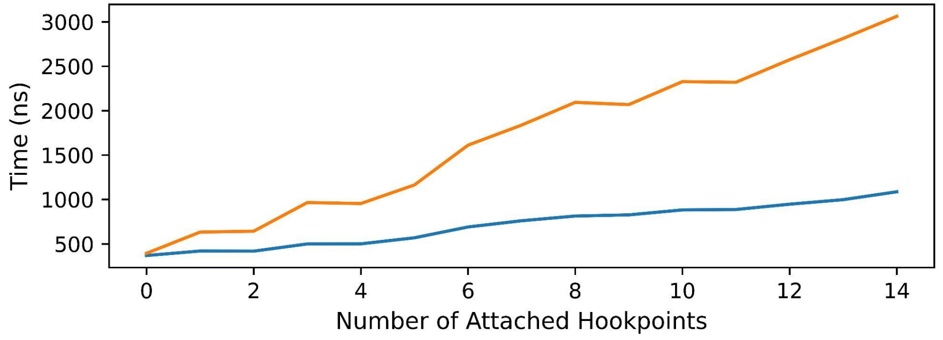
- Trends seem to indicate more eBPF programs attached





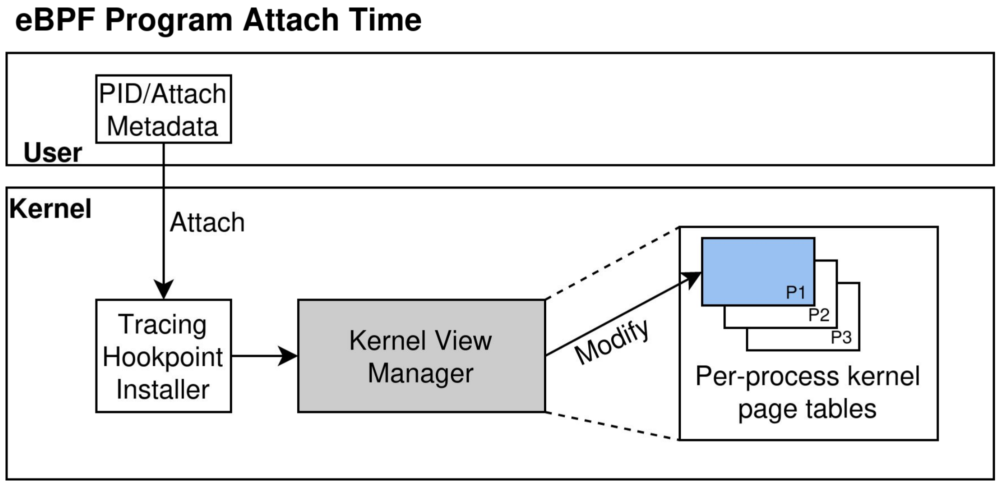
How can we achieve per-process tracing without untraced overhead?

Key Insights

- Unattached tracing hookpoints are fast
  - tracepoints are optimized
  - kprobes are not installed
- Attaching a tracing program requires writes to kernel text pages

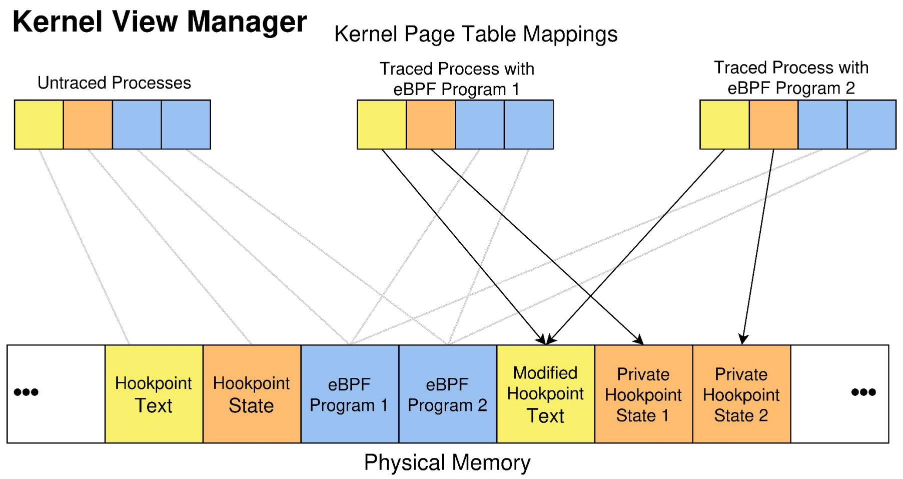
Per-process Kernel Views

- Give each process its own view of the kernel
- Allows for per-process sets of kernel hookpoints
- Modify tracing hookpoint installers to communicate with a *kernel view manager*



Kernel View Manager

- Creates copies of kernel text pages
- Modifies process kernel page tables to map copies of pages
- Installs tracing program
- Provides private hookpoint state


Kernel View Manager
Kernel Page Table Mappings
Untraced Processes
Traced Process with eBPF Program 1
Traced Process with eBPF Program 2
•••
Hookpoint Text
Hookpoint State
eBPF Program 1
eBPF Program 2
Modified Hookpoint Text
Private Hookpoint State 1
Private Hookpoint State 2
•••
Physical Memory

Open Questions

1. Tracing Hookpoint State
    a. What does this consist of? How can we manage it?

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4. Overhead of multiple kernel views
    a. What are the costs associated with changing page tables?

Extending Kernel Views

1. Different Granularities
    a. Other extension use cases need different granularity
    b. Per-flow kernel views
    c. Need to be able to identify and manage different network flows

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1. Different Granularities
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2. Increased Kernel State Management Complexity
   a. Ensure right kernel view is loaded when events occur
   b. Change kernel view for interrupts
   c. Private state for eBPF programs

Takeaways

- Identified that existing approaches for per-process tracing impose overheads on untraced processes
- We propose a system that uses virtual memory mappings to eliminate the overhead on untraced processes
- A kernel view manager gives each process its own view of the kernel

Questions?