Verifying Linked-List Programs and Beyond

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dsOli Day @ Bamberg, January 2016

VeriFast [JSP+11]

Fast, sound and modular verification tool for C and Java

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Checks that

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- Use LOC information to generate function contracts and proof machinery that specify program behaviour.

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Let's look at an example.

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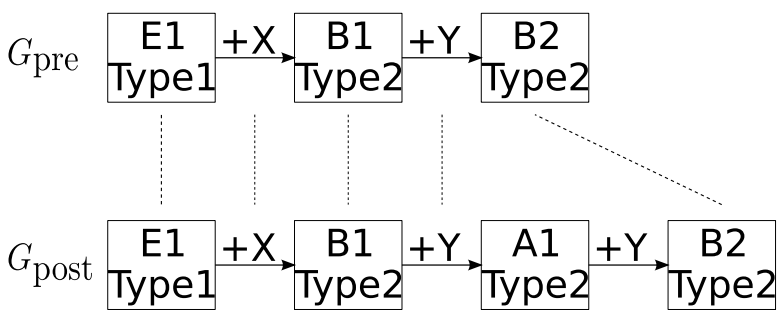


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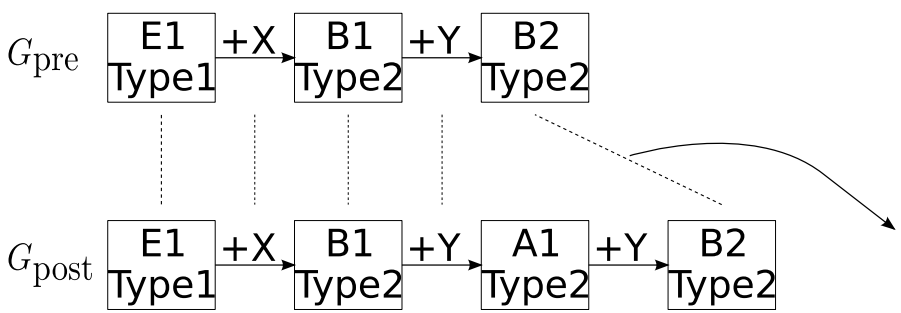


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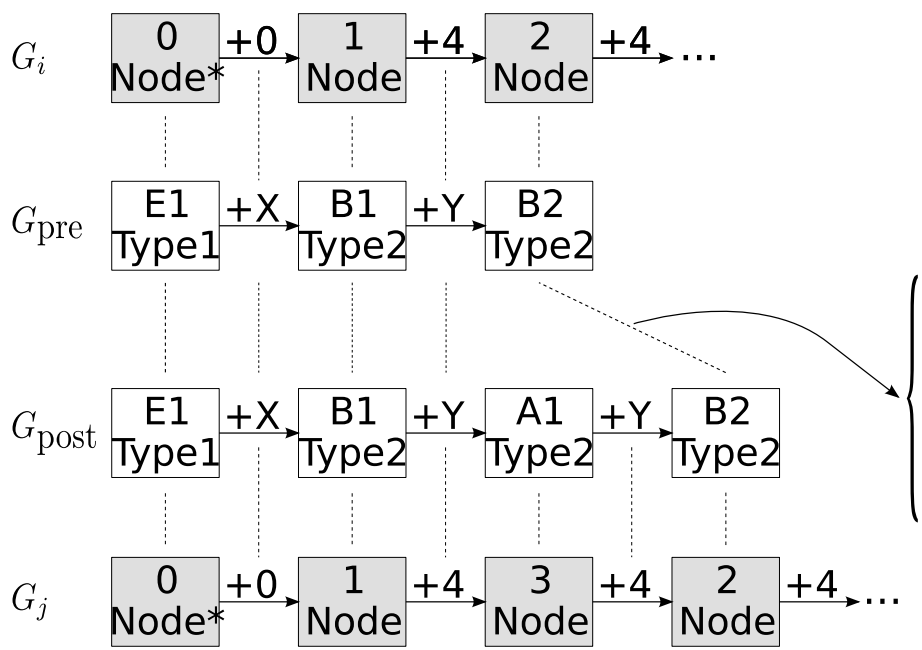

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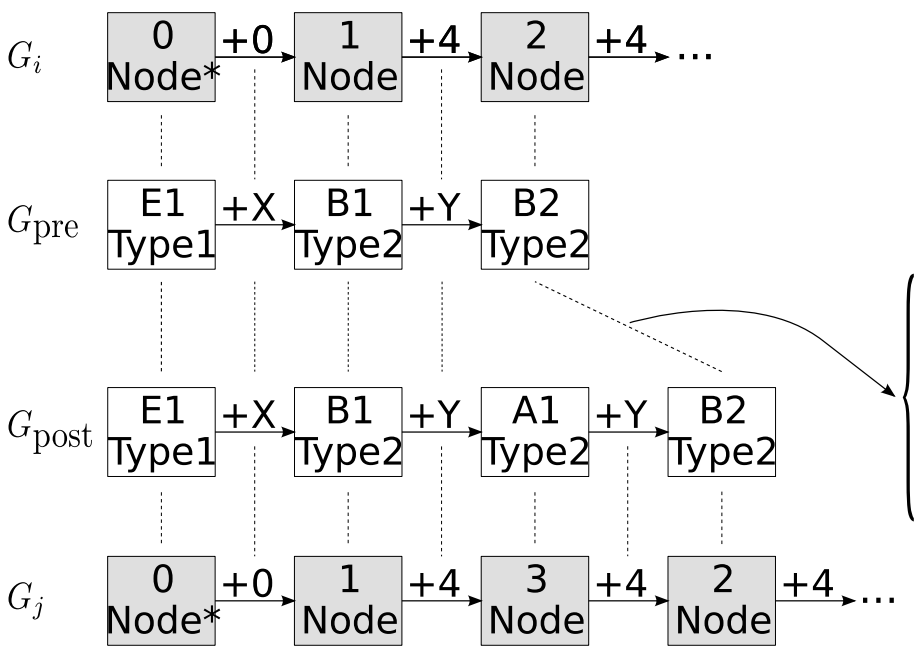


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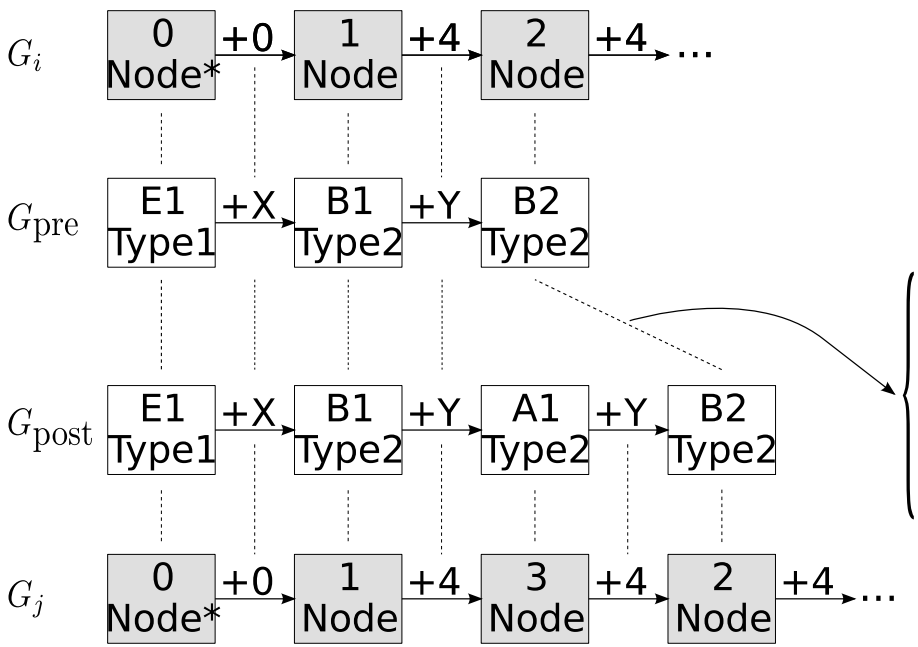


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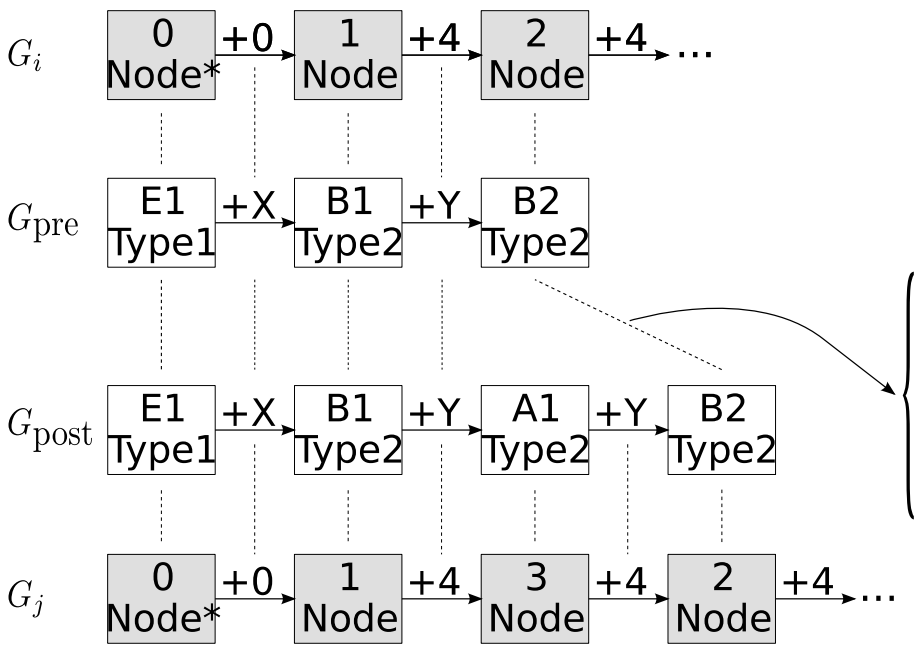


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We (used to) have a prototypic tool that parses C code and XML analysis output from dsOli, and outputs VeriFast annotations.

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- Almost enough for push-button-verification in 3 cases!
- Generated contracts allow for verifying basic safety properties only, but can be extended by the verification engineer.

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Memory safety is pretty cool, but what we actually want to do goes far beyond it: handling concurrency, race conditions, etc.; functional properties, correct I/O behaviour, cryptographic protocols; security properties, component isolation, information flow.

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- Java Smart Card (eID) [PMP+14]
- Linux drivers and low-level services [PMP+14, PMJSP12, PJP15]
- Polar SSL, Amazon s2n [VJ15]
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None of these case studies employs data structures beyond SLLs.

Protected Module Architectures

Protected Module Architectures: Sancus [NAD+13]

Sancus enables strong isolation, attestation and secure communication for embedded software components:

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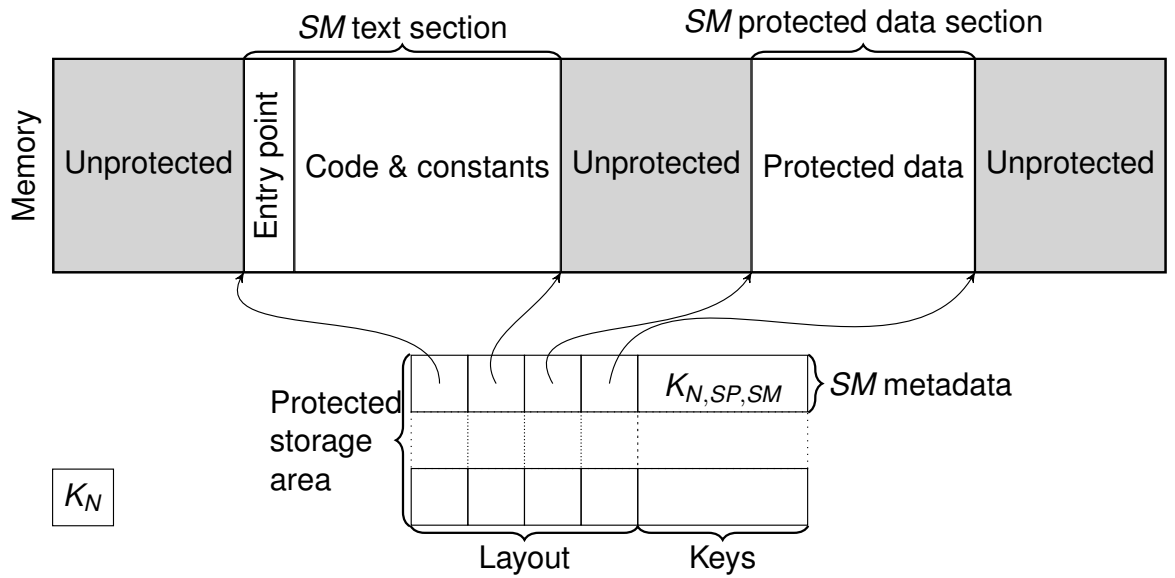

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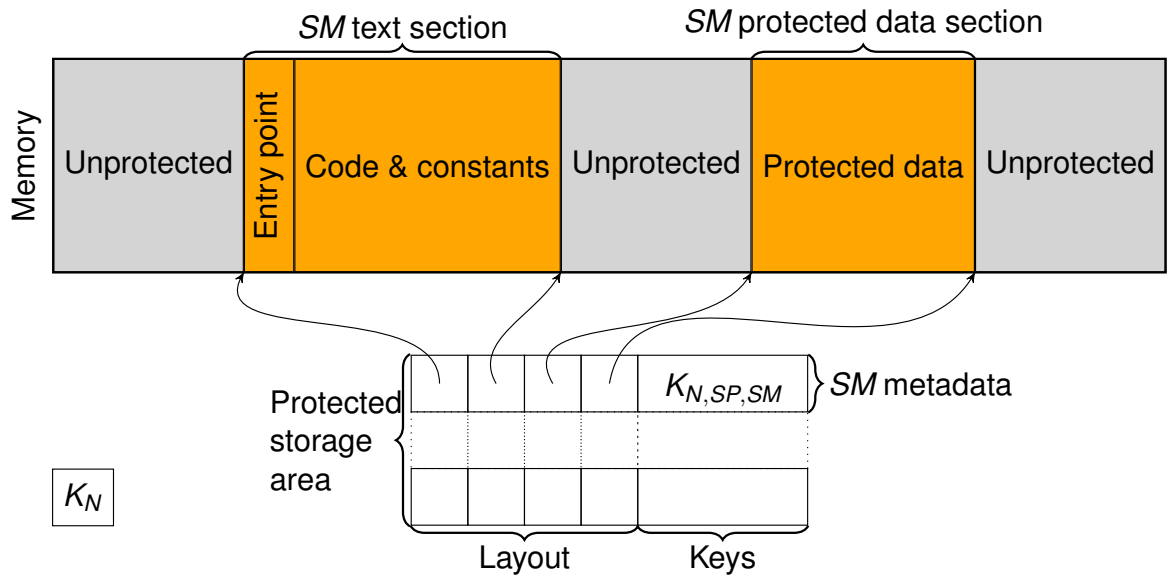
Public and protected sections



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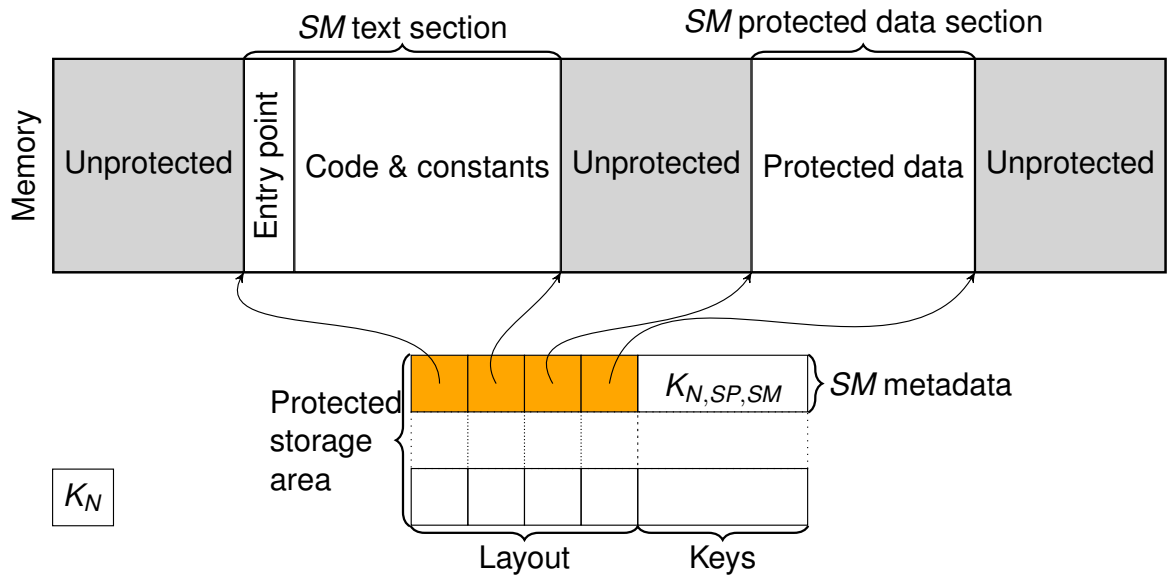

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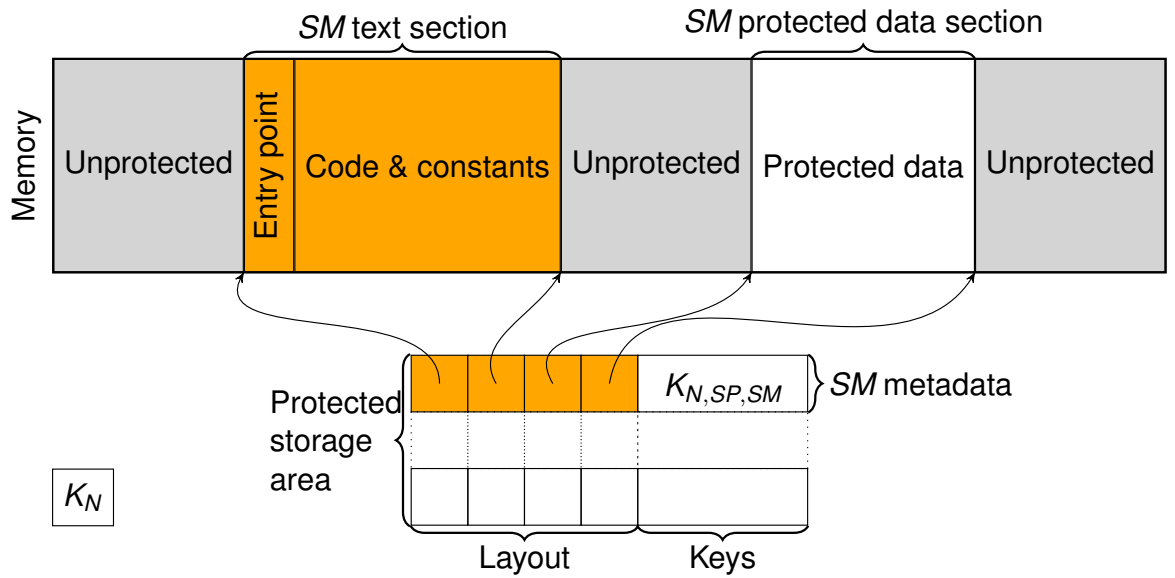

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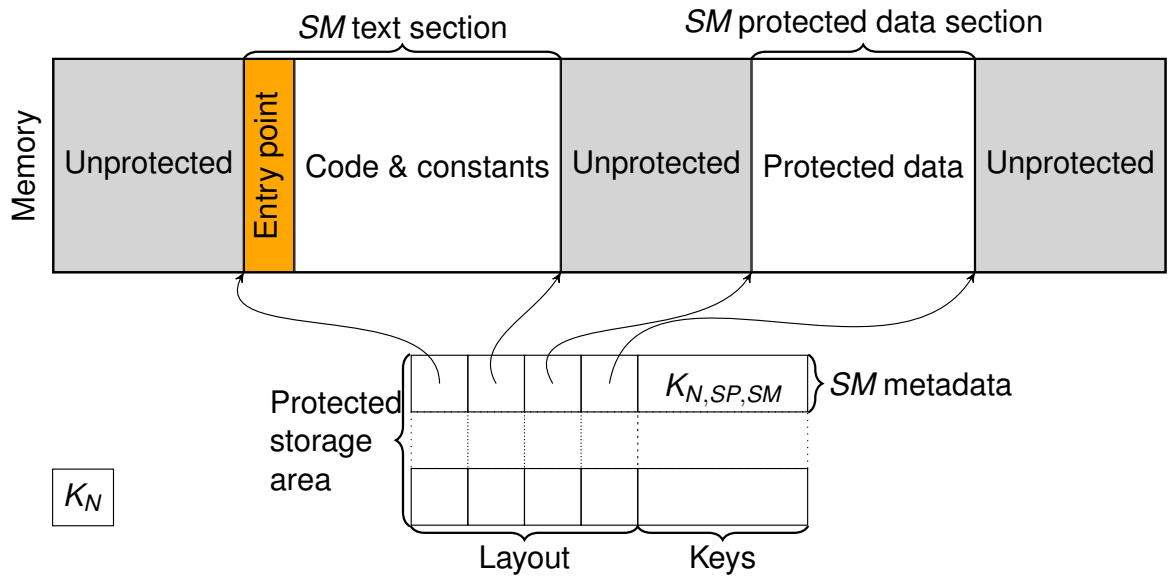

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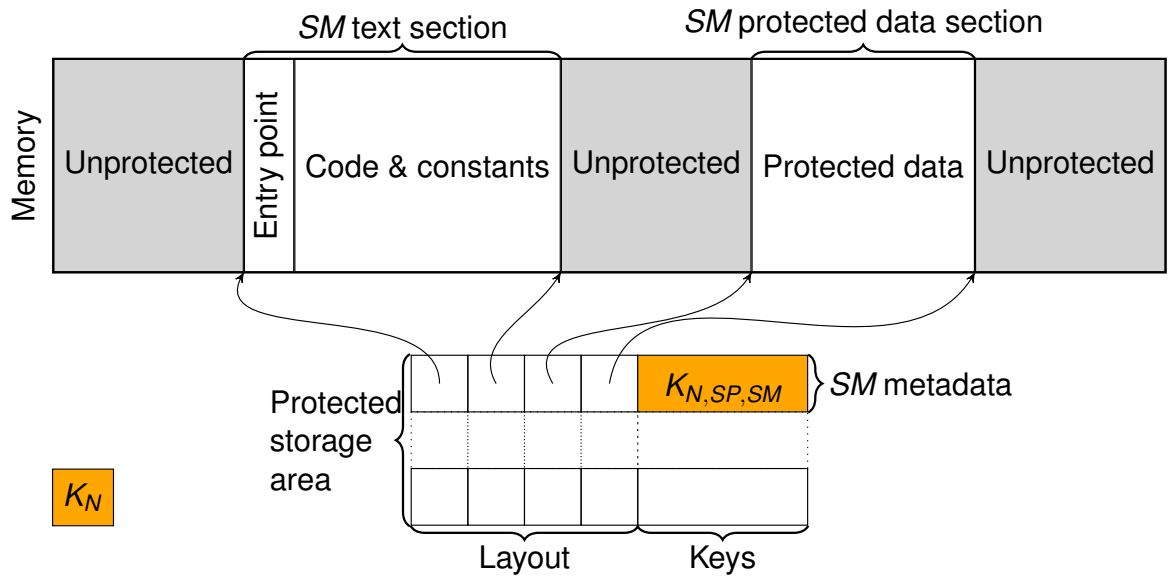

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- Does the SM perform I/O correctly? Does it construct valid cryptographic messages?
- SM re-entrance, thread safety, real-time behaviour, interaction with other SMs, etc.

Protected Module Architectures: Intuitive Semantics

```
1  DECLARE_SM(count, 0x1234);
2
3  static int SM_DATA(count)
4    counter = 0;
5  static void SM_DATA(count)
6    (*observer)(int);
7
8  void SM_FUNC(count)
9  inc_internal(void) {
10   printf ("%i\n", counter);
11   counter = counter + 1;
12   printf ("%i\n", counter);
13 }
14
15 void SM_ENTRY(count)
16 set_observer(void o(int)) {
17   observer = o;
18 }
19
20 void SM_ENTRY(count)
21 inc() {
22   inc_internal();
23   observer(counter);
24 }
```

```
25 int SM_ENTRY(count)
26 get_count() {
27   return counter;
28 }
29
30 int main(int ac, char** av)
31 {
32   counter = 42;
33   inc_internal();
34   int *c = &counter;
35
36   sancus_enable(&count);
37   counter = 43;
38   set_observer(NULL);
39
40   do {
41     inc();
42   } while (get_count !=
43     SOME_OPCODE - 1)
44   set_observer(c);
45   inc();
46
47   return 0;
48 }
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Interacting Protection Domains

- Similar to threads and locks
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Real-Time Behaviour

- Approximation of Worst Case Execution Time
- *Verify a scheduler*

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- Labelled heaps

Interruption and Re-Entrance

- *Implementation still unclear*

Real-Time Behaviour

- Approximation of Worst Case Execution Time
- *Verify a scheduler*

Automation

- Automatic `open`/`close` for precise predicates

Summary & Conclusions

Brief intro to VeriFast [PMP+14].

Presented an extensible approach to automated verification of programs that employ list-based dynamic data structures [MWD+15] in VeriFast, based on dsOli [WL13] output.

There is lots of ongoing research that involves VeriFast, data structures are currently not in the focus.

Security architectures for the IoT can benefit from formal verification (or safe languages). Challenges are with respect to changes in the semantics of C, information flow properties and concurrency.

Current work on the VeriFast tool involves support for different CPU architectures, isolated (labelled) heaps, timing properties, cryptography, and (marginally) on automation.

Thank you!

Thanks for listening!

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