Runtime Code Polymorphism as a Protection against Physical Attacks
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Core Idea: Runtime Code Polymorphism

Definition
Regularly changing the behaviour of a (secured) component, at runtime, while maintaining unchanged its functional properties.

What for?
- Protection against reverse engineering of SW
- The secure code is not available before runtime
- The secure code regularly changes its form (code generation interval $\omega > 1$)
- Protection against physical attacks
- Polymorphism changes the spatial and temporal properties of the secured code: side channel & fault attacks
- Combine with usual SW protections against focused attacks

How?
deGoal: runtime code generation for embedded systems
- Fast code generation
- Tiny memory footprint: proof of concept on TI’s MSP430 (512 bytes of RAM)

Complets & deGoal in a Nutshell

A compilette is:
- An ad hoc code generator that targets one kernel
- Aimed to be invocated at runtime

Polyorphic Code Generation

deGoal runtime capabilities
- Performed in this order:
  - register selection
  - instruction selection
  - instruction scheduling

Adaptation to achieve runtime code polymorphism:
- Portability to very small processors and secure elements
- Limited memory consumption
- Fast runtime code generation
- Ability to combine with hardware countermeasures
- Introduce alea during runtime code generation [1,2,3]

Polymorphism:
- Random mapping to physical registers [1]
- Use of semantic equivalences [2]
- Instruction scheduling [3]
- Insertion of dummy operations [3]

Example: polymorphic AES

Polymorphic implementation of the SubBytes function:

```c
void gen_subBytes( cdg_insn_t* code, uint8_t* state_addr)
{
    #
    Begin code Prelude
    Type uint32 int 32
    Alloc uint32 state, sbox, i, x, y
    nv state, #(@state_addr)
    nv sbox, #(@sbox_addr)
    #(1)
    loop:
        lb x, #(@state+i) // x := state[i]
        lb y, #(@sbox+x) // y := sbox[x]
        sb @state+i, y // state[i] := y
        add i, 1, #(1)
        bneq loop, i, #(16)
    rt

    End
};
```

Execution times (in cycles), over 1000 runs:

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<th></th>
<th>min</th>
<th>max</th>
<th>average</th>
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<td>12910</td>
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<td>9745</td>
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Impact of the code generation interval $\omega$:

$\%$: percentage contribution of runtime code generation to the performance overhead

$1000$ runs:

```
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```

References