www.iss.net

Full Potential of Dynamic Binary Translation for AV Emulation Engine

VB Conference (Oct 12, 2006)

Jim Wu
ISS X-Force

INTERNET | SECURITY | SYSTEMS®
Ahead of the threat.™

Agenda

- Roles of emulation in AV
- Survey of software emulation technologies
- Dynamic binary translation (DBT), demystified
- Unique challenges and opportunities of DBT for AV
- The road ahead…

Roles of emulation in AV

- Generic unpacker for unknown or modified packers.
- Detection of polymorphic malware.
- Behavioral AVs for zero-day detection.

An essential weapon in an AV arsenal

INTERNET | SECURITY | SYSTEMS®

Survey of Software Emulation Technologies

- Interpretation:
  - fetch-decode-execute for each instruction.
  - Example: SimpleScalar®
  - Based on the instruction set manual.

Survey of Software Emulation Technologies

INSTRUCTION SET REFERENCE, A-M

intel

AAA—ASCII Adjust After Addition

Opcode	Instruction	Description
37	AAA	ASCII adjust AL after addition

Operation

```
IF ((AL AND 0FH) > 9) OR (AF = 1)
    THEN
        AL ← AL + 6;
        AH ← AH + 1;
        AF ← 1;
        CF ← 1;
    ELSE
        AF ← 0;
        CF ← 0;
FI;
AL ← AL AND 0FH;
```

INTERNET | SECURITY | SYSTEMS®

Survey of Software Emulation Technologies

- Interpretation:
  - fetch-decode-execution for each instruction.
  - Example: SimpleScalar®
  - Based on the instruction set manual
  - Advantage: portable
  - Disadvantage: slowest (100x slower)

Survey of Software Emulation Technologies (Con't)

- Dynamic Binary Translation (DBT):
  - Translation in the runtime
  - Execution of the generated code.
  - Examples: JIT compilers, Embra.
  - Translated code for "AAA":
    - Load_state->AAA-> save_state
  - Advantage: faster for loops
  - Disadvantage: not portable

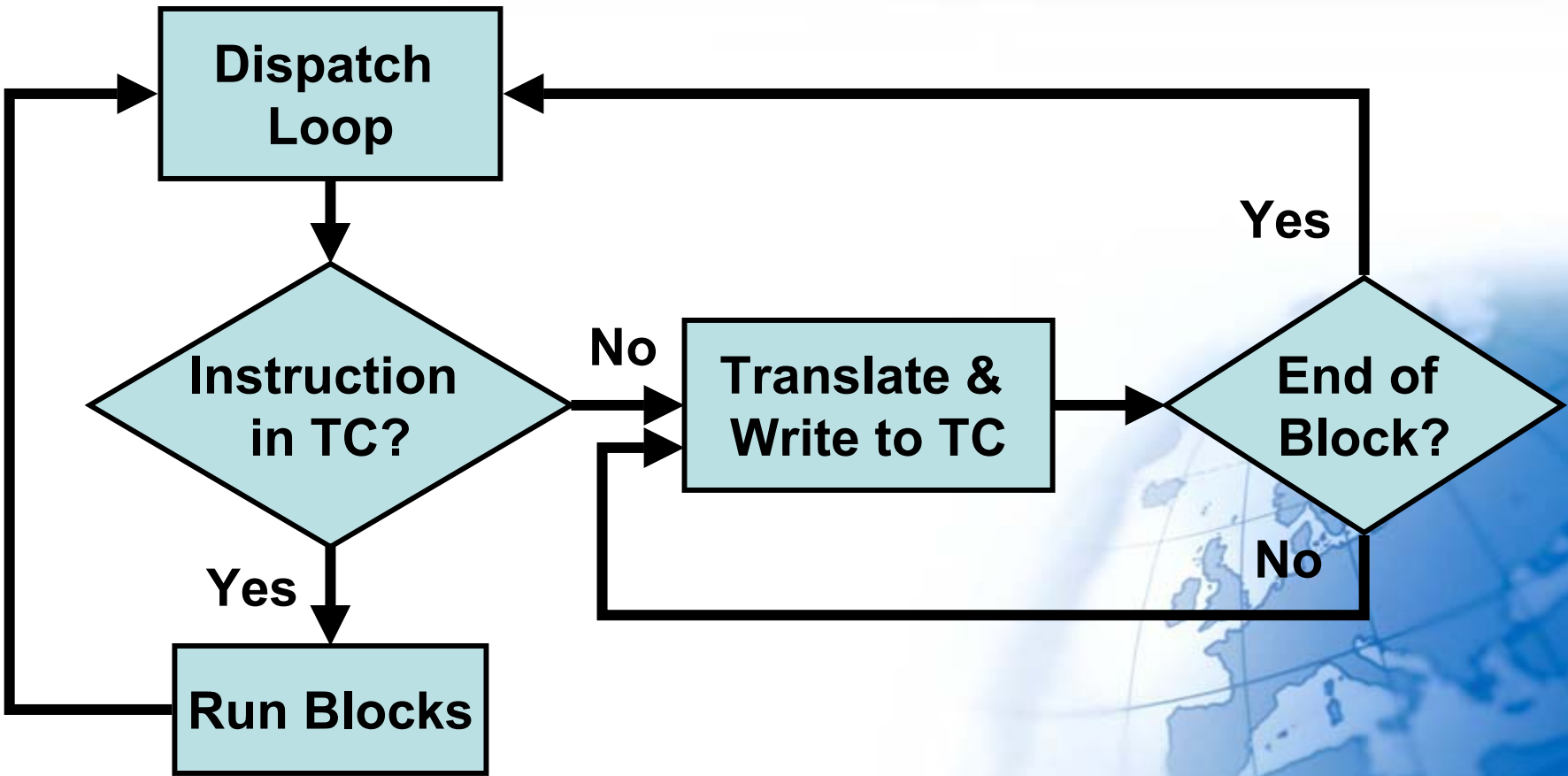
Survey of Software Emulation Technologies (Con't)

- Direct execution:
  - Set up a safe environment to run the sample directly.
  - Example: most Ring3 code in VMware®
  - New VM hardware allows the classical trap-and-emulate virtualization.
  - Advantage: fastest, up to native speed
  - Disadvantage: difficult to interact

Survey of Software Emulation Technologies (Con't)

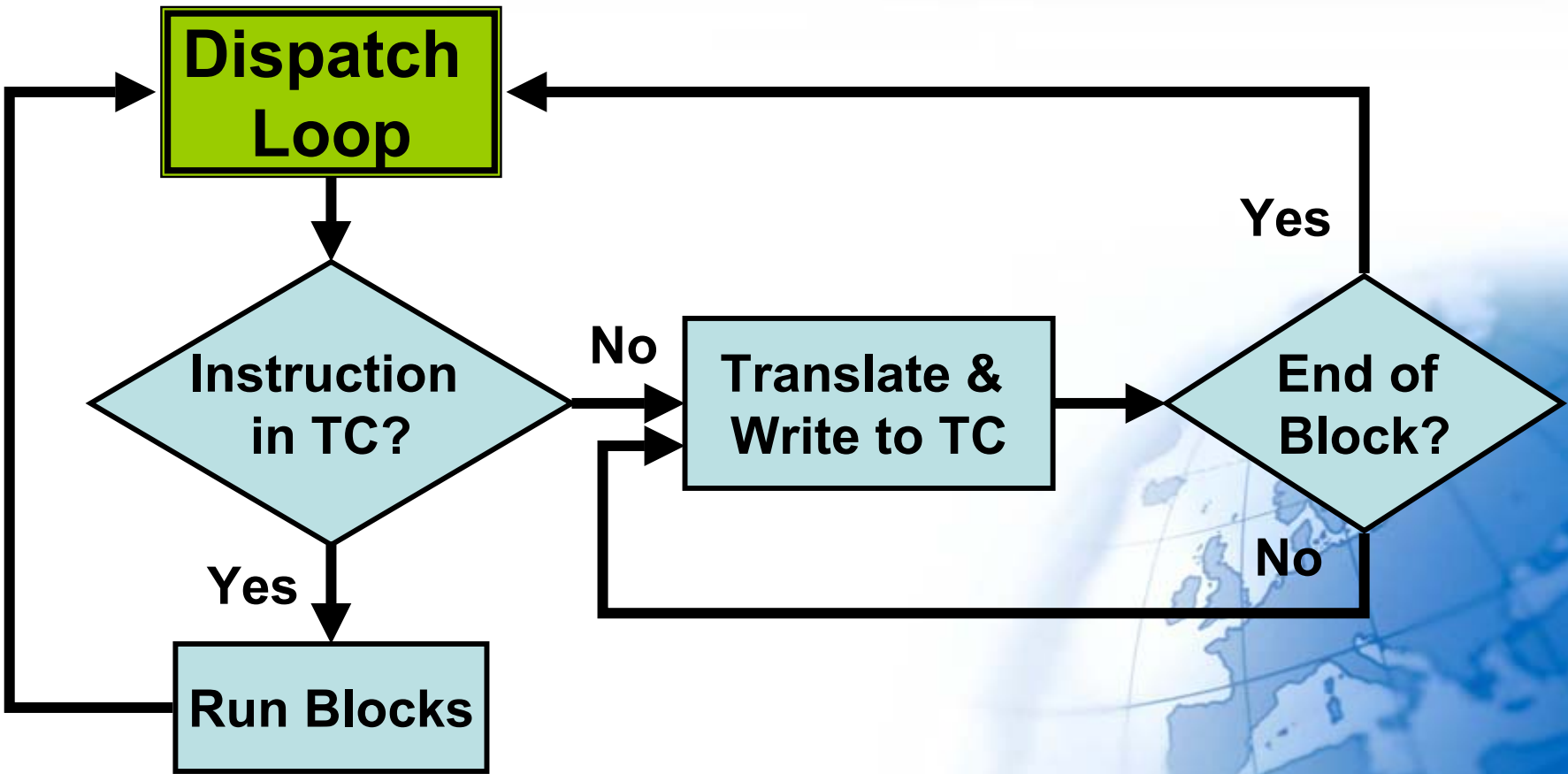
- Current status in AV:
  - Emulation technology in AV is leaping from interpretation to DBT.
  - Need to get more out of DBT
    - Example: packed samples in Wildcore
      - Currently AV engines have to use heuristics to run less instructions.

Dynamic binary translation (DBT), demystified



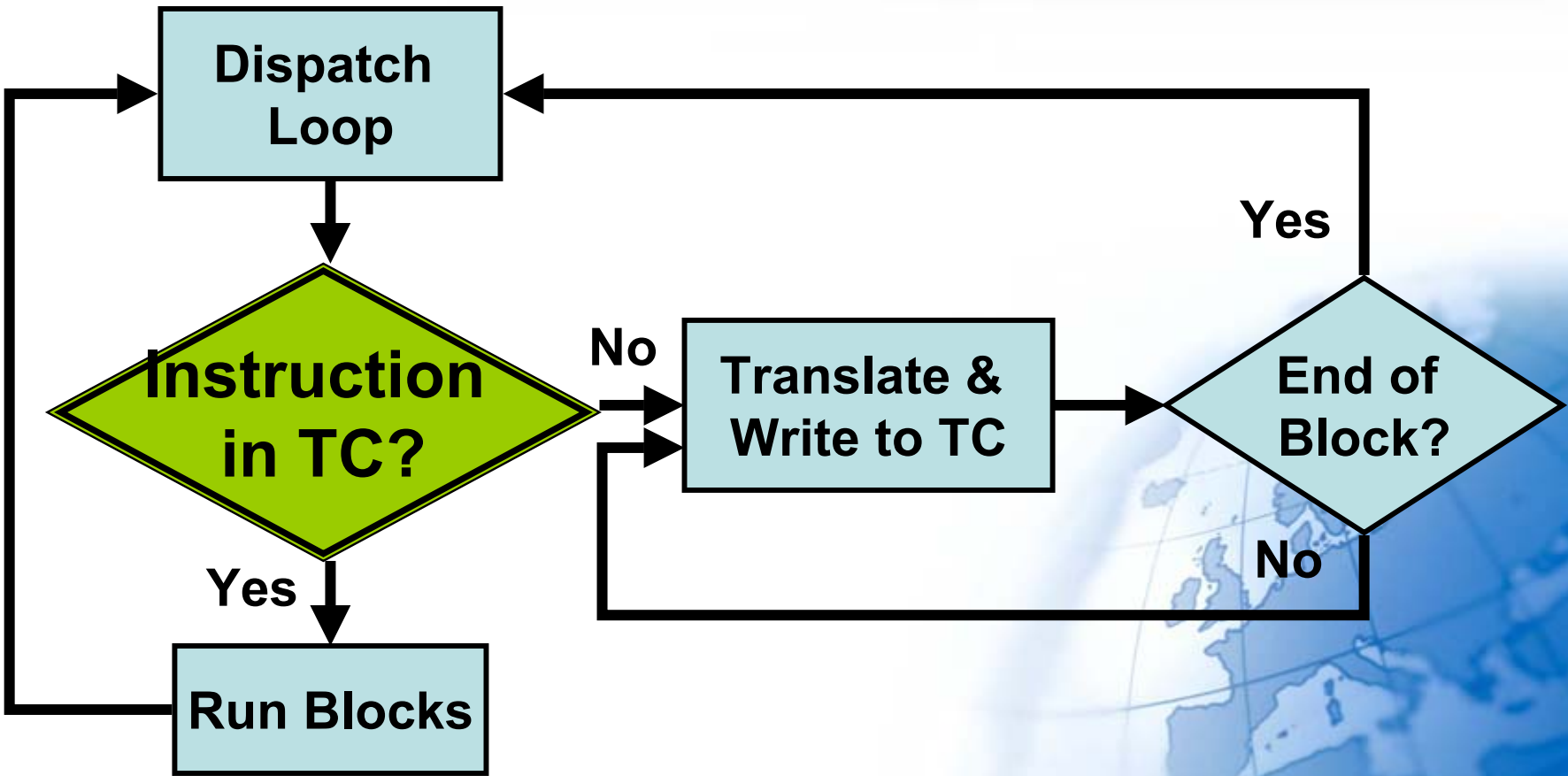
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



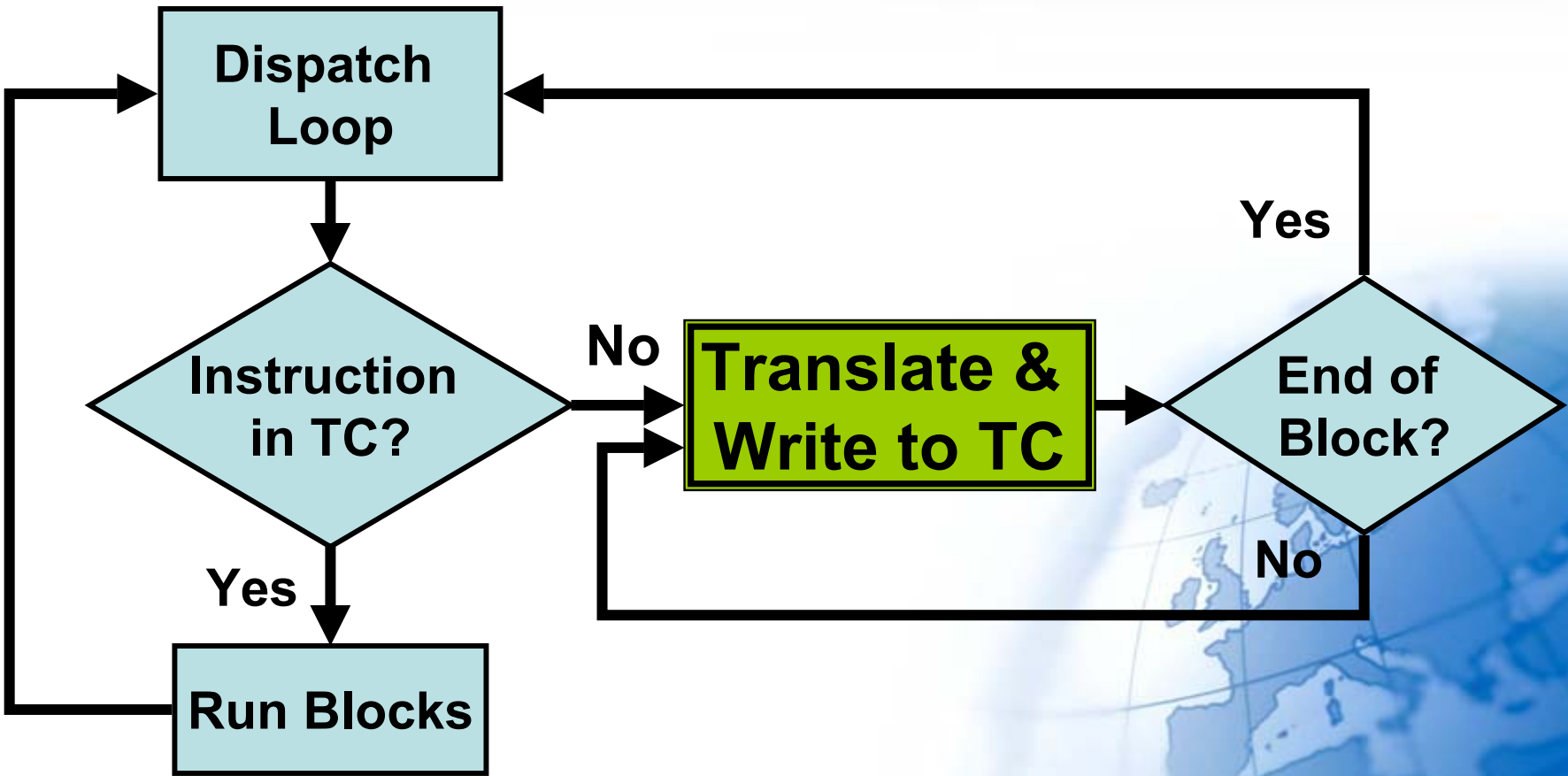
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



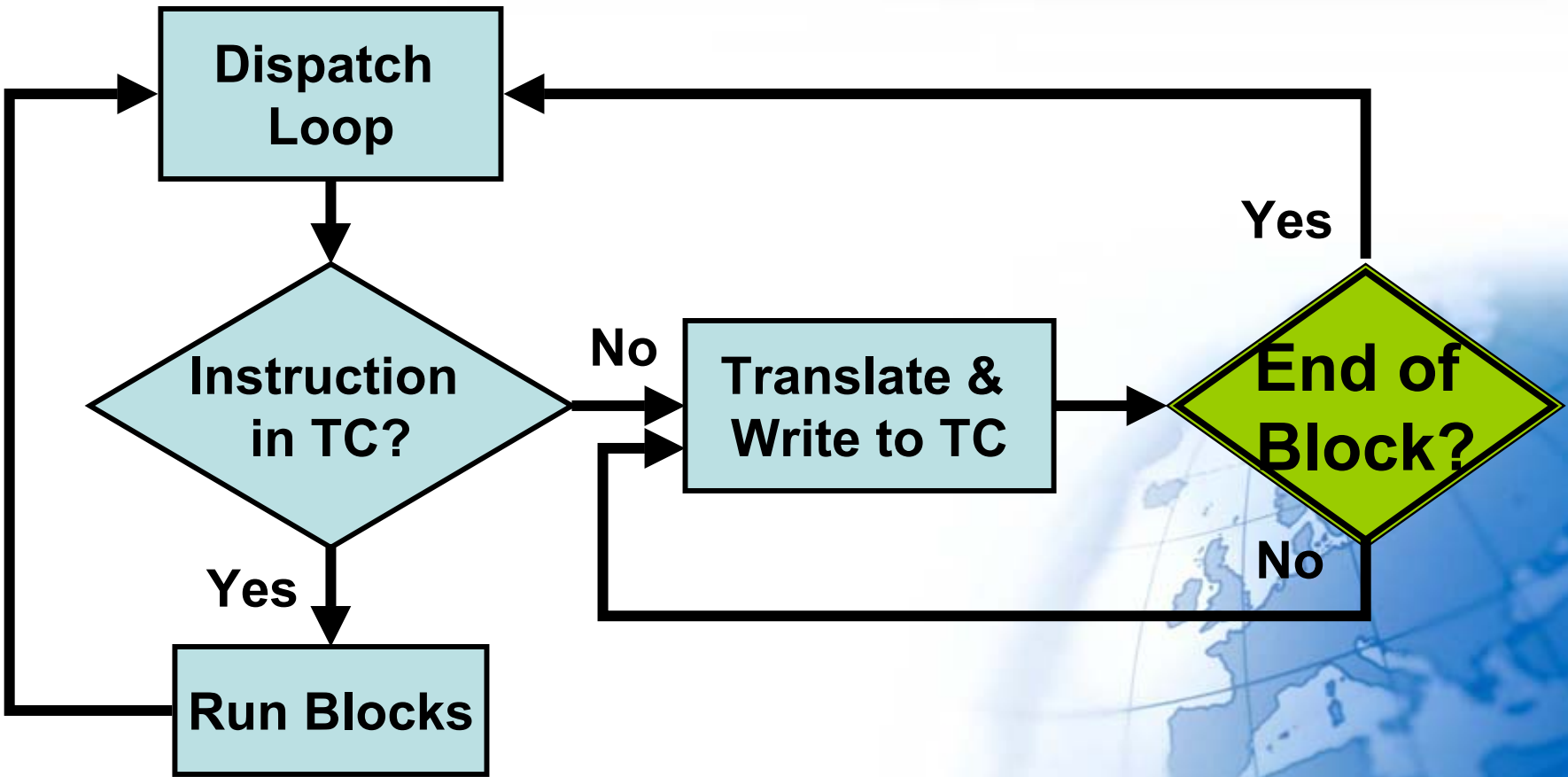
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



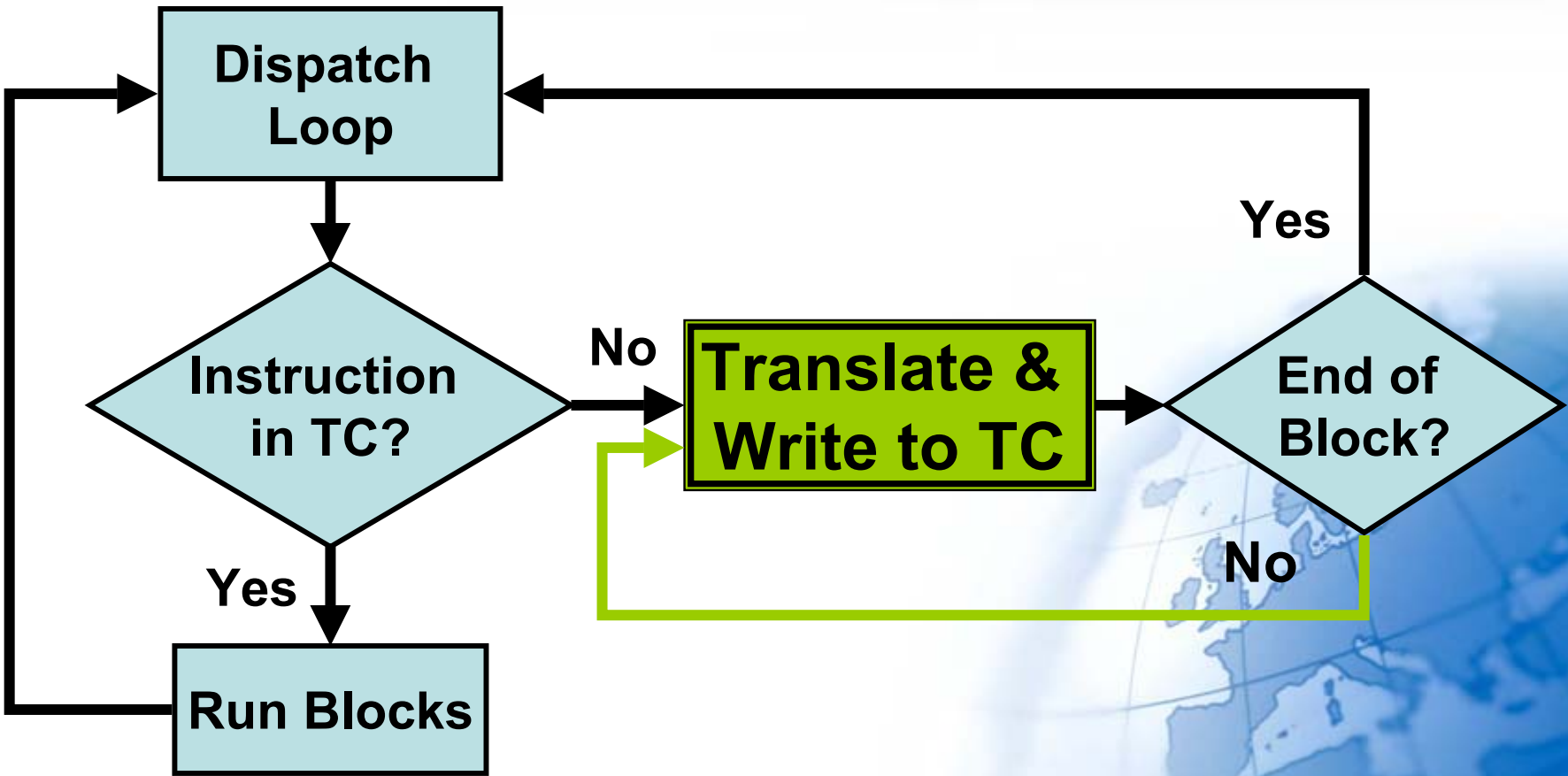
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



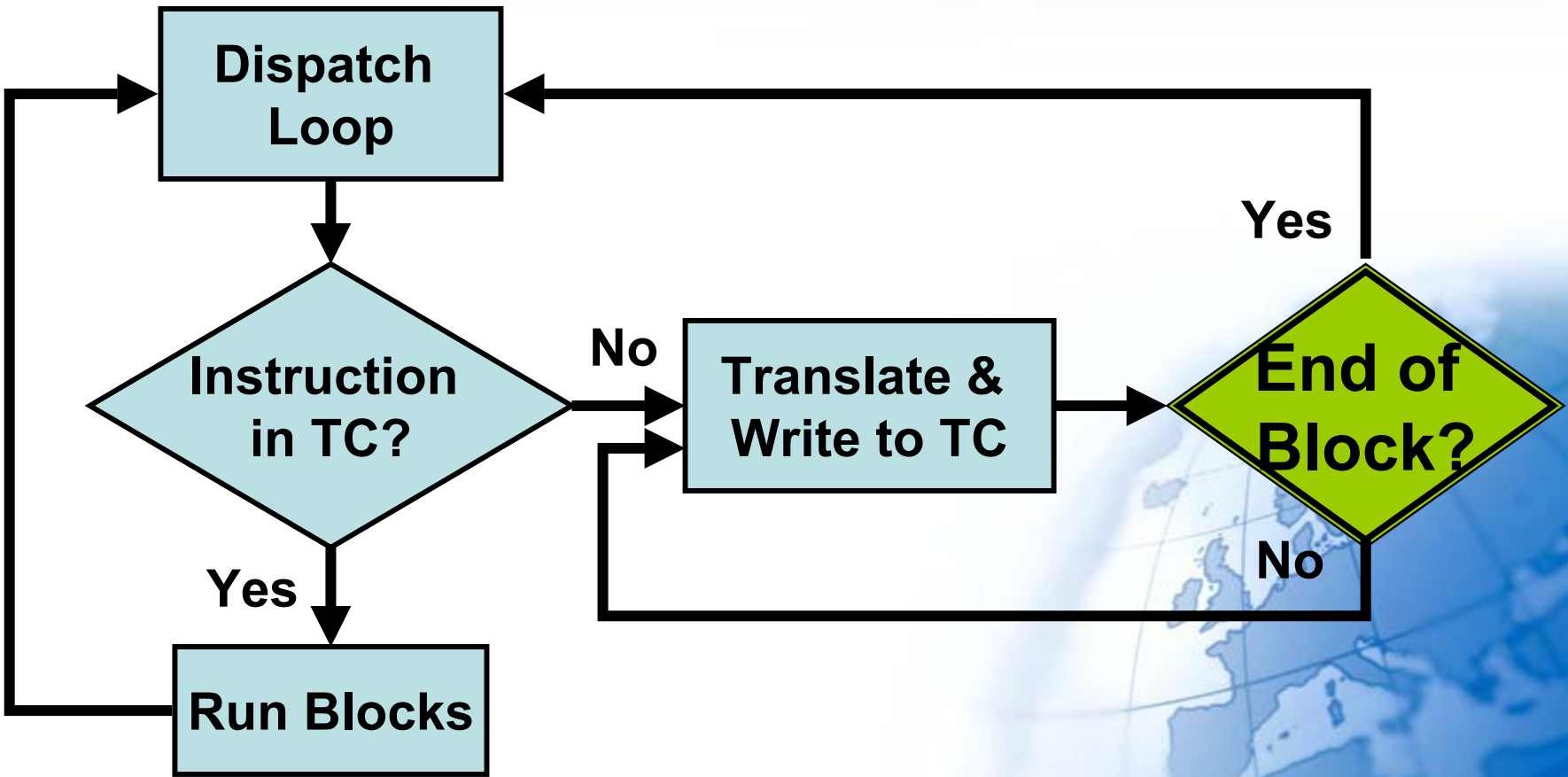
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



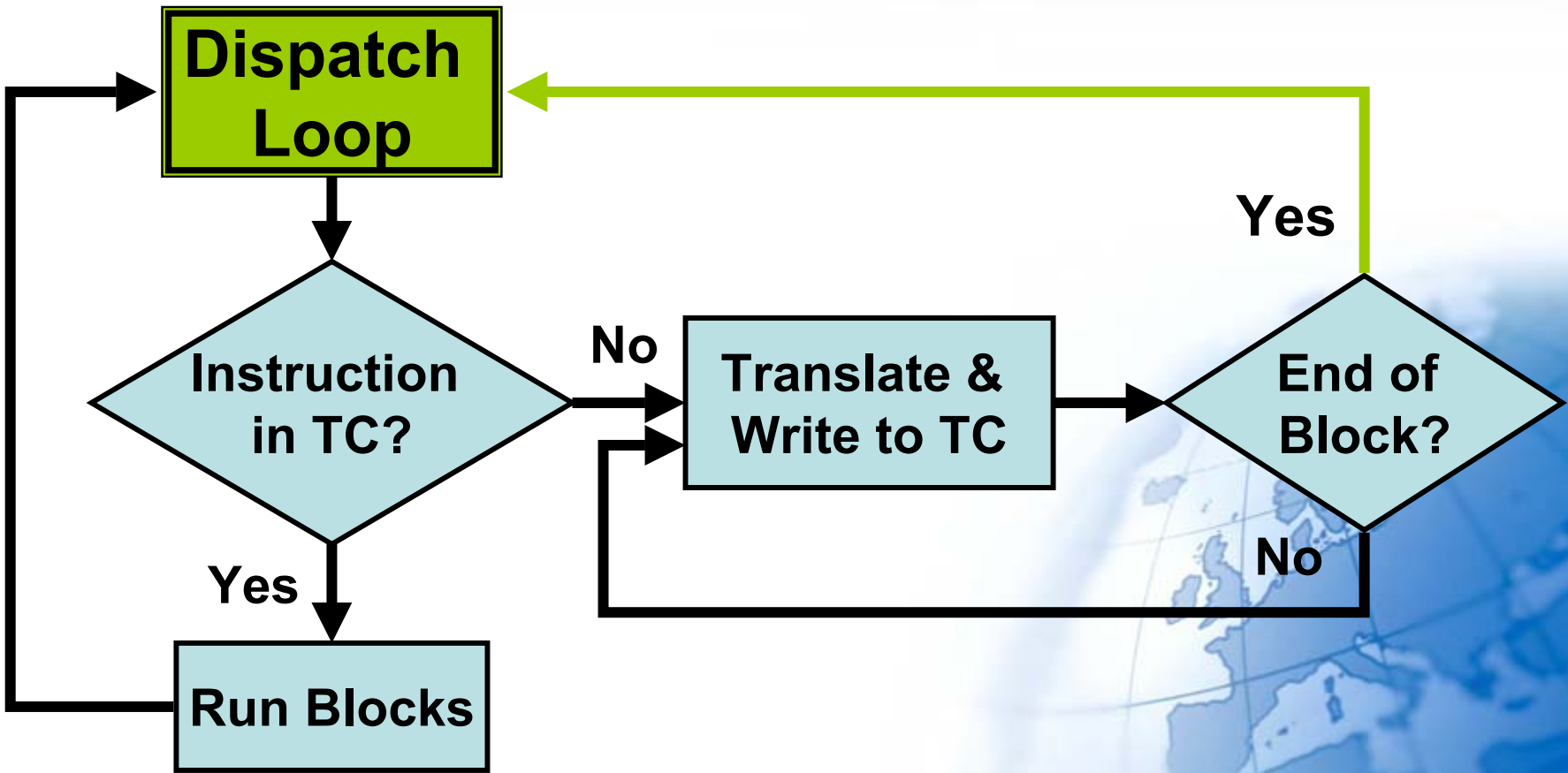
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



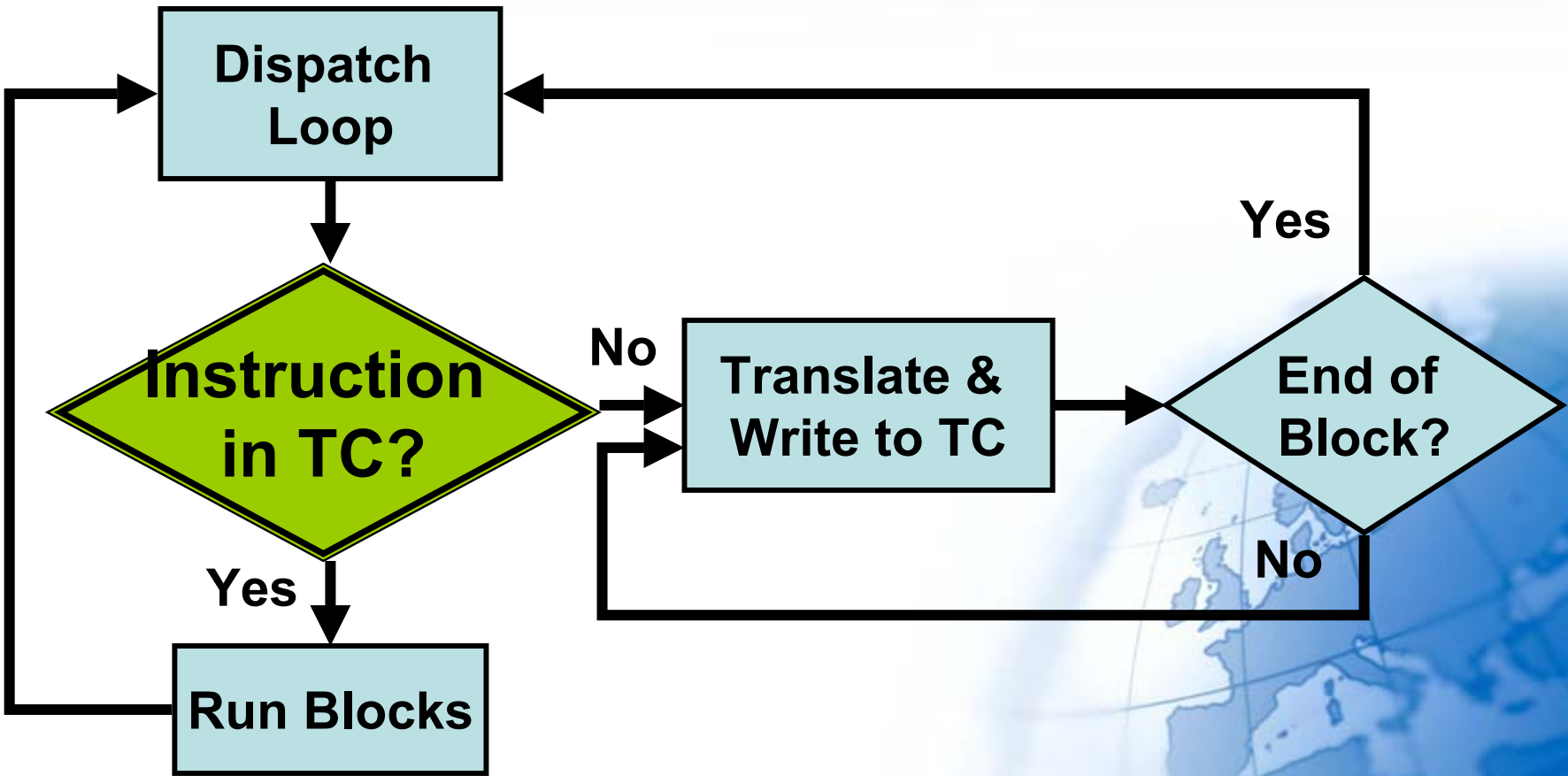
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



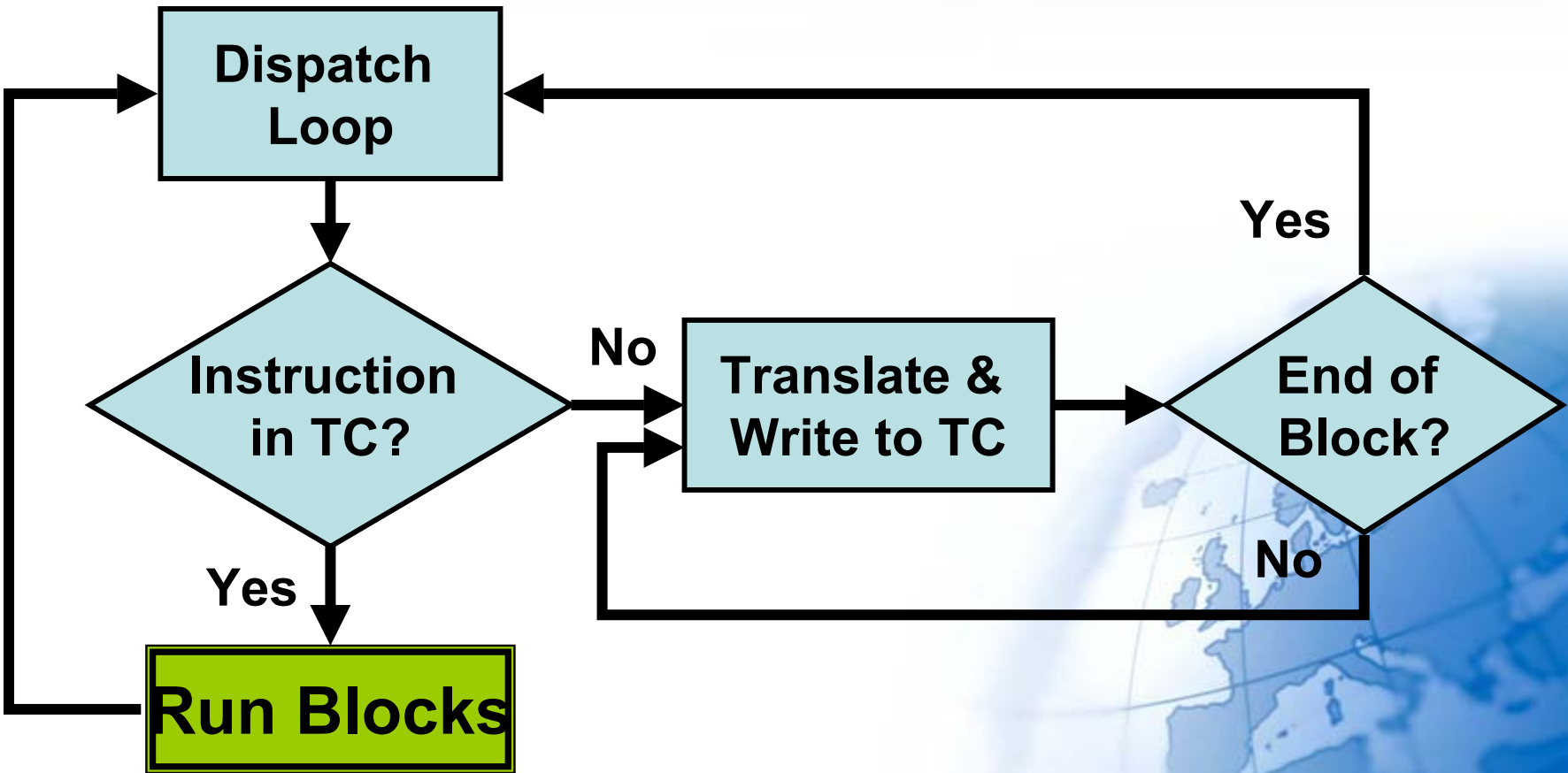
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



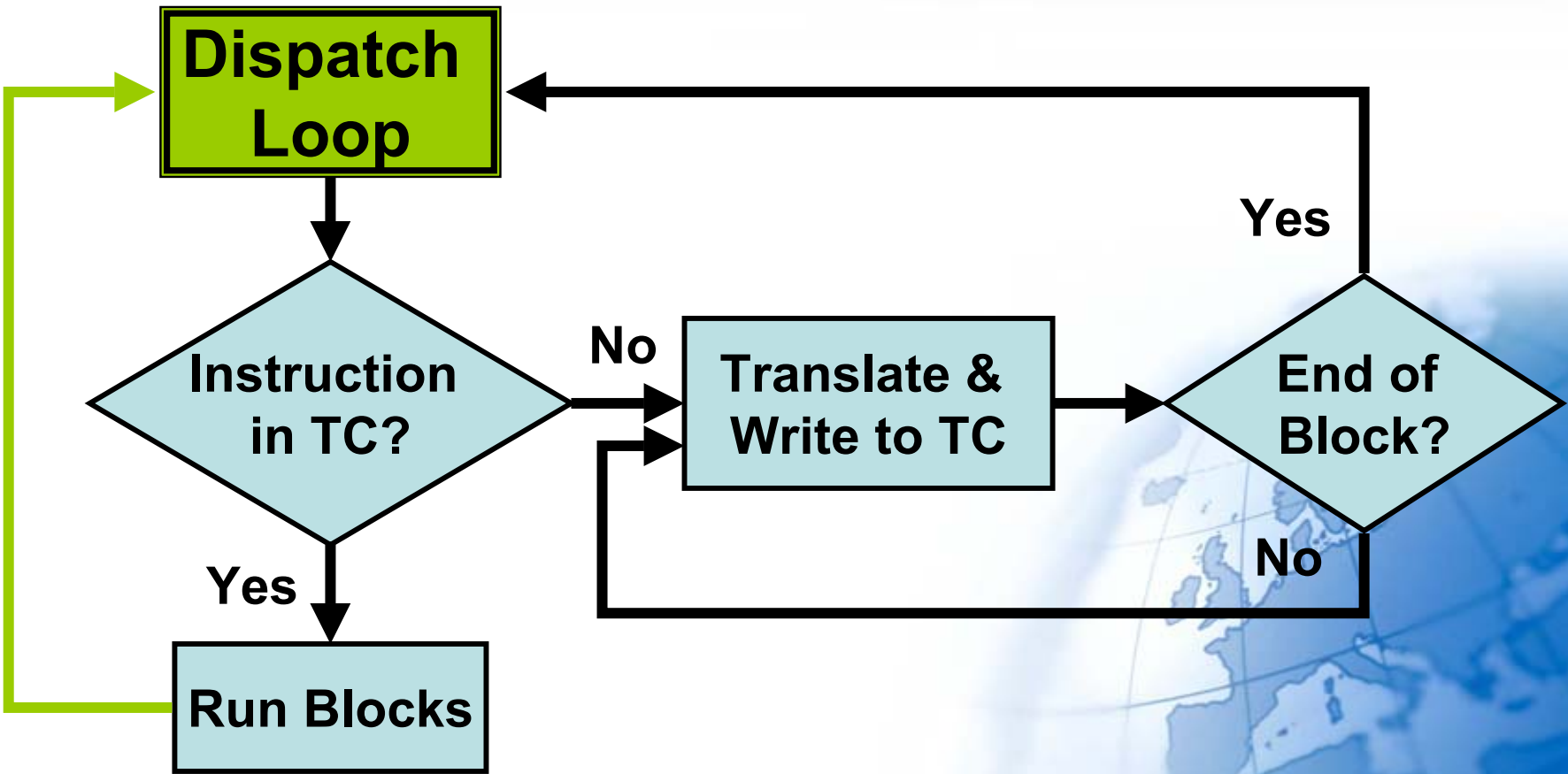
INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



INTERNET | SECURITY | SYSTEMS®

Dynamic binary translation (DBT), demystified



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

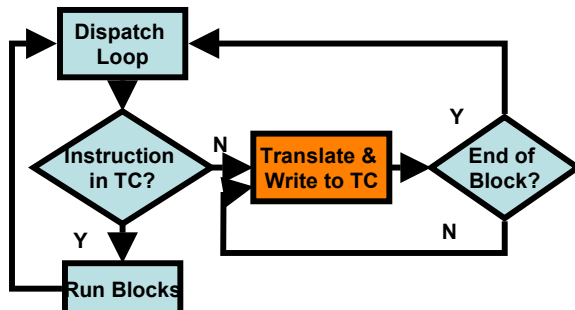
- Translation Unit:
  - Simple/repeatable for most instructions
  - Example: "add edx, ecx"

    TRANS_M2R*(MOV, EBX, &(regs->ECX));*

    TRANS_R2M*(ADD, &(regs->EDX), EBX);*

    ➔ write "01 1D xxxxxxxx" to TC

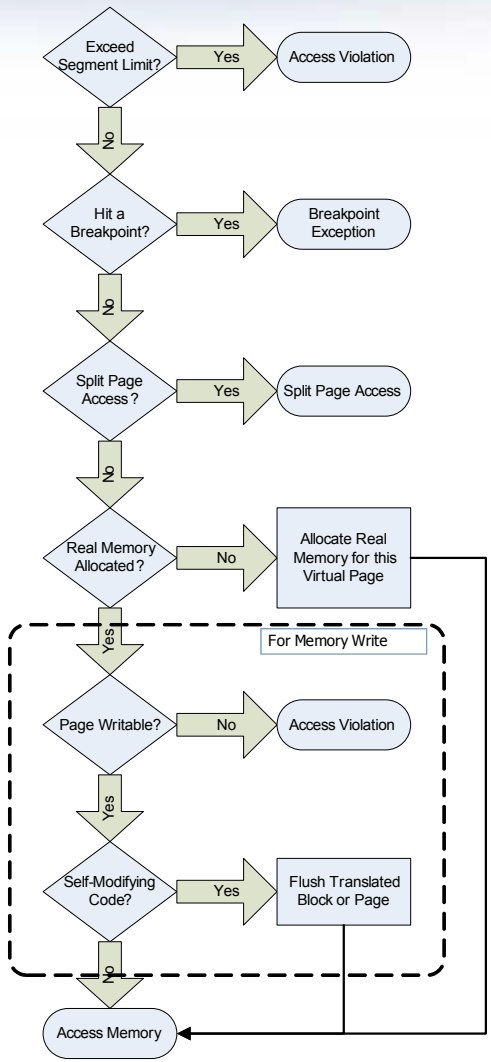
    MERGE_EFLAGS();



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

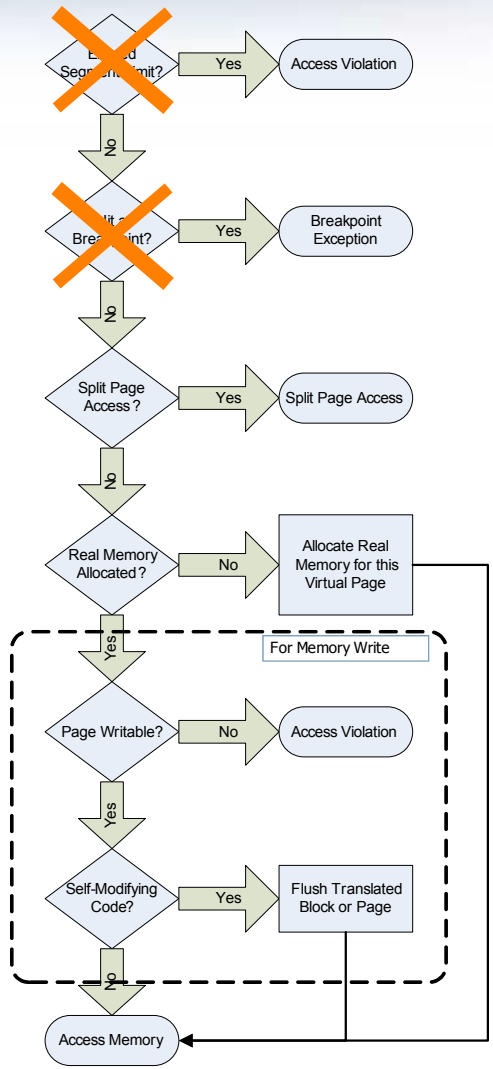
- Typical memory design:
  - (0 + 0 + 30)/3 = 10
  - Four read/write checks:
    - Segment limit, HW breakpoint, split page access?
    - Real memory allocated?
  - Two write-specific checks:
    - Writable? Self-modifying-code?



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

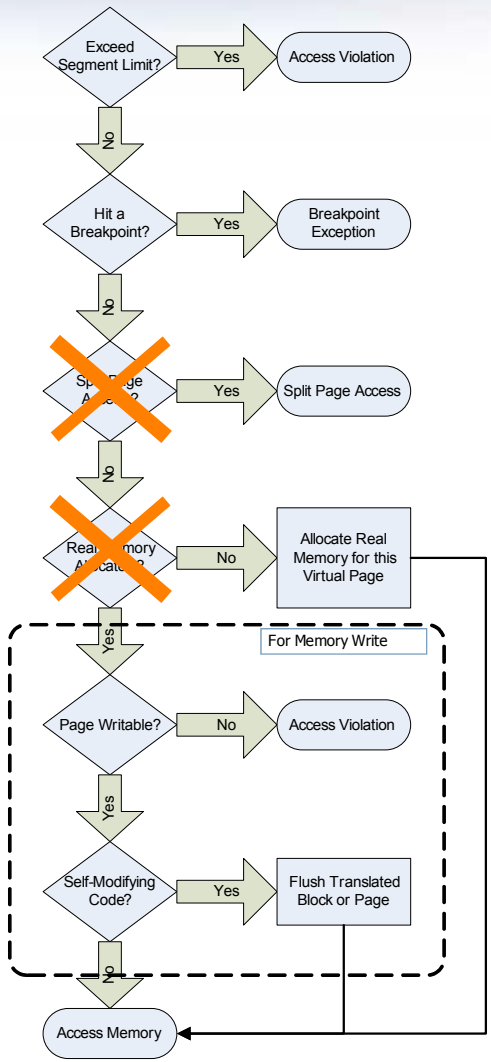
- Improved memory design -- method #1
  - Skip segment limit check if the segment is flat.
  - Hardware breakpoint becomes page based.



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

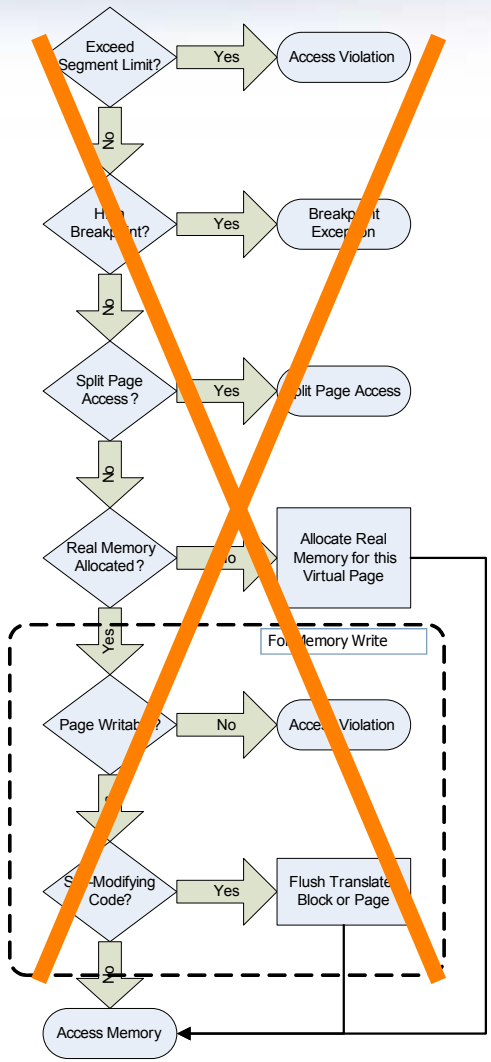
- Improved memory design – method #2
  - Allocate reserved memory to avoid split page access.
  - Use real exception if memory isn't committed



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

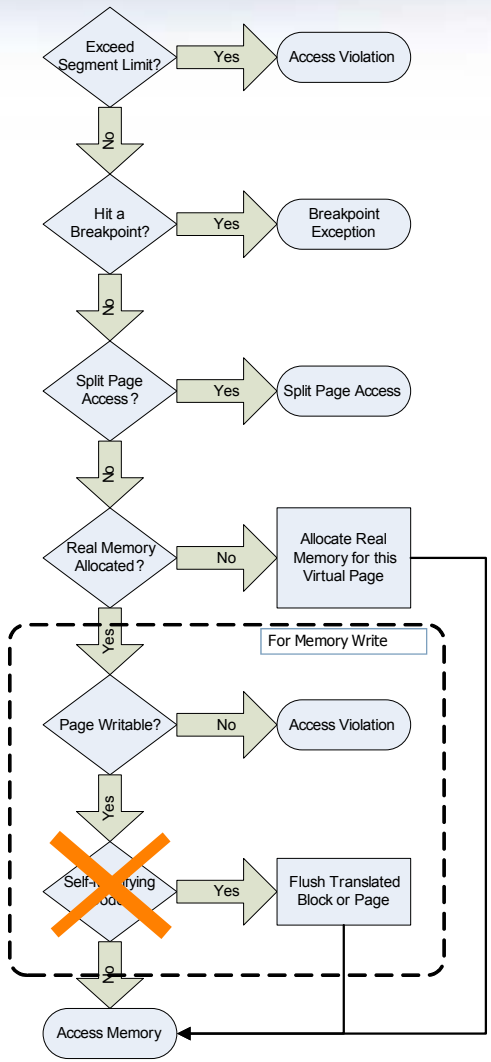
- Improved memory design – method #3
  - Use hardware protection instead of insertion of explicit address checks.
  - Require Ring0 programming.
  - Provide the best of DBT and direct execution.



INTERNET | SECURITY | SYSTEMS®

DBT, demystified (Con't)

- Self-modifying code
  - Write to translated code
  - Entry in TC becomes stale:
    - Flash the whole TC
    - Flash the block
      - Complicate SMC check
    - Flash the page
      - Simplify SMC check



INTERNET | SECURITY | SYSTEMS®

Unique challenges and opportunities of DBT for AV

- Translation time can't be the bottleneck
  - Some optimizations might not worth the effort.
  - Translation might cause SMC on host machine.
- Build DBT on top of the interpreter:
  - Allow quick proof-of-concept of DBT.
    - Pack some large executables with UPX.
    - Just translate the UPX unpacking code in POC.
  - Only translate frequent loops.
  - Knowledge of the current state during translation.

The road ahead…

- Continue the transition from interpretation to DBT.
- Continue to squeeze more out of DBT.
- Explore the impact of hardware virtualization for emulation in AV.
- More research and collaboration in emulation.

INTERNET | SECURITY | SYSTEMS®

Questions?

- **Thank you!**
- **Jim Wu, ISS X-Force**
  - jwu@iss.net or jywuca@yahoo.com

INTERNET | SECURITY | SYSTEMS®