TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Computer Science Institute for System Architecture, Operating Systems Group

Native Client: A sandbox for portable, untrusted x86 native code

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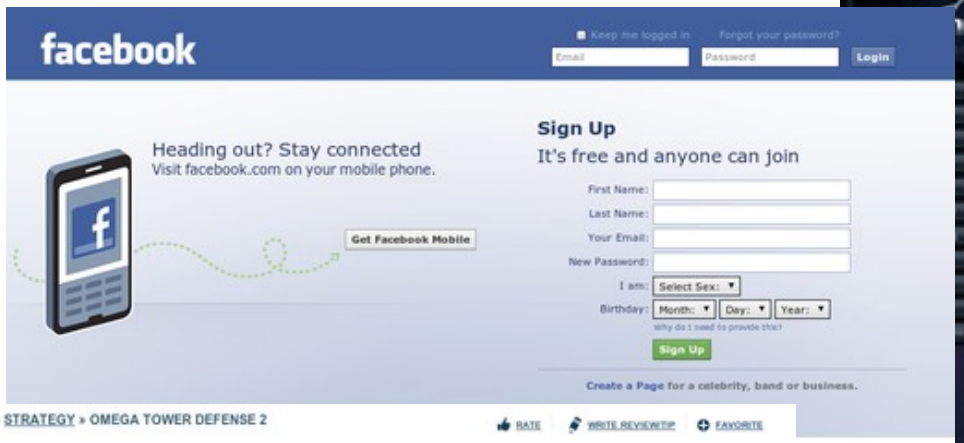
Dresden, 2010-04-27

Web 2.0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7 hours ago
danielliejonas Sooooo proud of my husbad!!! He killed it!! <3
7 hours ago
WBrettWilson 18 hours 2 add followers - to kick up my donation 2 Military Families Fund - and 2 be eligible for an iPad draw. If you can help - pls do!!
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Give it a try ›
Customize Twitter by choosing who to follow. Then see tweets from those folks as soon as they're posted.
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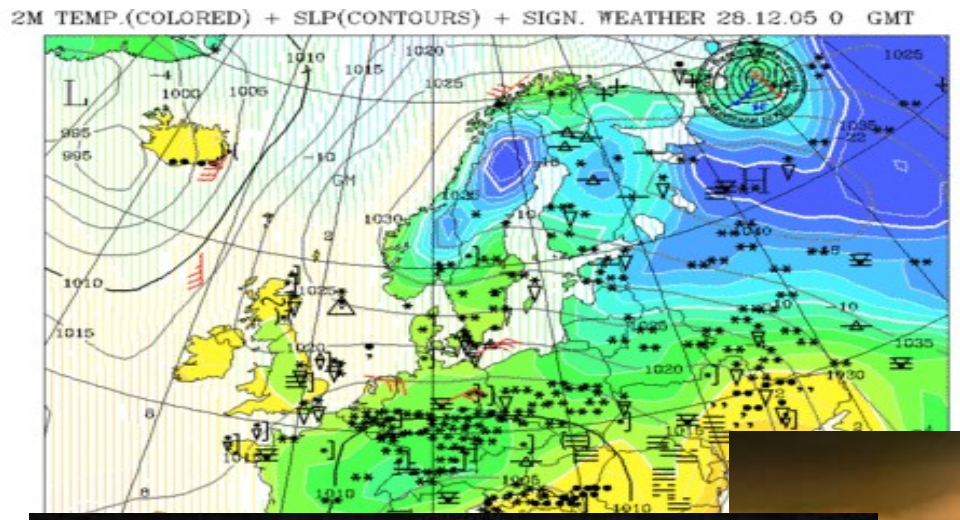
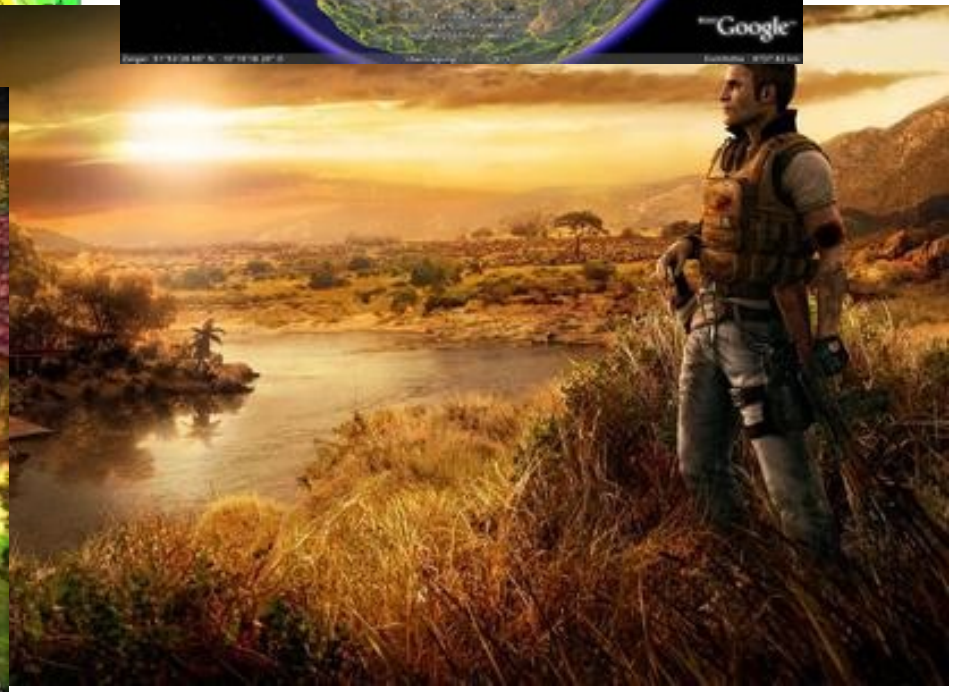
Not yet Web 2.0





Native code execution

- Faster than interpreted code
- Make use of platform-specific assembly (e.g., SSE)
- Arbitrary code → Security threat
- **NaCl:** framework to support safe execution of x86 machine code in a sandbox

Recap: Software Fault Isolation

- Robert Wahbe, 1993
- Plugins in sub-address spaces (segments)
  - Segment matching: check that plugin stays within sandbox
    - Mostly static checks
    - Additionally insert runtime checks
  - Address sandboxing
    - For each memory access fix upper bits of address to segment idx
  - System calls & system resource accesses → cross-domain RPC
- Limitations
  - RISC (extended to CISC: XFI, Erlingson 2006)
  - x86 register scarcity

Native client

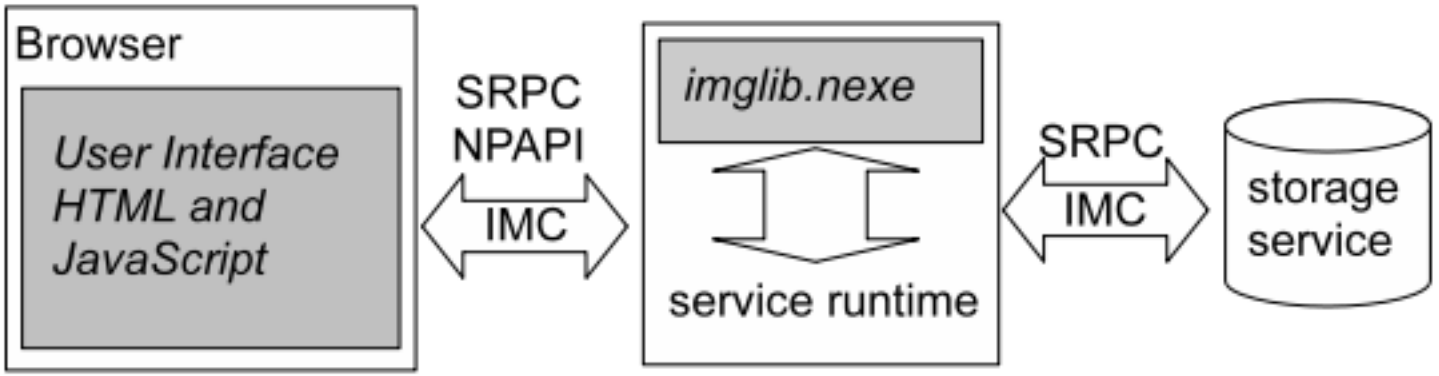


Figure 2: The hypothetical photo application of Figure 1 with a trusted storage service.

Sandboxing native code

- Outer sandbox:
  - System-call monitoring
- Inner sandbox
  - Static checking at load-time
  - Dynamic runtime checks
- Service runtime
  - System-level interface

Static checking

- Reliable disassembly
  - All valid code within text segment
  - No self-modifying code
- No unsafe instructions
  - SYSENTER, INT, segment-related instructions, RET
  - Ring 0 instructions
- Control-flow integrity
  - Ensure each jmp goes to a valid instruction

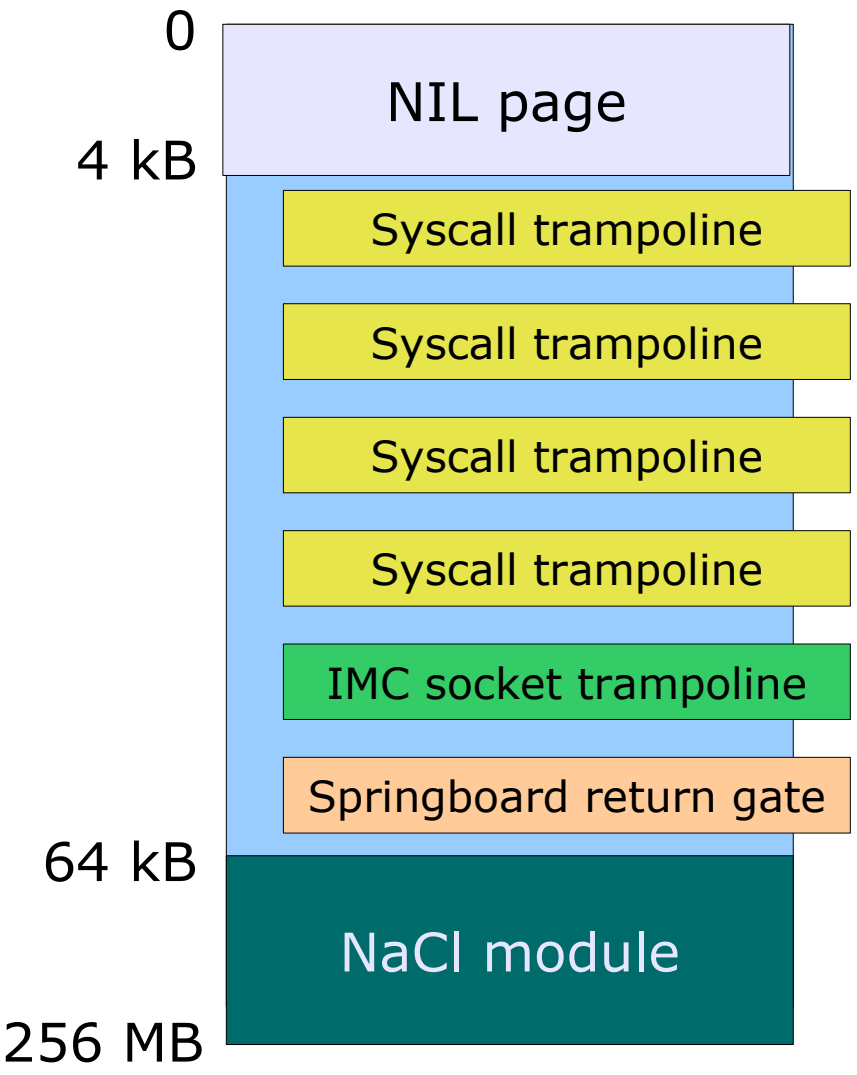
Runtime checks

- Indirect jumps: nacl_jump

  ```
  and %eax, 0xFFFFFFe0
  jmp *%eax
  ```

- Use x86 segmentation to enforce sandbox
  - Restriction: x86/32bit
- Disallow (asynchronous) hardware exceptions
  - Would need to copy with stack segment, which is invalidated during NaCl execution

Service runtime



- Unrestricted code
- System call trampolines
  - save/restore segments
  - 32-byte aligned
  - one per system call
- Springboard
  - Allow calls into NaCl modules
  - Potentially unrestricted
  - Start with HLT
- IMC sockets
  - Datagram-based
  - Higher-level protocols on top

Evaluation

- Modified GCC 4.2.2 + Binutils 2.18
- SPEC2000: average 5%., top 12% overhead in NaCl mode
- Near-native performance for
  - Computer graphics
  - H.264 decoding
  - Quake (yeah!)
- Going into Google Chrome

Ben Hawks @ HAR 2009

"This is my tentative endorsement, that, yes, Native Client could actually win

…

but only if they lock Tavis Ormandy in a room for a year or two

…

and I'm worried about the outer sandbox, so you should be too."

Discussion

- Hack it?
  - Return-oriented programming works for fixed-length RISC instruction sets.
  - Doing harm depends on configuration of outer sandbox.