



Native CPU Performance in the Browser with Google Native Client

<http://code.google.com/p/nativeclient>

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Why Native Code?



Close the gap between desktop and web apps...

- Performance
- Choice of programming language
- Leverage legacy code

... but do not sacrifice

- Portability
- Safety

What we mean by “Performance”



Key performance features include

- POSIX-like thread support
- Straightforward access to vector instructions
- Hand-coded assembler

Substantially all the CPU performance
of desktop applications

A Simple Example

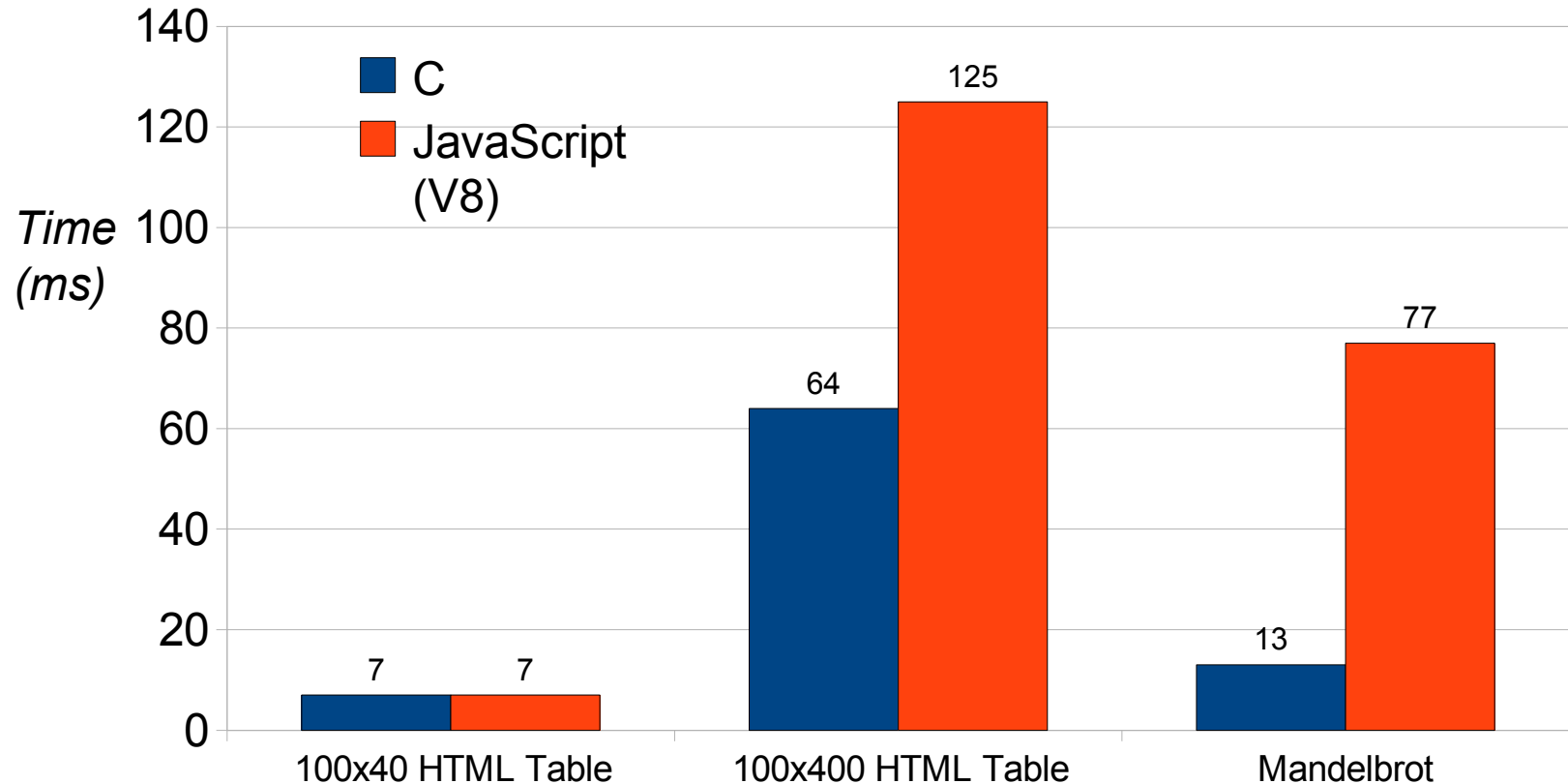


Scenario: An AJAX application

- generates a large HTML table on the client
- computes a floating-point intensive result

How does JavaScript perform compared to C?

A Simple Example



C and Javascript Performance. C times include delivering data into browser. **N.B.:** Obvious C++ implementation is 2x slower than JavaScript.

What does it mean for the Web?



Desktop CPU performance will enable Web apps with:

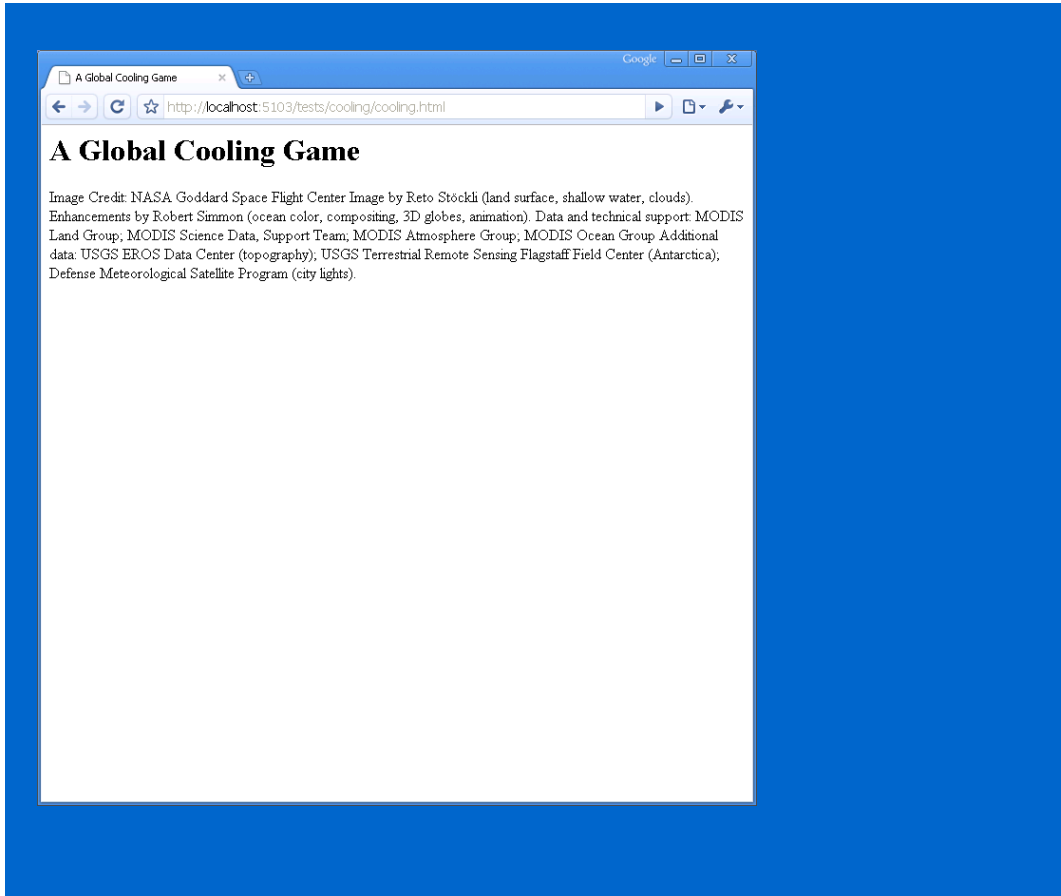
- Safer multimedia codecs
- Real-time audio and video synthesis
- Real-time physics simulations
- Local audio/video analysis and recognition
- Multimedia editors
- Flexible, high-throughput cryptography
- Application-specific data compression
- ...

Together with O3D we will enable:

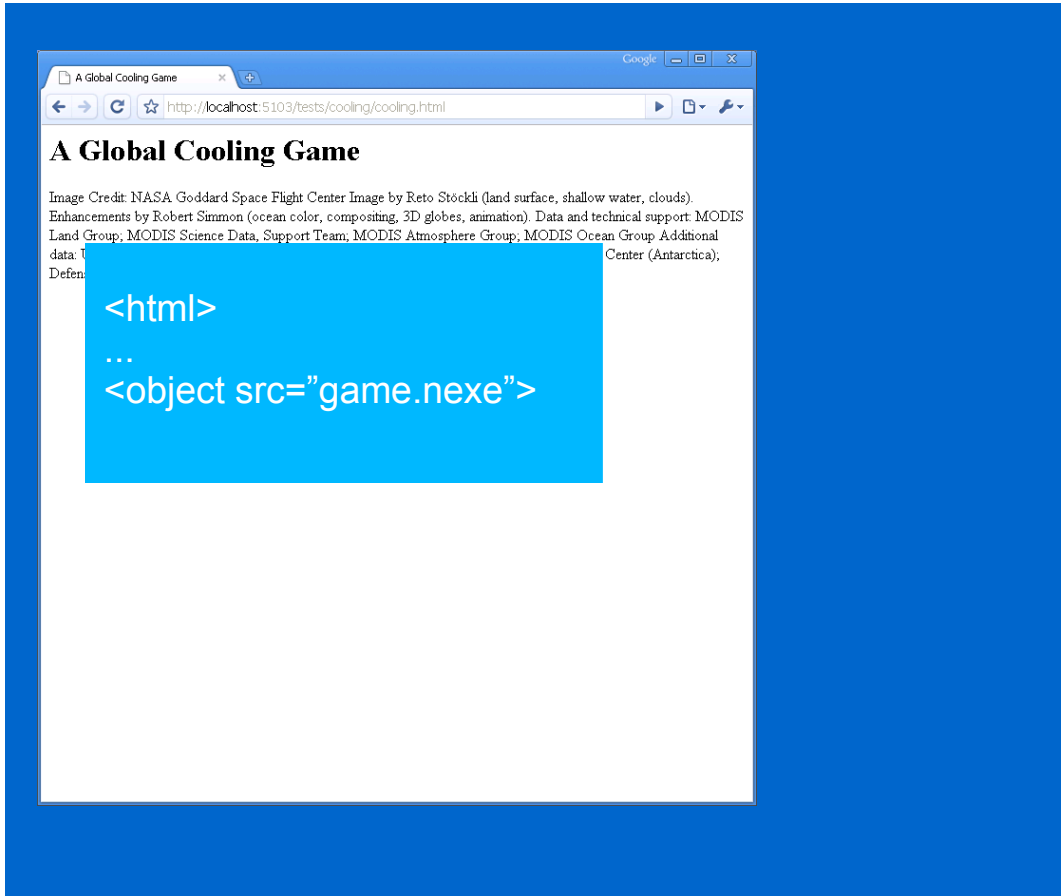
- High quality games
- CAD applications
- ...

The Life of a NaCl-Enabled Web App

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The Life of a NaCl-Enabled Web App



The Life of a NaCl-Enabled Web App



The screenshot shows a web browser window titled "A Global Cooling Game" with the URL `http://localhost:5103/tests/cooling/cooling.html`. The page content includes a title, a credit line, and a code overlay. The code overlay is a blue box containing the following HTML code:

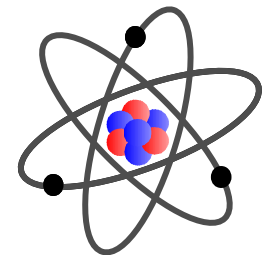
```
<html>
...
<object src="game.nexe">
```

A green box labeled "Native Client Helper" is positioned at the bottom right of the browser window.

The Life of a NaCl-Enabled Web App



The screenshot shows a web browser window with the title "A Global Cooling Game" and the URL "http://localhost:5103/tests/cooling/cooling.html". The page content includes a title "A Global Cooling Game", a credit line "Image Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group, MODIS Science Data, Support Team, MODIS Atmosphere Group; MODIS Ocean Group Additional data: Center (Antarctica), Defen", and a code overlay showing HTML tags: `<html>`, `...`, and `<object src="game.nexe">`. A green box labeled "Native Client Helper" is positioned at the bottom right of the browser window.



The Life of a NaCl-Enabled Web App



The screenshot shows a web browser window with the title "A Global Cooling Game" and the URL "http://localhost:5103/tests/cooling/cooling.html". The page content includes a title, a paragraph of text, and a code overlay. The code overlay is a blue box containing the following HTML code:

```
<html>
...
<object src="game.nexe">
```

A green callout box at the bottom right of the browser window contains the text "Native Client Helper".



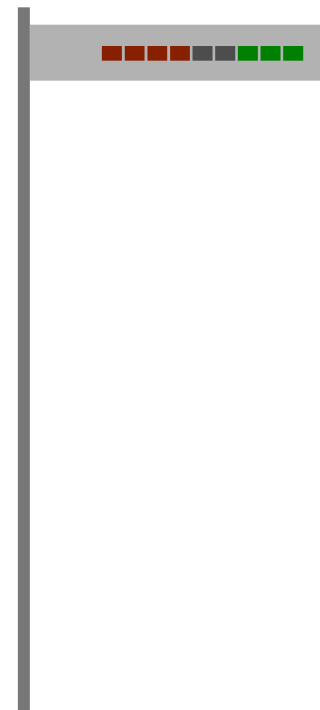
The Life of a NaCl-Enabled Web App



A screenshot of a web browser window titled "A Global Cooling Game" at the URL `http://localhost:5103/tests/cooling/cooling.html`. The page content includes a title, a paragraph of credits, and a blue rectangular overlay containing the following HTML code:

```
<html>
...
<object src="game.nexe">
```

Below the code overlay, a green box contains the text "Native Client Helper".



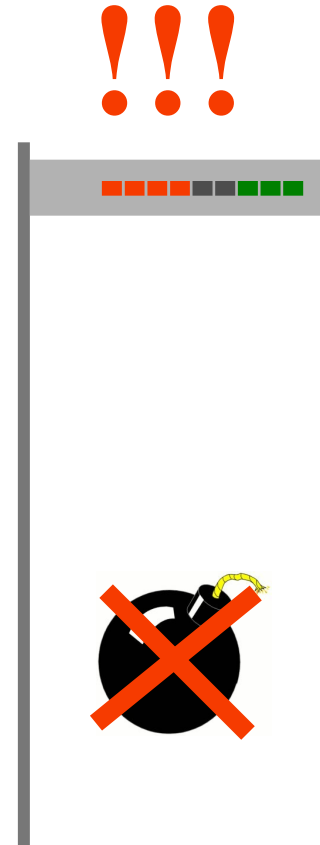
The Life of a NaCl-Enabled Web App



A screenshot of a web browser window titled "A Global Cooling Game". The address bar shows the URL "http://localhost:5103/tests/cooling/cooling.html". The page content includes the title "A Global Cooling Game" and a paragraph of text: "Image Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group, MODIS Science Data, Support Team, MODIS Atmosphere Group; MODIS Ocean Group Additional data: Center (Antarctica), Defen". A blue rectangular box highlights the following HTML code:

```
<html>
...
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```

 A green rectangular box with the text "Native Client Helper" is positioned at the bottom right of the browser window.



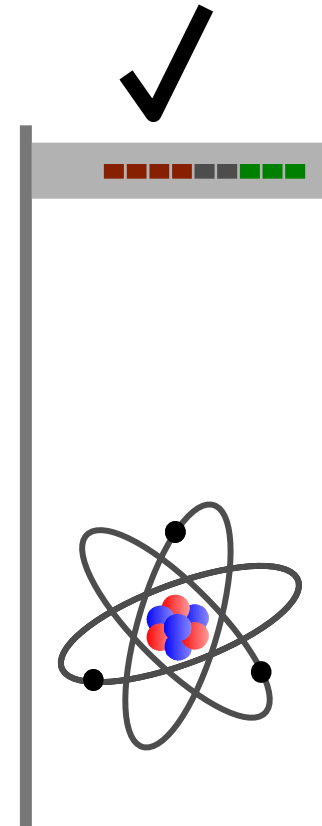
The Life of a NaCl-Enabled Web App



A screenshot of a web browser window titled "A Global Cooling Game". The address bar shows "http://localhost:5103/tests/cooling/cooling.html". The page content includes a title "A Global Cooling Game", a credit line for NASA, and a code overlay with the following HTML snippet:

```
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A green box labeled "Native Client Helper" is positioned at the bottom right of the browser window.



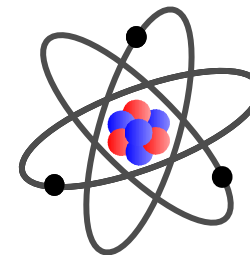
The Life of a NaCl-Enabled Web App



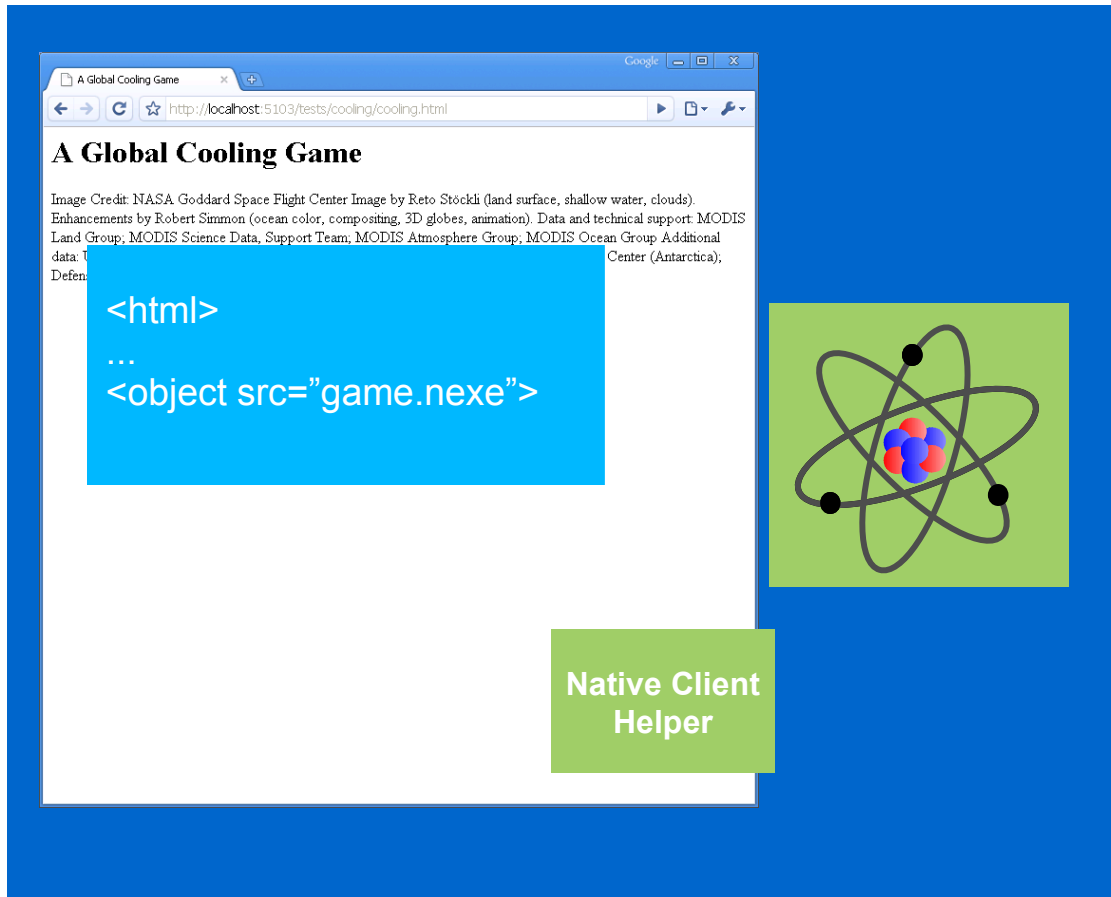
The screenshot shows a web browser window with the title "A Global Cooling Game" and the URL "http://localhost:5103/tests/cooling/cooling.html". The page content includes a title, a paragraph of text, and a blue box containing HTML code. A green box labeled "Native Client Helper" is positioned below the code box. To the right of the browser window is a large green square.

```
<html>
...
<object src="game.nexe">
```

Native Client Helper



The Life of a NaCl-Enabled Web App



The screenshot shows a web browser window with the title "A Global Cooling Game" and the URL "http://localhost:5103/tests/cooling/cooling.html". The page content includes a title, a paragraph of text with a line break, and a blue box containing HTML code. To the right of the code box is a diagram of an atom with a central nucleus of red and blue spheres and three black electron orbits. Below the code box is a green box with the text "Native Client Helper".

A Global Cooling Game

Image Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group, MODIS Science Data, Support Team, MODIS Atmosphere Group; MODIS Ocean Group Additional data: 1 Center (Antarctica), Defen

```
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Native Client Helper

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A Global Cooling Game

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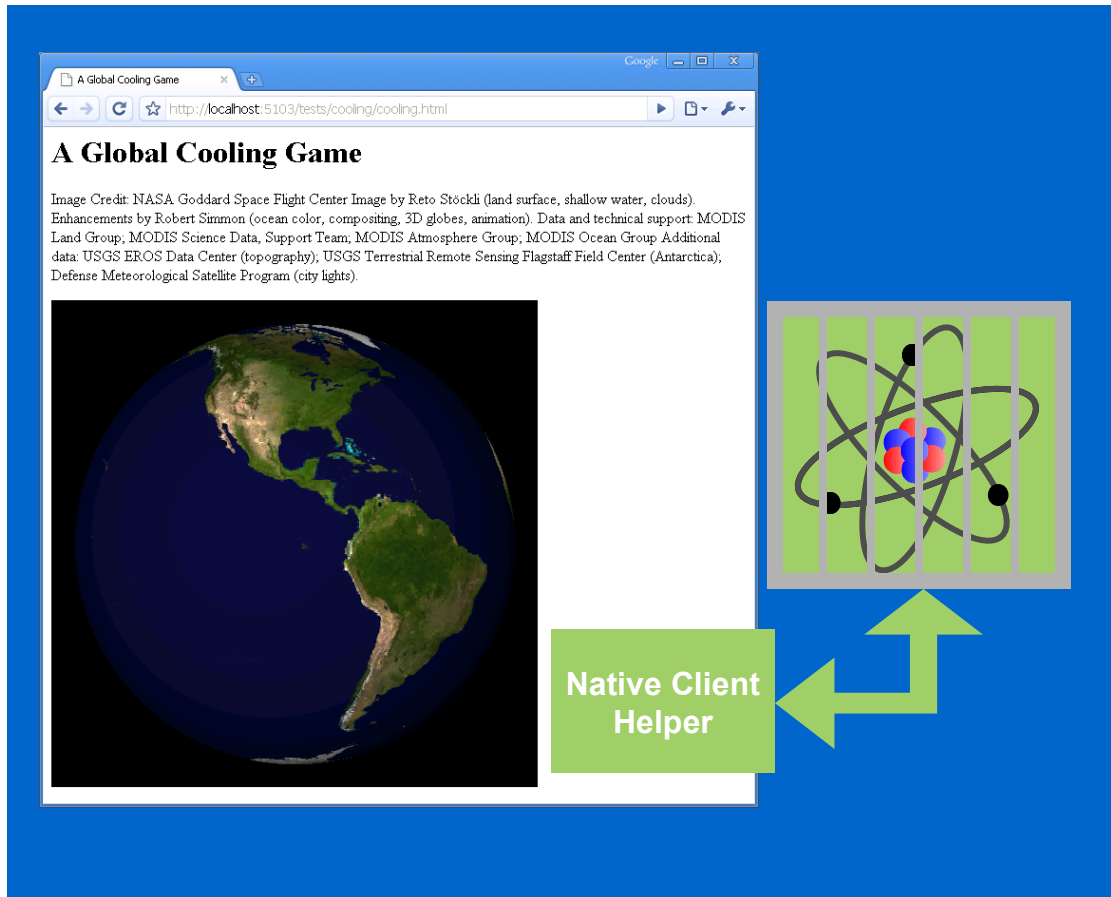
```
<html>  
...  
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```

Native Client Helper

The Life of a NaCl-Enabled Web App



The Life of a NaCl-Enabled Web App



The image shows a browser window with the title "A Global Cooling Game" and the URL "http://localhost:5103/tests/cooling/cooling.html". Below the title is a paragraph of text: "Image Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group, MODIS Science Data, Support Team, MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography), USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica), Defense Meteorological Satellite Program (city lights)." Below the text is a 3D globe of Earth. To the right of the globe is a diagram of a Native Client Helper, which is a green box containing a stylized atomic symbol with a nucleus of red and blue spheres and three black electrons orbiting it. A green arrow points from the "Native Client Helper" box to the globe, and another green arrow points from the globe back to the "Native Client Helper" box.

A Global Cooling Game

Image Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group, MODIS Science Data, Support Team, MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography), USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica), Defense Meteorological Satellite Program (city lights).

Native Client Helper

Native Client Security

Native Client Security



Our goal: make native code at least as safe as JavaScript.

Steps we've taken include:

- Multiple internal security reviews
- Open sourced our system; encouraged critical public review
- Published a peer reviewed technical paper in the *IEEE 2009 Symposium on Security and Privacy*
 - See <http://oakland09.cs.virginia.edu>
- Held a security contest

Native Client Security Contest



- 25 February to 5 May 2009
- Over 400 teams and 600 individuals participated
- 22 valid issues submitted
- Profile of valid issues:
 - Inner sandbox (1 + 1 prior to contest)
 - Outer sandbox (not yet enabled)
 - Binary module loader
 - Trampoline interfaces (1 – direction flag)
 - IMC communications interface
 - NPAPI interface (3 – including same origin issues)
 - System calls (1 – unmap / map)
 - Browser integration (8)

NaCl Today and Tomorrow

Today

- NPAPI plugin
- x86-32 only
- Raster graphics
- Mirrored public SVN

Today

- NPAPI plugin
- x86-32 only
- Raster graphics
- Public SVN

The Future

- *Built into browser*
 - *Web Workers*
 - *Revised NPAPI*
- *x86-32, x86-64, ARM*
- *O3D integration*

Porting a H.264 transcoder from Linux

- ◆ Based on a Google internal H.264 decoder
- ◆ Original test code decoded H.264 into raw frames
- ◆ 20-line change to create simple video player
- ◆ 230-lines to add audio and frame-rate control

Porting a Linux application to
Native Client can be very simple.

```
int main(int argc, char *argv[]) {
    ...
#ifdef __native_client__
    int r = nacl_multimedia_init(NACL_SUBSYSTEM_VIDEO);
    if (-1 == r) {
        printf("Multimedia system failed to initialize!  errno: %d\n", errno);
        exit(-1);
    }
    r = nacl_video_init(NACL_VIDEO_FORMAT_RGB, image_width, image_height);
    if (-1 == r) {
        printf("Video subsystem failed to initialize!  errno; %d\n", errno);
        exit(-1);
    }
    write_file_ptr = NULL;
#else
    write_file_ptr = fopen("output.yuv", "wb");
#endif
    ...
}
```

```
...
#ifdef __native_client__
    YV12toRGB24_generic(img->luma_sample, img->luma_width,
                        img->chroma_sample[0], img->chroma_sample[1],
                        img->chroma_width, RGB24_out,
                        img->luma_width, img->luma_height,
                        img->luma_width);

    r = nacl_video_update(RGB24_out);
    if (-1 == r) {
        printf("nacl_video_update() returned %d\n", errno);
    }
#else
    fwrite(img->luma_sample,      frame_size,      1, write_file_ptr);
    fwrite(img->chroma_sample[0], frame_size>>2, 1, write_file_ptr);
    fwrite(img->chroma_sample[1], frame_size>>2, 1, write_file_ptr);
#endif
...
```

Demo: H.264 Video Decoder

Demo: Native Client Darkroom

Questions?



On the web: <http://code.google.com/p/nativeclient>

Related projects:

Chromium: <http://dev.chromium.org>

O3D: <http://code.google.com/p/o3d>

Contribute



Please visit us at <http://code.google.com/p/nativeclient>

- Write new apps
- Port existing C/C++ libraries
- Help us test



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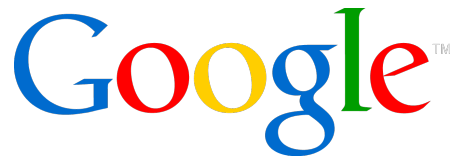
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Web Workers: Simple threading model for the browser

- ◆ No shared data, no DOM access
- ◆ `postMessage`, `XMLHttpRequest`, `openDatabase`
- ◆ See specification at <http://whatwg.org/ww>

Goals of Native Web Workers:

- ◆ Support workers in C, C++, Ruby, ...
- ◆ Maintain the simplicity of the Web Worker model
- ◆ Support 'low frequency' applications



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