The Parallel Browser & Program Synthesis

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2007: Future of the Browser?

1) Web on 1 Watt

2) Visualization
Obstacle: Programmability

- Schedule?
- Correctness?
- Data representation?

Parallel JavaScript Impl.
Parallel Browser APIs
Parallel Browser Impl.

Program Synthesis!
Parallelism for Energy Efficiency

Mobile Today

200 sites @ 4.5 Watt-Hours

4-8 cores x 128b SIMD

GPGPU (ARM Mali)
Big Data Needs a Frontend

Analysis Result: No
BIG INTERACTIVE VISUALIZATIONS
What to Parallelize in the Browser?

- Parser: 20%
- Selector engine: 29%
- Layout engine: 10%
- Renderer: 23%
- JavaScript: 12%

“Compiler”
“LaTeX”
“Game”
Parallel Browser System Design

1. parallel components
2. parallel event loop
3. multiple design expt’s
4. automatic parallelization
Parallel Browser System Design

Parser

Selectors

Layout

Renderer

Parallelization

- GPU
- MIMD + GPU
- Multicore
- Multicore + SIMD

- [Intel, Qualcomm, Mozilla, Microsoft, Samsung]
- [HotPar'09]
- [WWW'10]
- [PPOPP'13, HotPar'11]
- [LASH-C'13]
- [WWW'10, PPOPP'13]

JavaScript VM

HTML data

CSS styling

JS script

Pixels

Event loop

Data Loading Optimization: Preprocessing and Parallelization

- ownership transfer (msg copy)
- init, GPU transfer
- data loading

- 2611
- 338
- 85

- runtime flattening (BASELINE)
- preprocessing
- preprocessing + parallel loading

Speedup vs. cores

- optimized
- baseline

3. multiple designs

1. parallel components
2. parallel event loop
3. parallelization

Optimized baseline

Av. Speedup

0X
2X
4X
6X
Parallel Programming w/ Synthesis

Output: locks (Armandol L.), SIMD, Green Arrays, SQL, …
class Paragraph:
    word1.w + word2.w = self.w
...
//Constraints: bidirectional, OO, ...

Parallel Programming w/ Synthesis
Schedule Layout as Parallel Tree Traversals!

\[ \text{sched} = \uparrow \{ w, h \}; \quad \downarrow \{ x, y \}; \quad \uparrow \{ \ldots \}; \quad \ldots \]

Logical joins

Logical spawns

Document tree

Constraints on node attributes

\[ w_0 = \text{sum}(w_1, w_2) \]
\[ h_0 = \text{max}(h_1, h_2) \]

\[ \text{sched valid for all webpages (in subset)} \]

Synthesizer automatically schedules  

[WWW 2010, PPOPP 2013]
How to Control Parallel Traversals

OK: rescheduling attribs

CSS 1.0, 2.0, 2.1, 3.0, 4.0, …

Hole for code to generate via synthesis: \[x, y\], “||”, …

• Edits should not break schedule
• But do want to manually parallelize

Structured programming:
Helped sharing code, testing ideas, and debugging

Synthesizer rejects programs that cannot obey sketch

w, h

sequential_inorder\{y,r\}
Lessons

**Parallel Browser**
Requires algorithms, automation

**Program Synthesis**
Future of patterns, autotuning

**Surprise wins:**
- mobile, data viz, layout tools

**Superconductor**
Parallel Web Programming for Massive Visualizations

[GitHub link]