

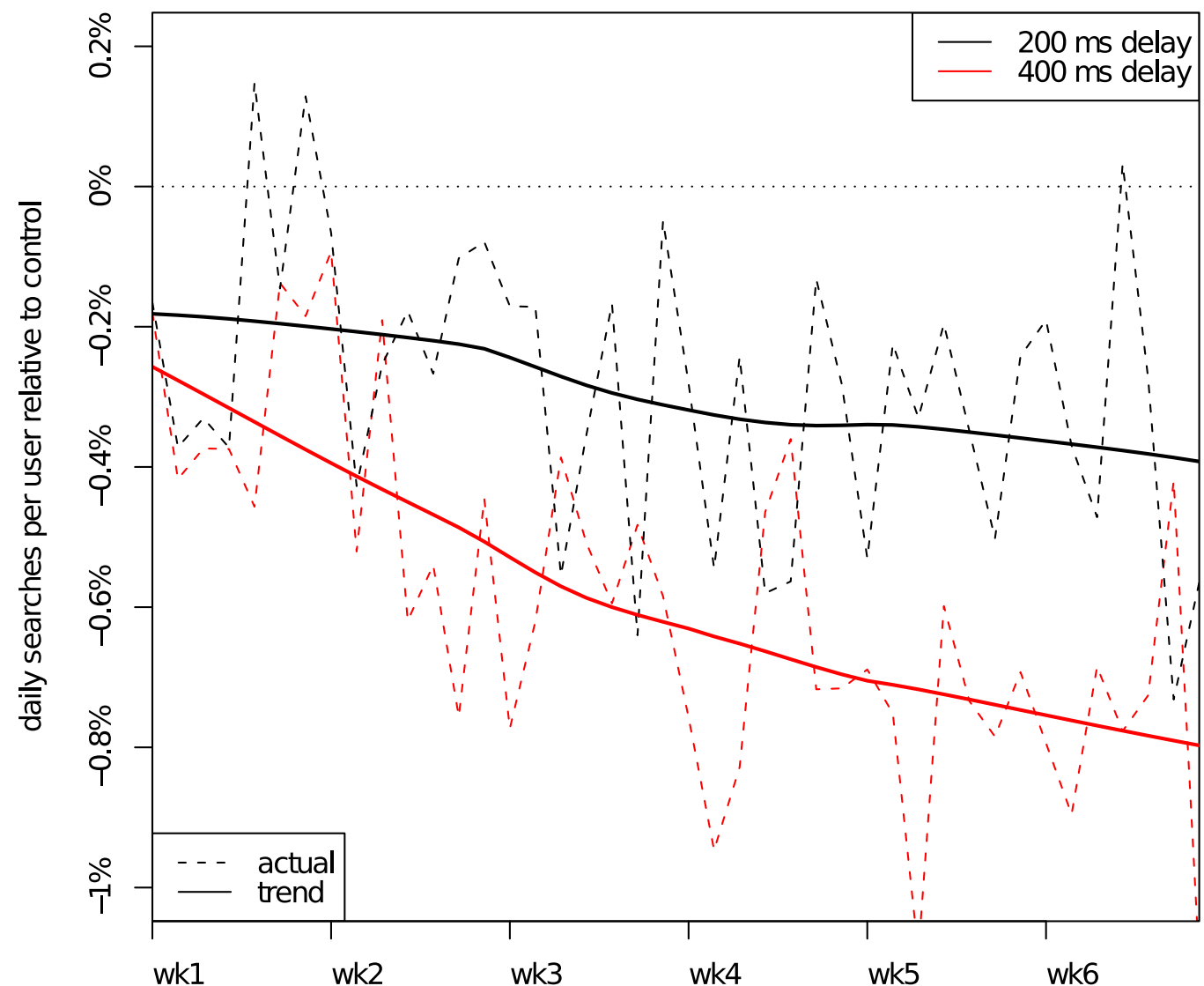
A Case for Parallelizing Web Pages

Haohui Mai, Shuo Tang, Samuel T. King
University of Illinois and Valkyrie Computer Systems

Calin Cascaval, Pablo Montesinos
Qualcomm Research

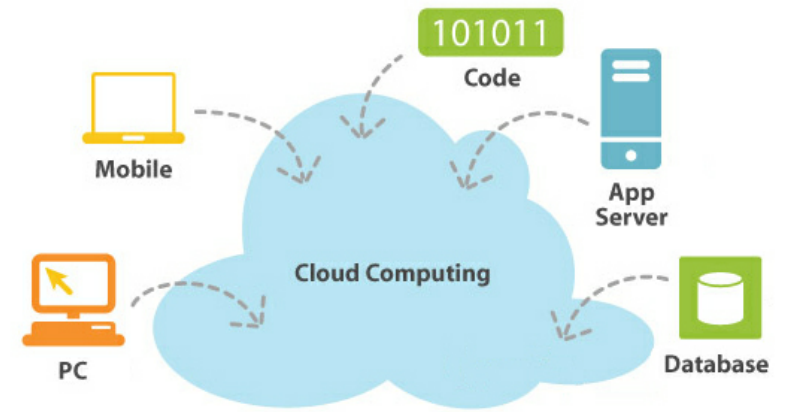
Google: slower web, fewer searches

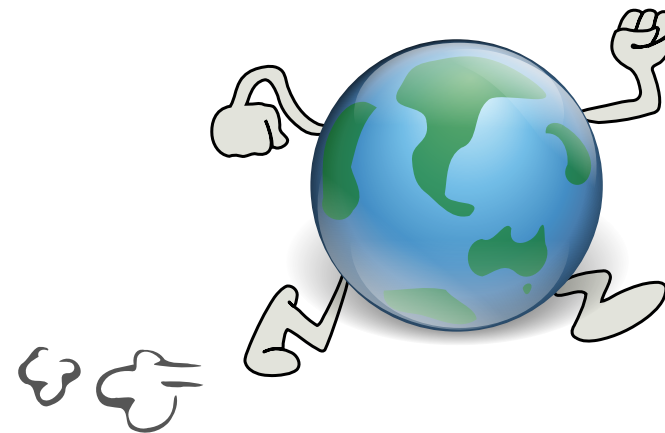
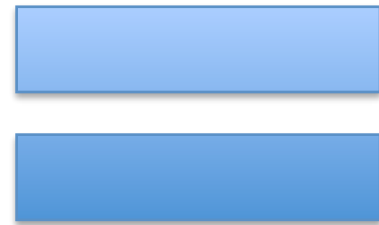
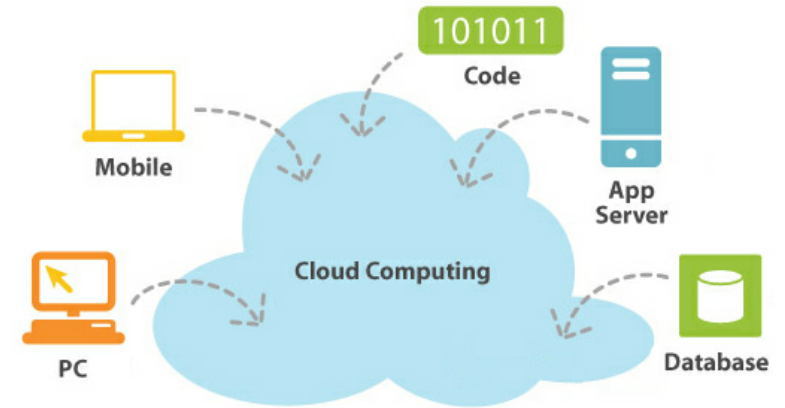
- ~\$200m / yr
- 2 weeks until search rate recovered
- Similar results from Facebook and Microsoft



[Figure from “Speed Matters for Google Web Search” by Jake Brutlag]



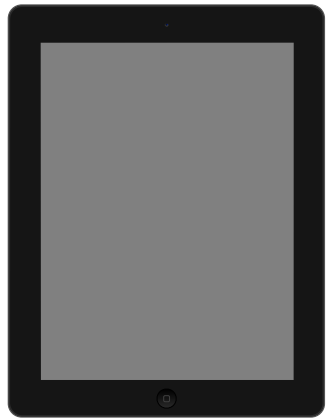




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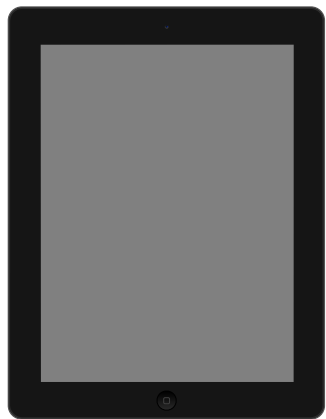
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Adrenaline
Browser

Overview

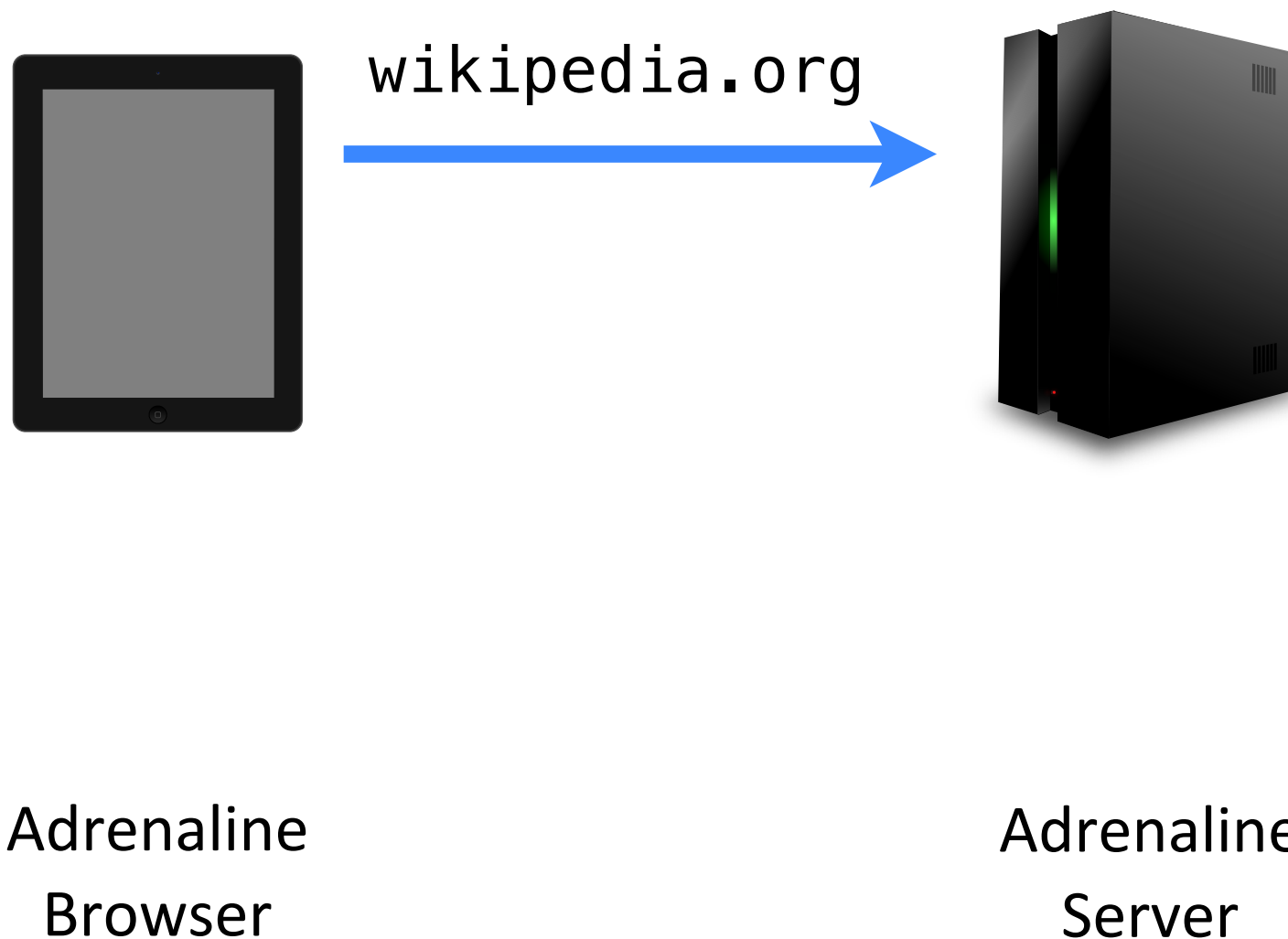


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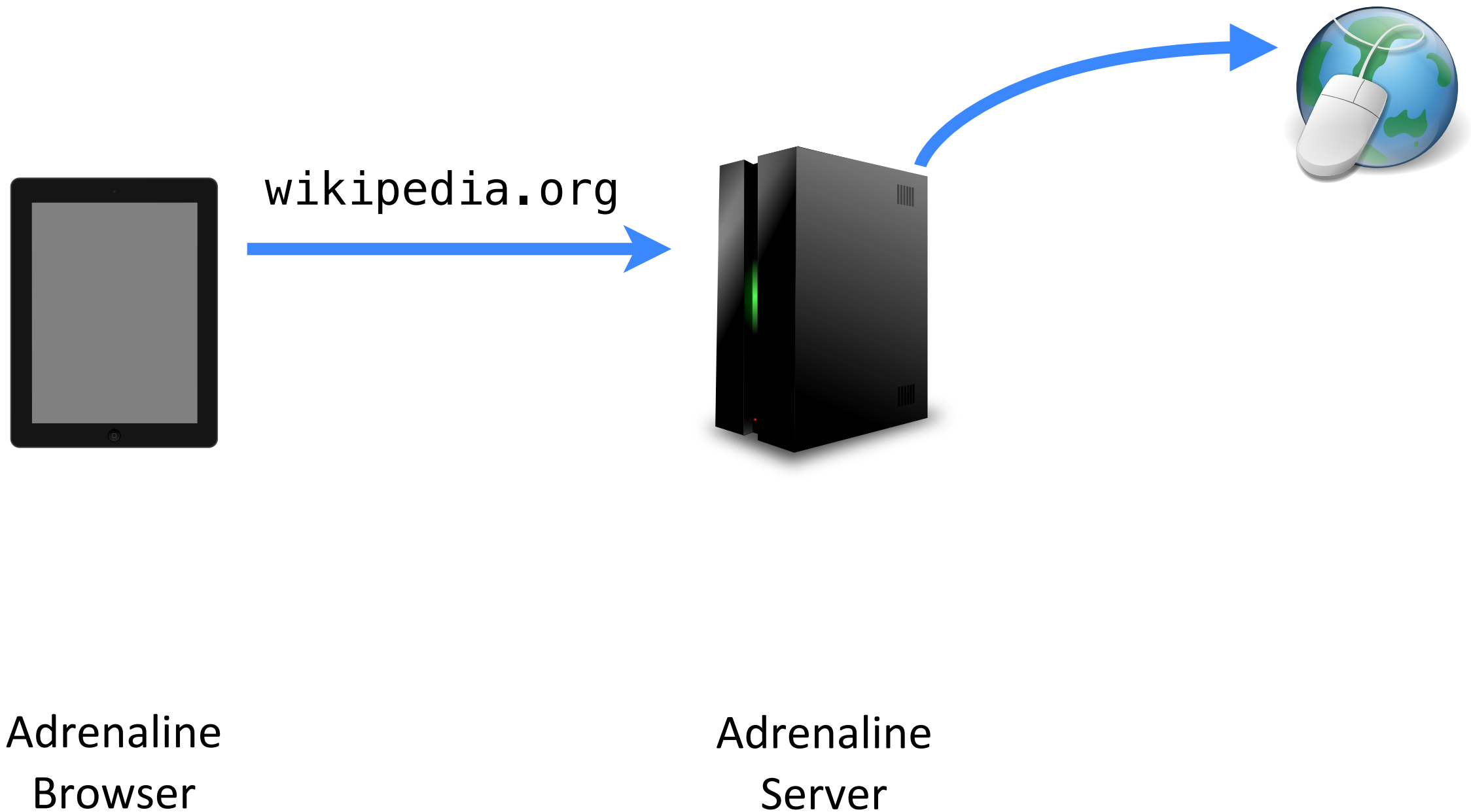


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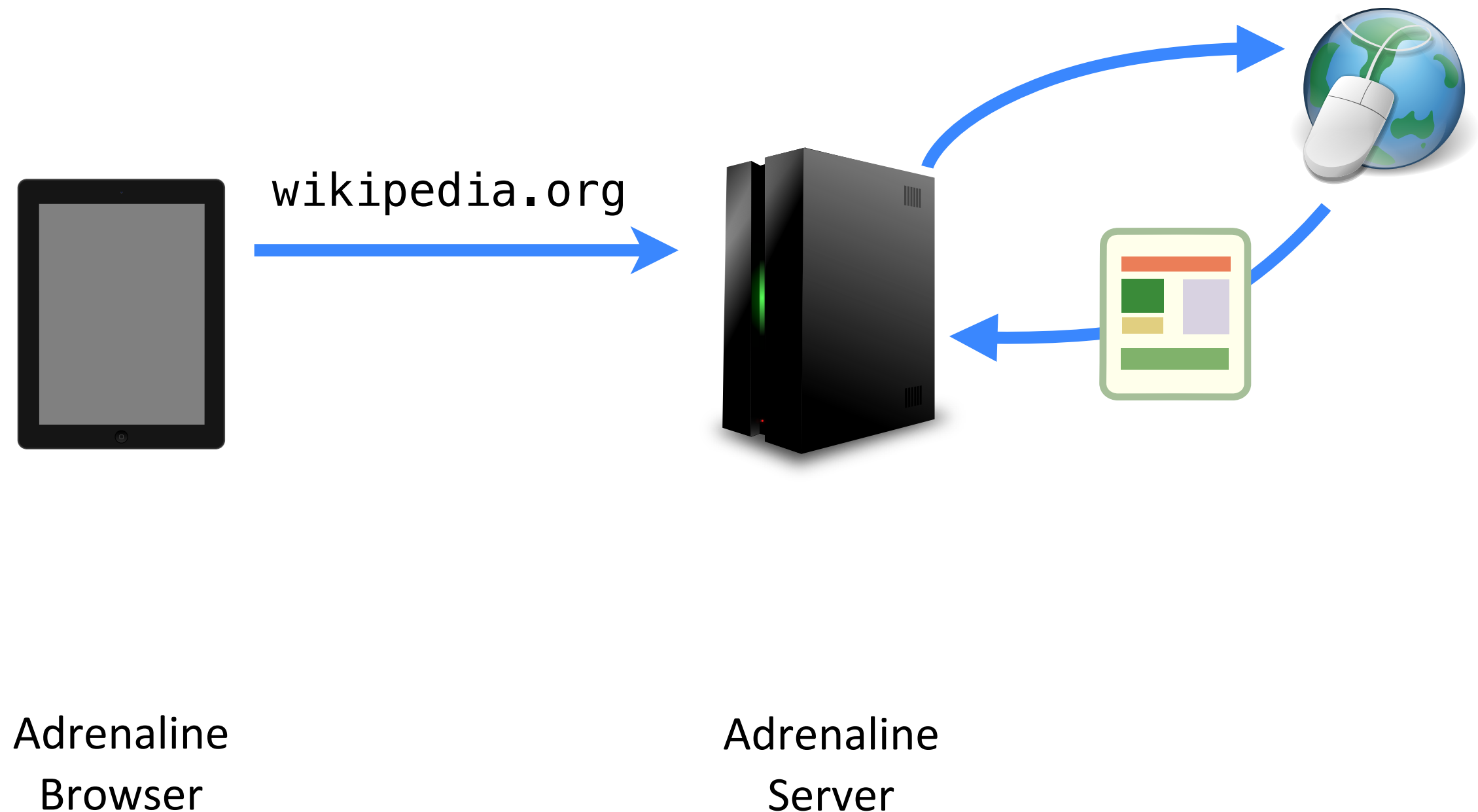
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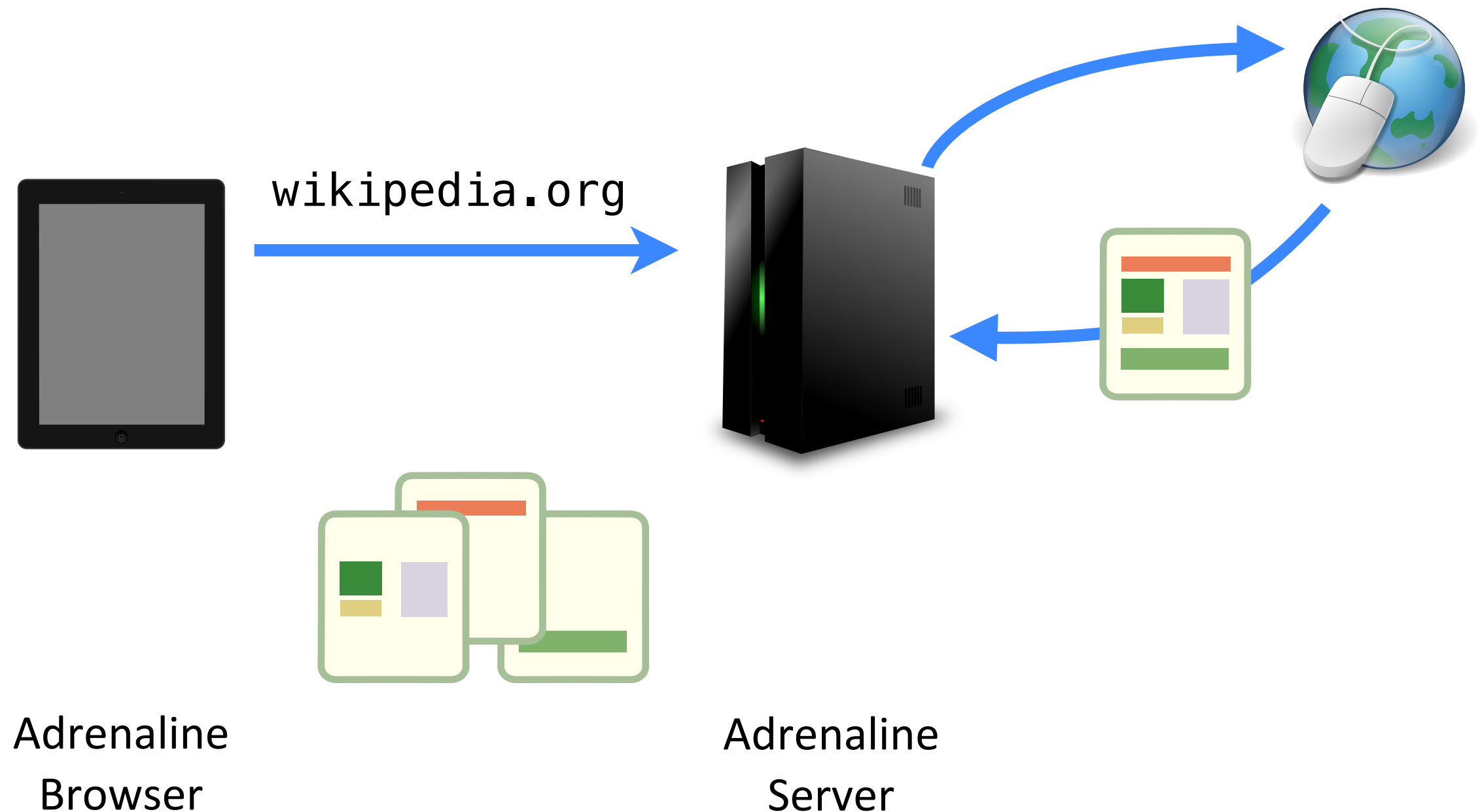
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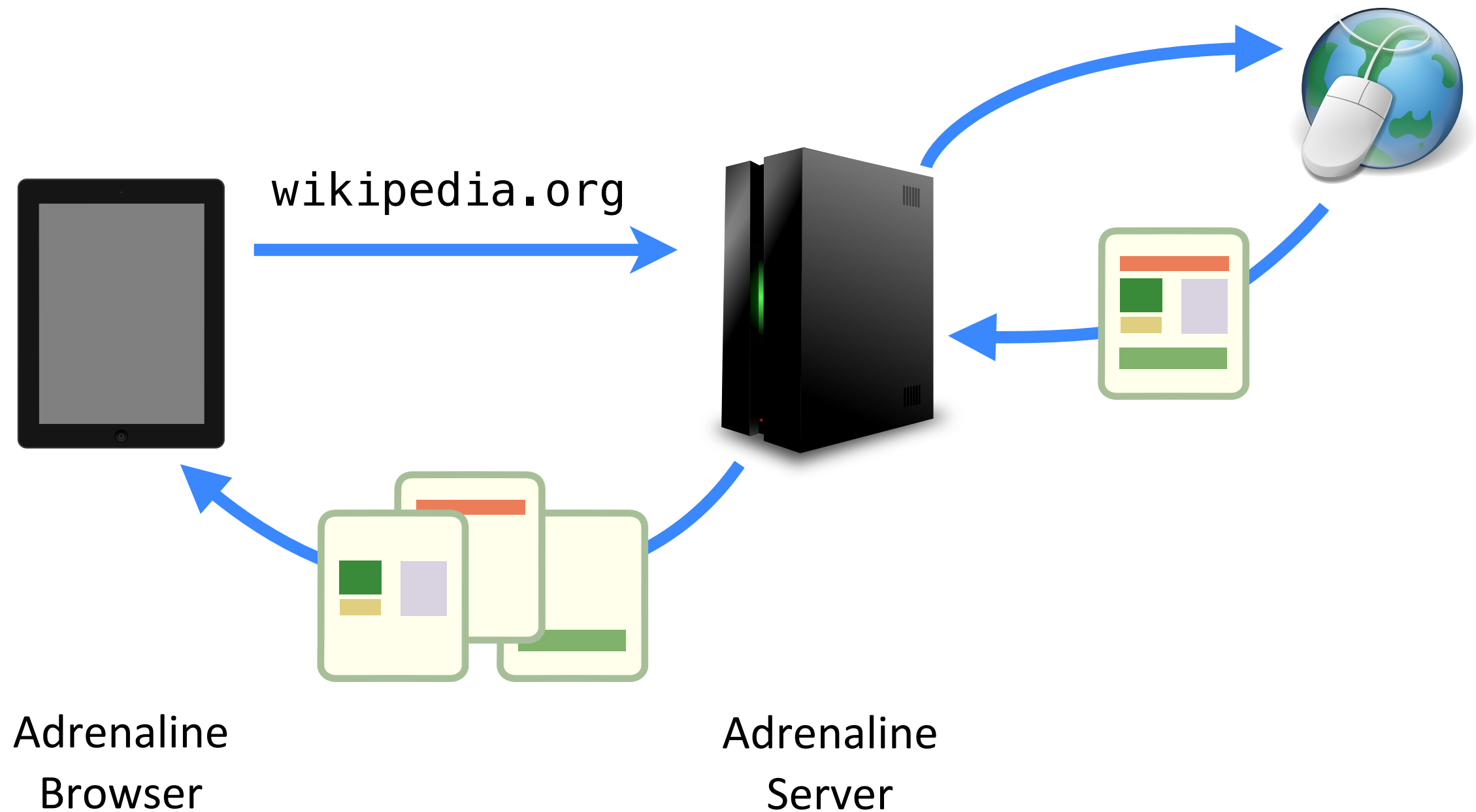
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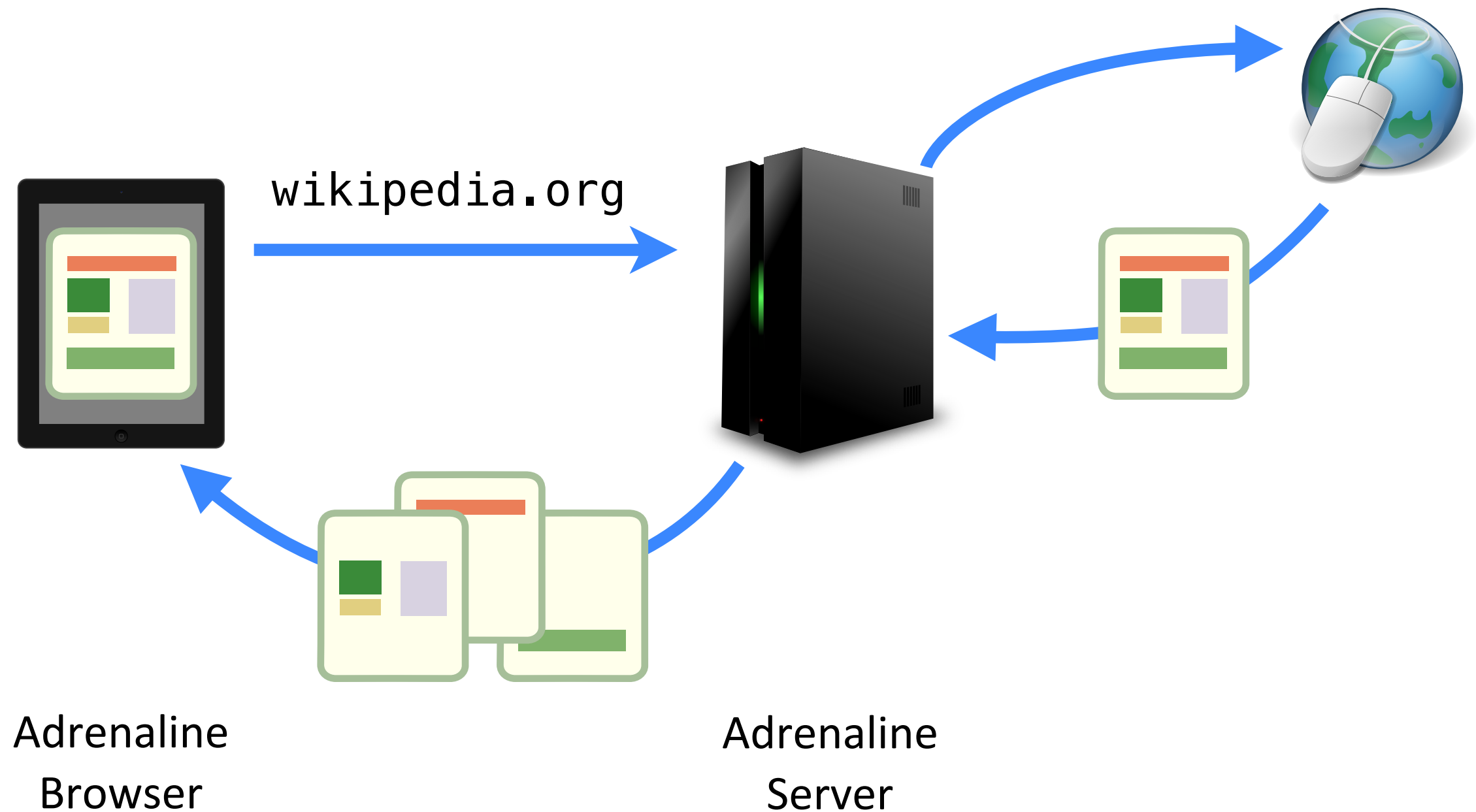
Overview



Overview



Overview





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Today's featured article



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- ... that there were attempts to **ban yerba mate** in early 17th-century South America?

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Today's featured picture



An **Australian Pelican** (*Pelecanus conspicillatus*) in flight. This species of pelican can be found on the inland and coastal waters of Australia and New Guinea, also in Fiji, parts of Indonesia and as a vagrant to New Zealand. At about 1.7 m (5.6 ft) and with a wingspan of about 2.4 m (7.9 ft), it is medium-sized by pelican standards, but has the largest beak of any bird; the largest one on record was 49 cm (19 in) long. Widespread throughout its large range, the Australian Pelican is evaluated as Least Concern on the IUCN Red List of Threatened Species.

Photo: Pix002

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- The 14th Dalai Lama submits his resignation as political leader of the Tibetan government in exile.
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[Wikinews](#) – [Recent deaths](#) – [More current events...](#)

On this day...

March 17: Saint Patrick's Day

- 1776 – **American Revolutionary War**: The British evacuated Boston, Massachusetts, withdrew from the city, ending the 11-month **Siege of Boston**.
- 1891 – The transatlantic steamship SS *Thetis* (pictured) **disappeared** while en route with the battleship USS *Assen* in the Bay of Gibraltar, sinking in less than twenty minutes and killing 342.
- 1942 – The **Holocaust**: The first mass killings of Jews began at **Belzec extermination camp** in occupied Poland, the first of the Aktion Reinhard camps to begin operation.
- 1955 – Six thousand people in Montreal rioted to protest the suspension of ice hockey star Maurice Richard.
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- 1992 – A car bomb **destroyed** the Israeli embassy and nearby buildings in Buenos Aires, killing 29 people and wounding 242 others.

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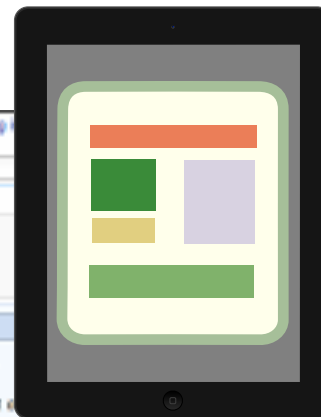
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Advantages

- Improve performance
- Easily adoptable
- Maintain current web app semantics

Browser I/O

Browser 101



Browser 101

```
...  
<body>  
<p id="bar">Hello</p>  
  
</body>  
...
```

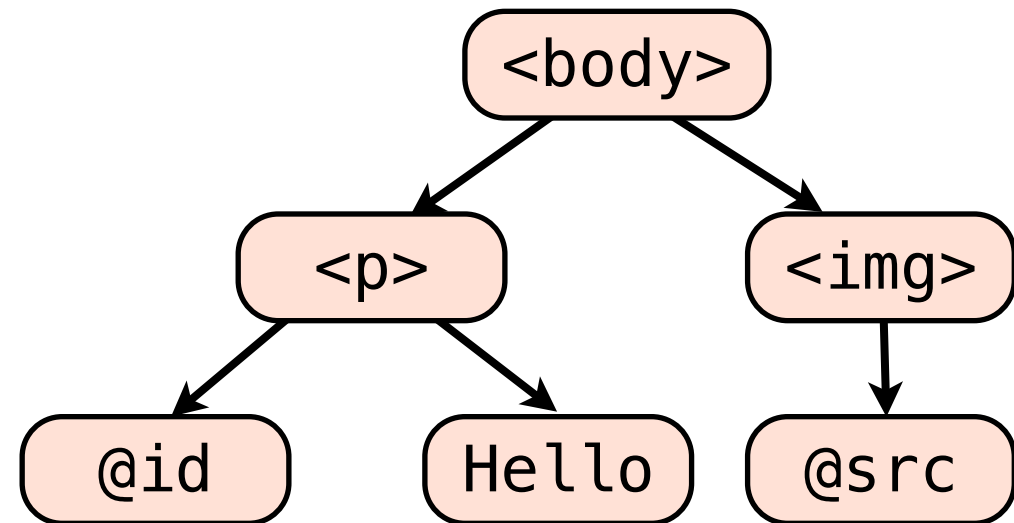
HTML



Browser 101

```
...  
<body>  
<p id="bar">Hello</p>  
  
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...
```

HTML



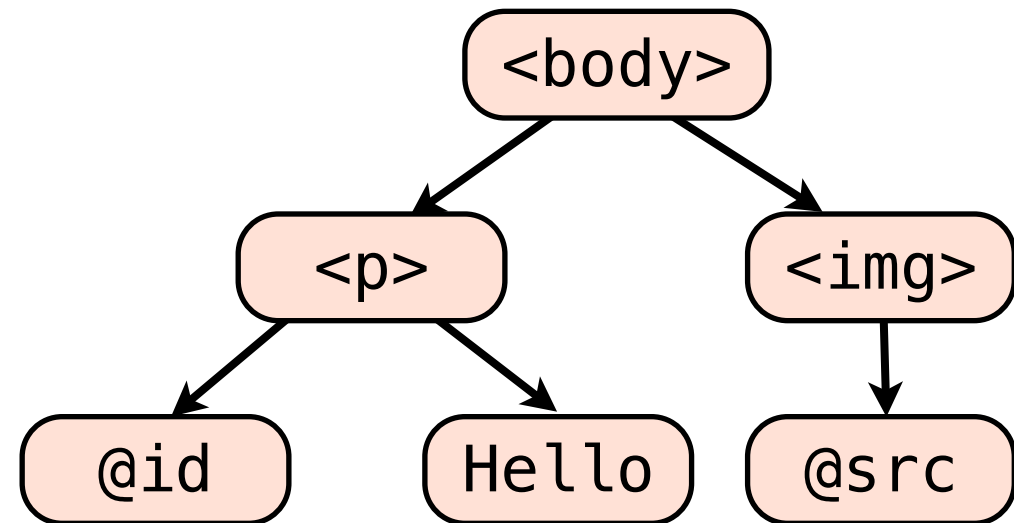
DOM



Browser 101

```
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<body>  
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</body>  
...
```

HTML



DOM

```
getElementById("bar")  
.innerText = "World";
```

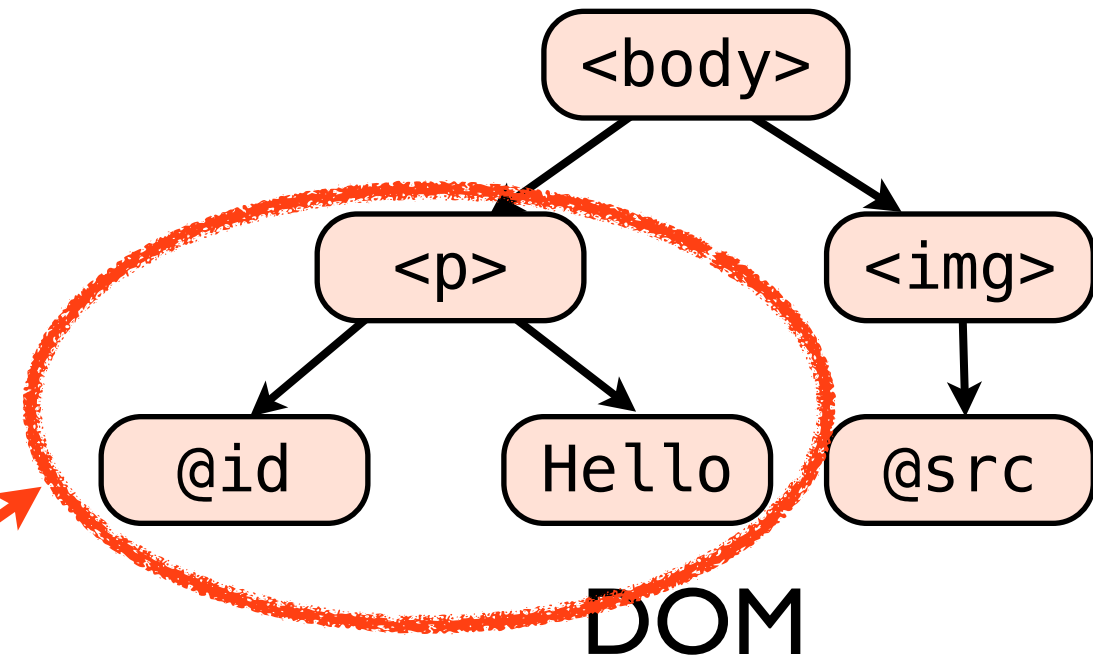
JavaScript



Browser 101

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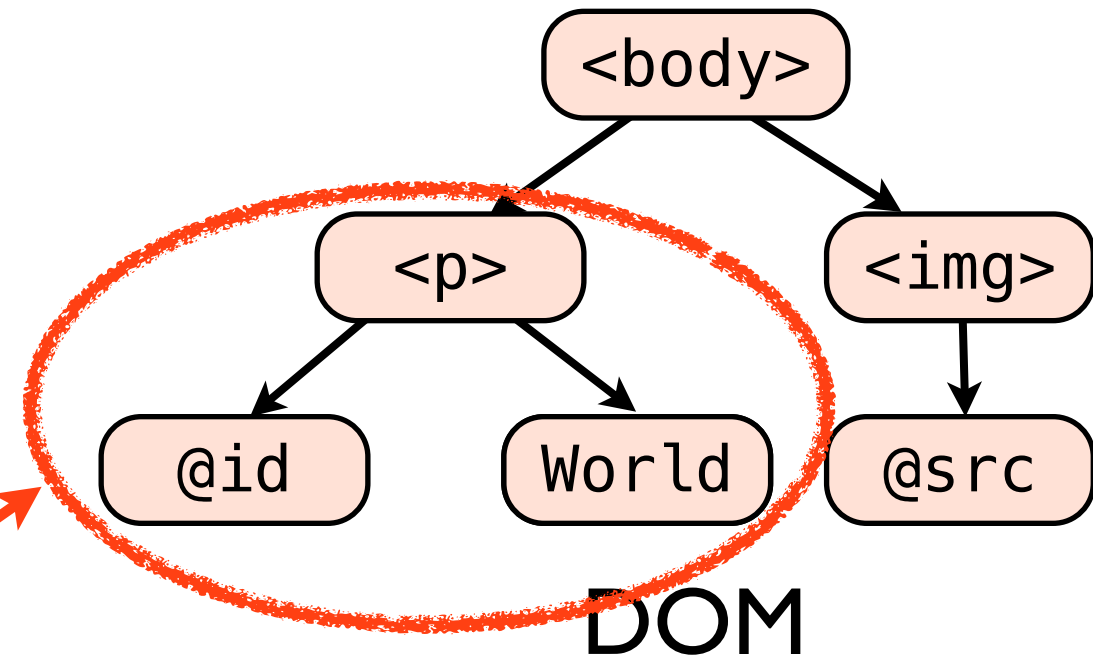
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JavaScript



Browser I/O

- DOM is the core data structure

- Motivation
- Overview
- Design challenges
- Evaluation
- Conclusion

Design challenges

- Distributed
- Compatibility

Design challenges

- Distributed
- Compatibility
- JavaScript and DOM compatibility
- Visual compatibility
- Reducing synchronization overhead
- ...

JavaScript and DOM compatibility

- Distributed states of DOM / JavaScript

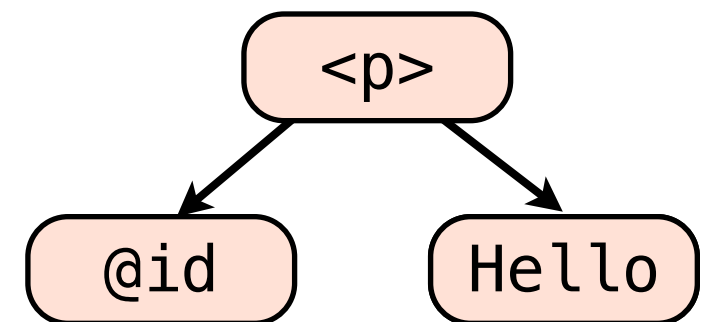
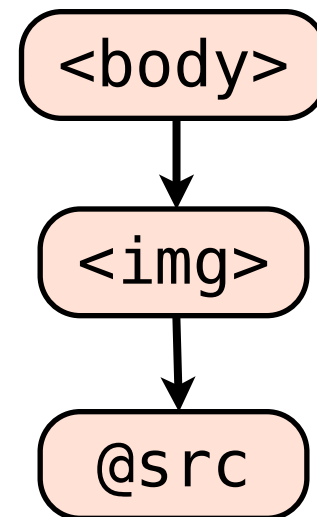
JavaScript and DOM compatibility

- Distributed states of DOM / JavaScript
- Solution
 - Only the main page executes JavaScript
 - Merge distributed states back into the main page on demand

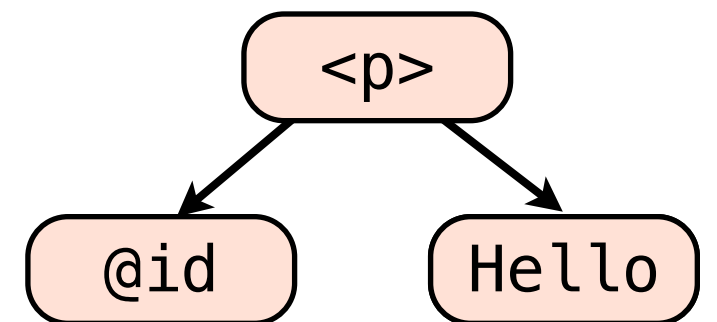
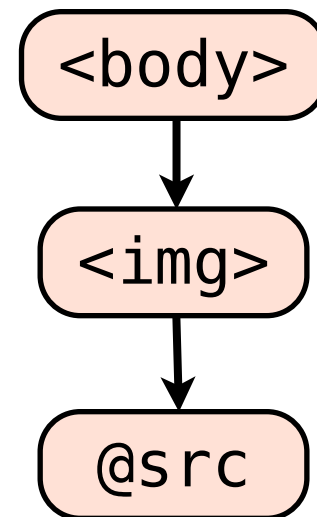
Example



Example

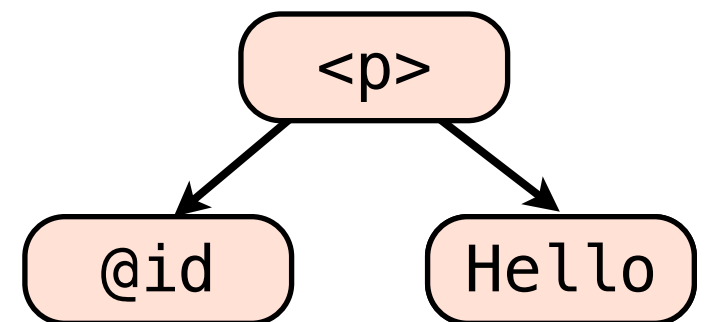
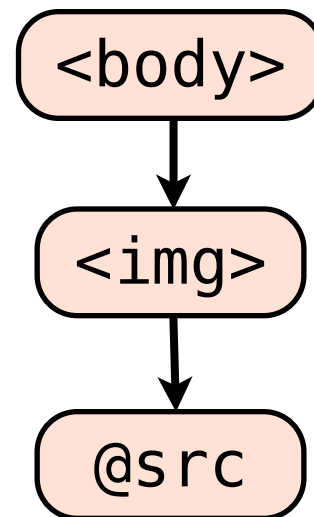


Example



```
foo = getElementById("bar");  
foo.innerText = "World";
```

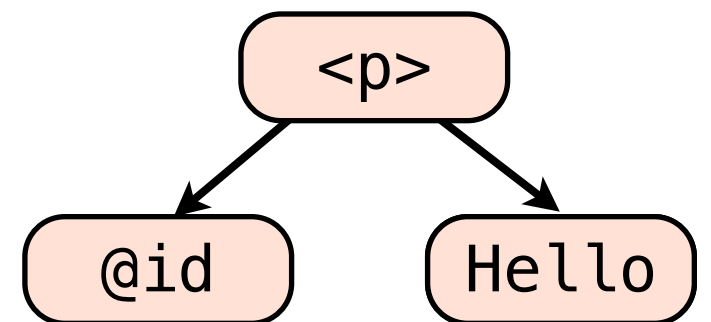
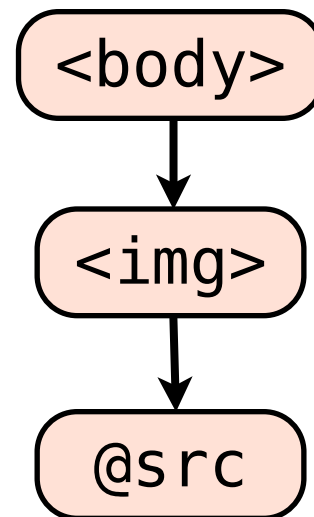
Example



```
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```
getElementById(id) {  
  foreach(m in minipages)  
    if(m->contains(id)) {  
      n = createNode(fetchDOM());  
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    }  
}
```

Example

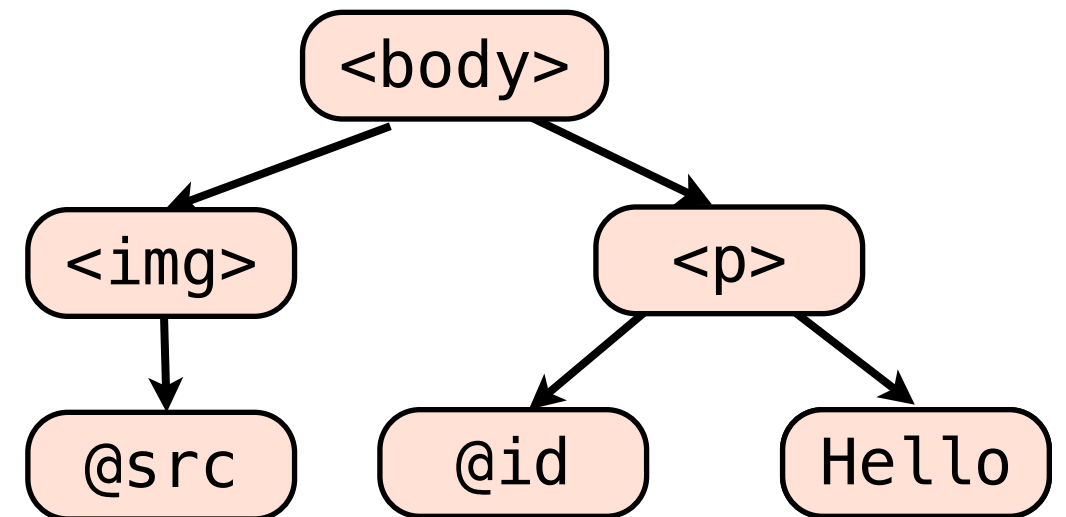


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Example(cont.)

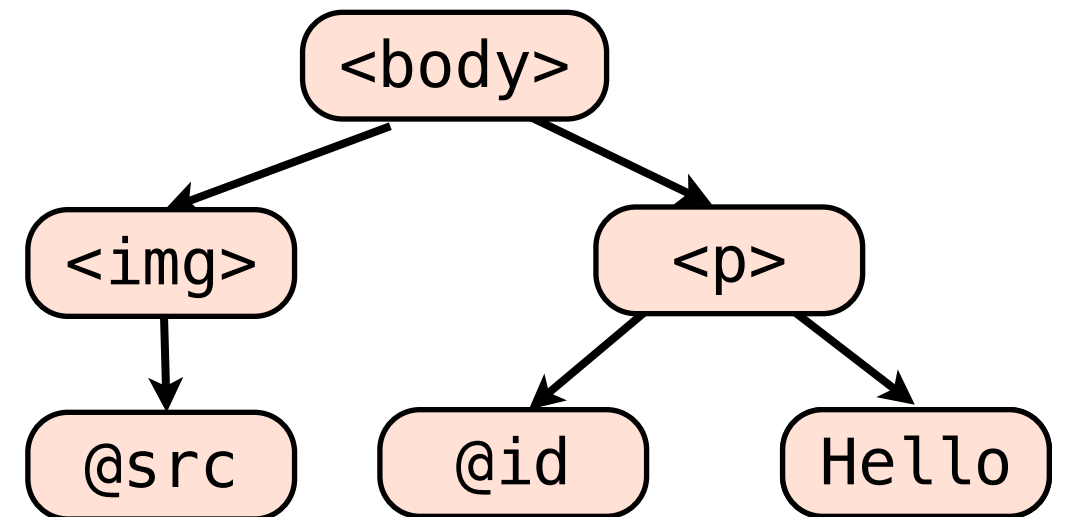


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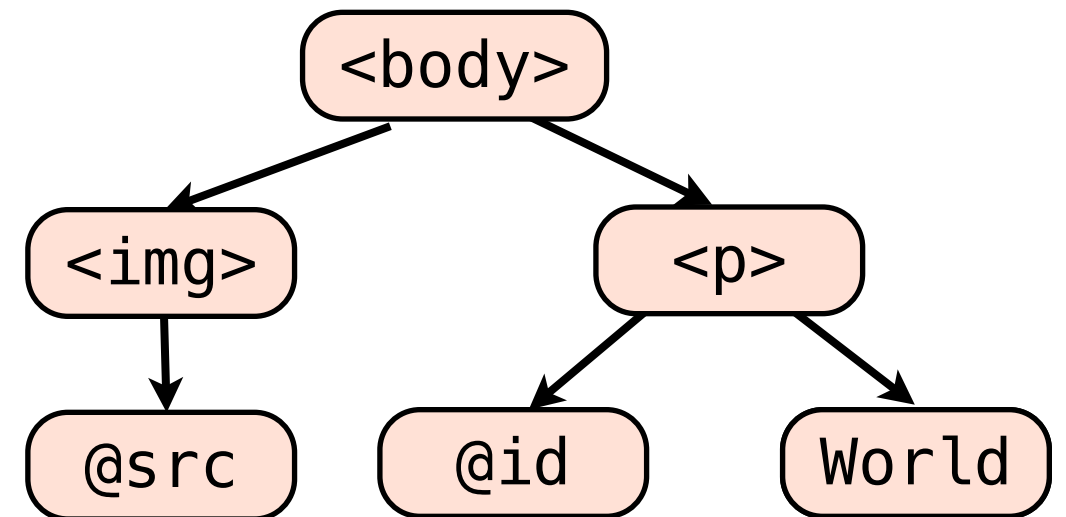
Example(cont.)



→ `foo = getElementById("bar");`
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Visual compatibility

- Users see “the same” page, and interact with it in the same way

Visual compatibility

- Users see “the same” page, and interact with it in the same way
- Solution
 - The main page resembles other mini pages into its display
 - Reroute events to mini pages

Example



Main page

Example



Main page

Example



Mouse
event



Main page

Mini page

Example



Mouse
event

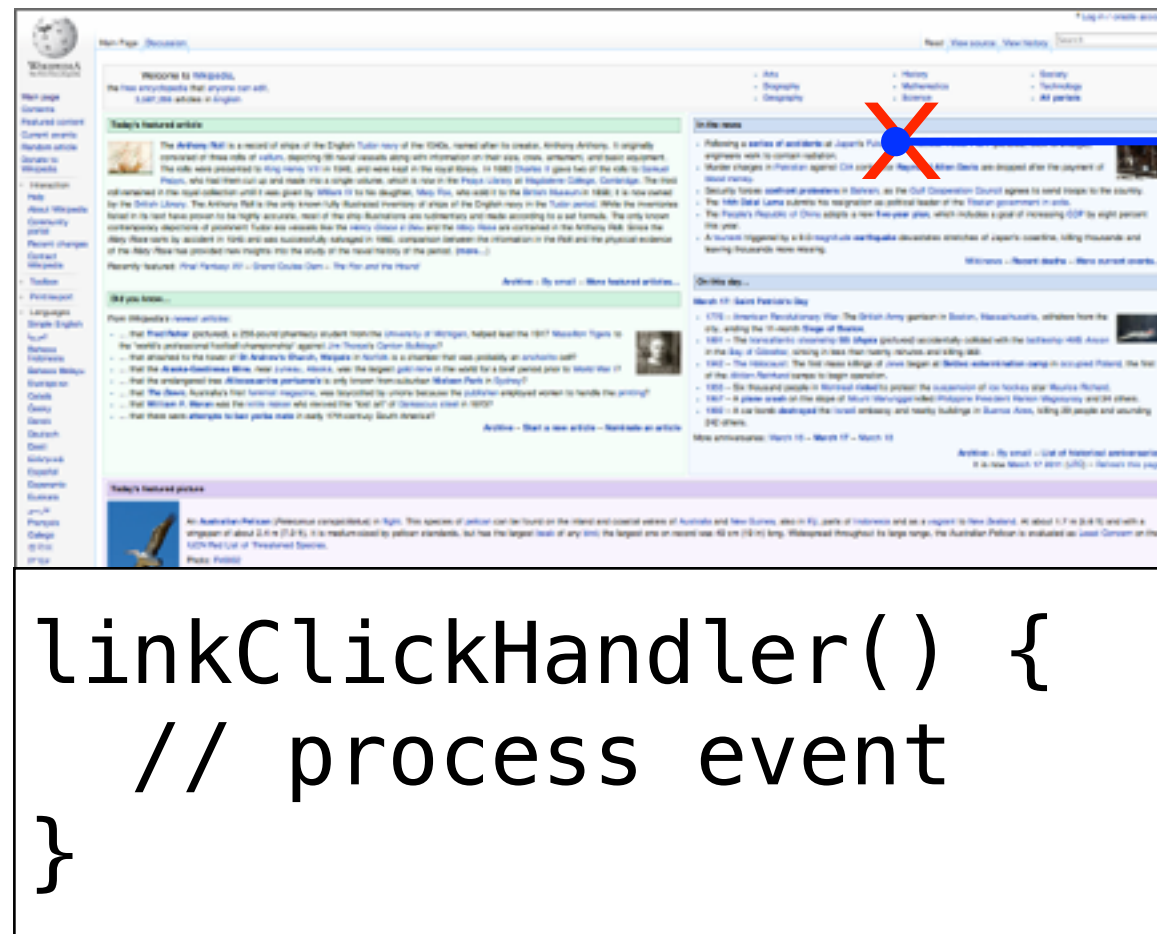


DOM
onclick

Main page

Mini page

Example



Main page

Mouse
event



DOM
onclick

Mini page

Reducing overhead

- >1k+ IPC calls for getElementById()

Reducing overhead

- >1k+ IPC calls for getElementById()
- Solution
 - Pre-compute a data structure to cache the results
 - Bloom filter: a space-efficient data structure without false negatives

Additional challenges

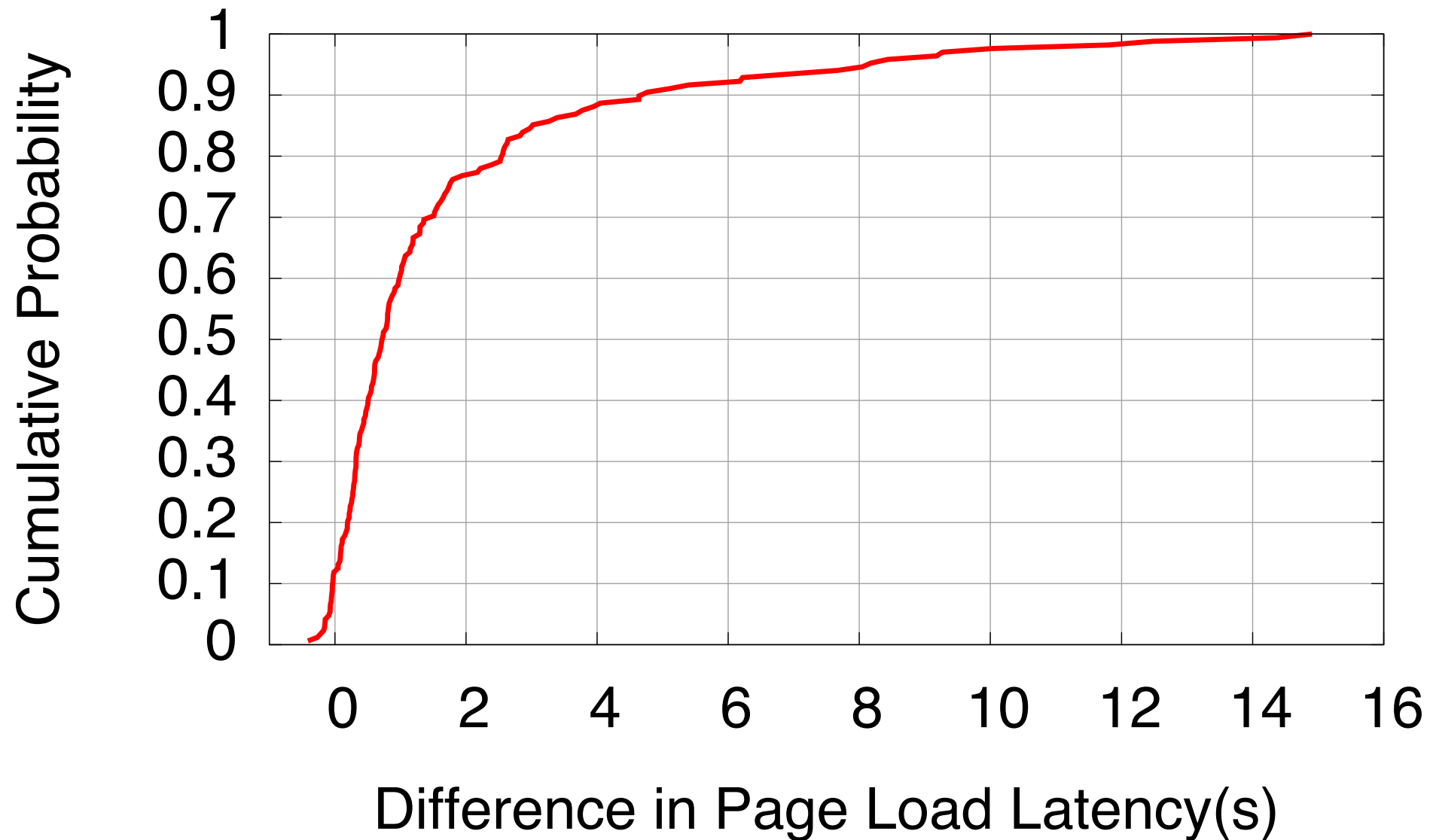
- Server architecture
- Algorithm to decompose web pages
- On going work

- Motivation
- Overview
- Design challenges
- Evaluation
- Conclusion

Evaluation

- Implementation on top of QtWebKit
- Evaluated 170 of the most popular sites
- Setup
 - Running on a quad-core ARM board
 - Local network

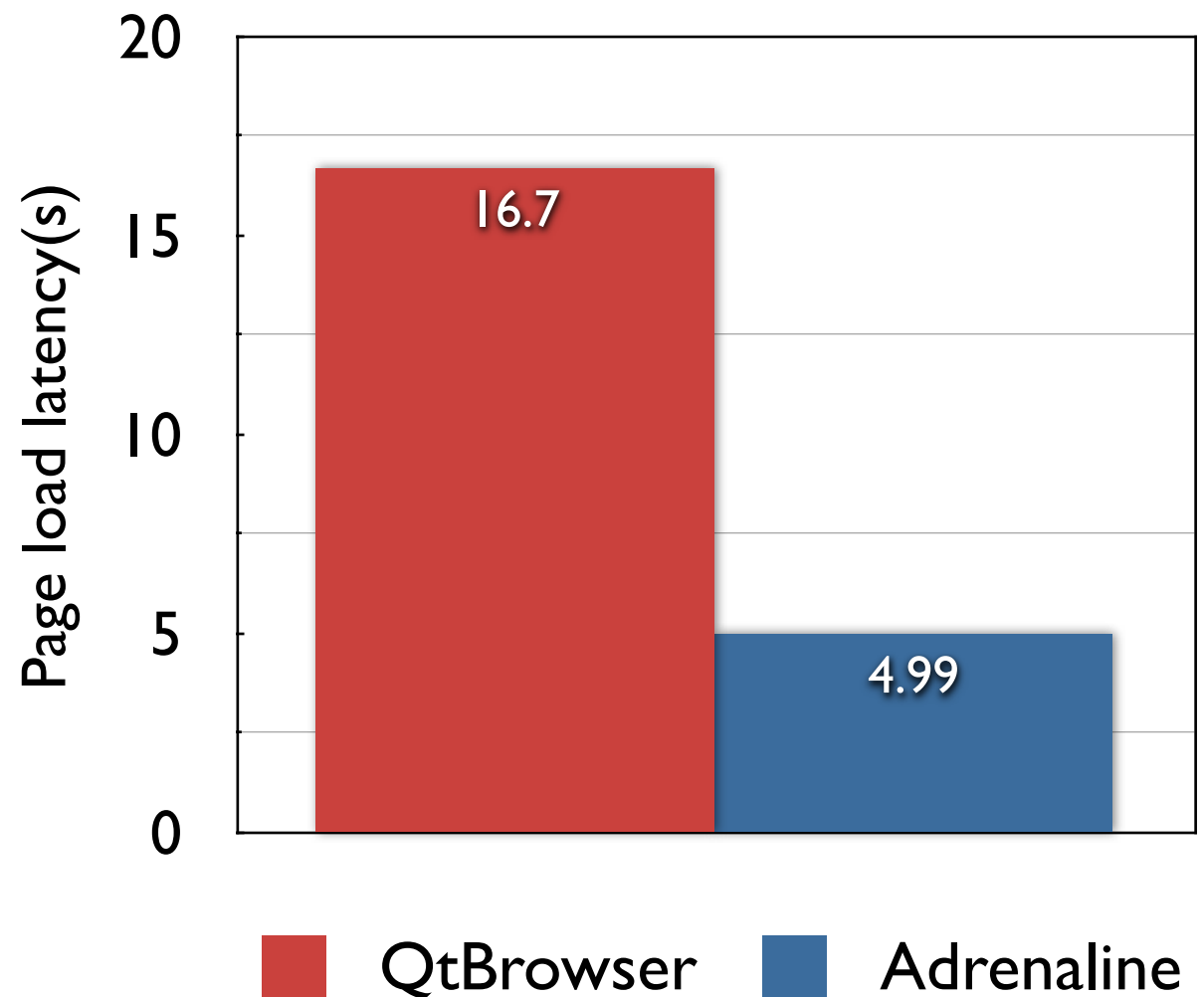
Performance

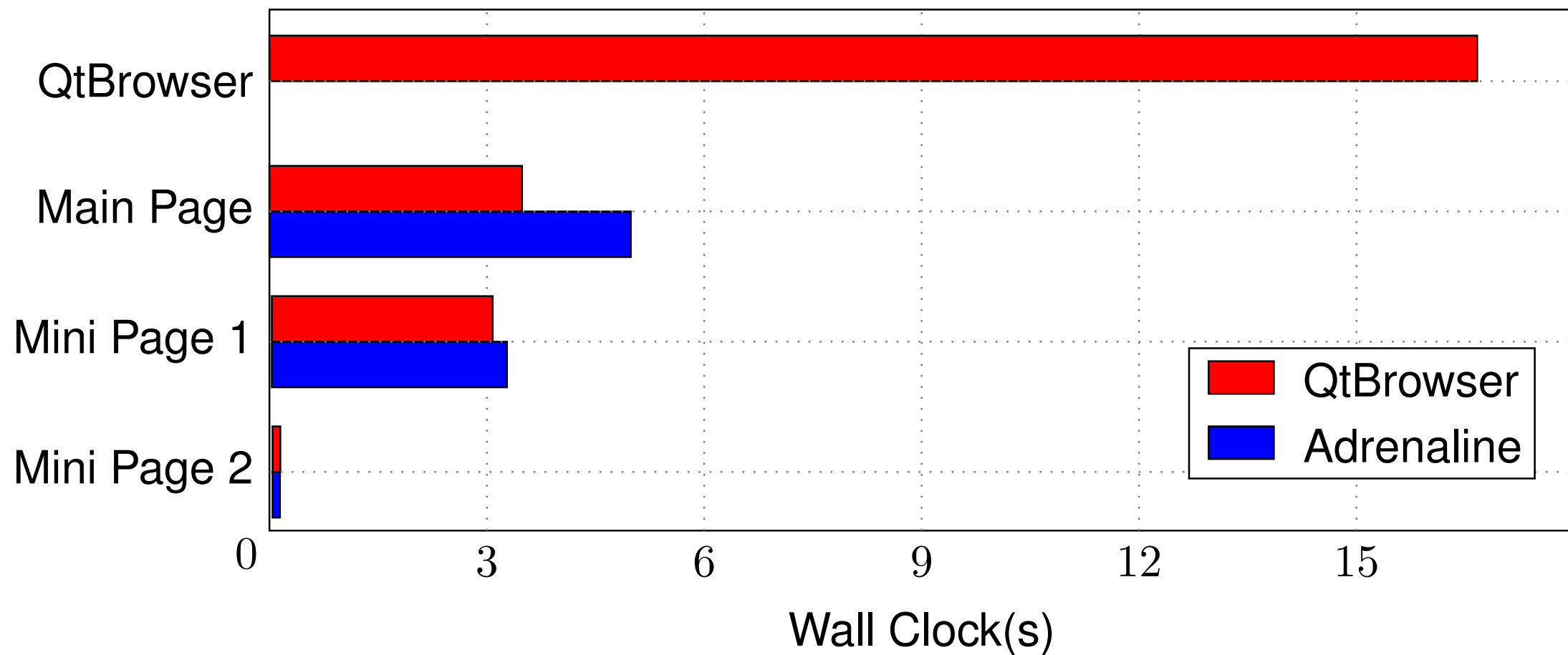


- Mean speed up / reduction of latency: 1.54x / 1.75s
- Speed up 89% of sites

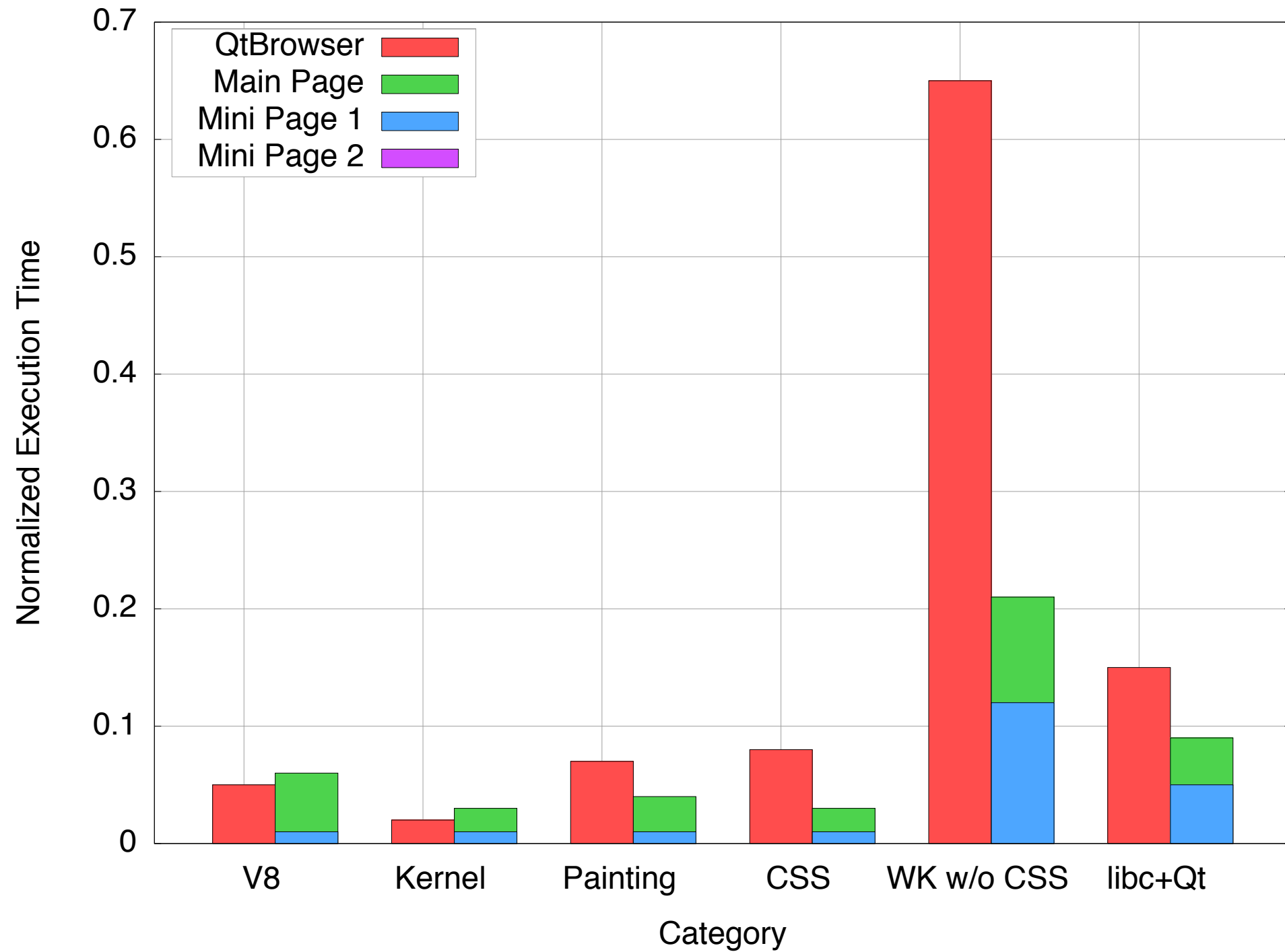
Case study: Wiki-Nokia

- 16.7s => 4.99s
- 3.34x speed up





Parallelization offloads ~33%
workload to Mini Page 1



Less work because of decomposition

Conclusion

- Early evaluation results are promising
- Browser developers should think about parallelizing web pages

Demo!

<http://www.youtube.com/watch?v=TBcurpe89PI>

Thanks!