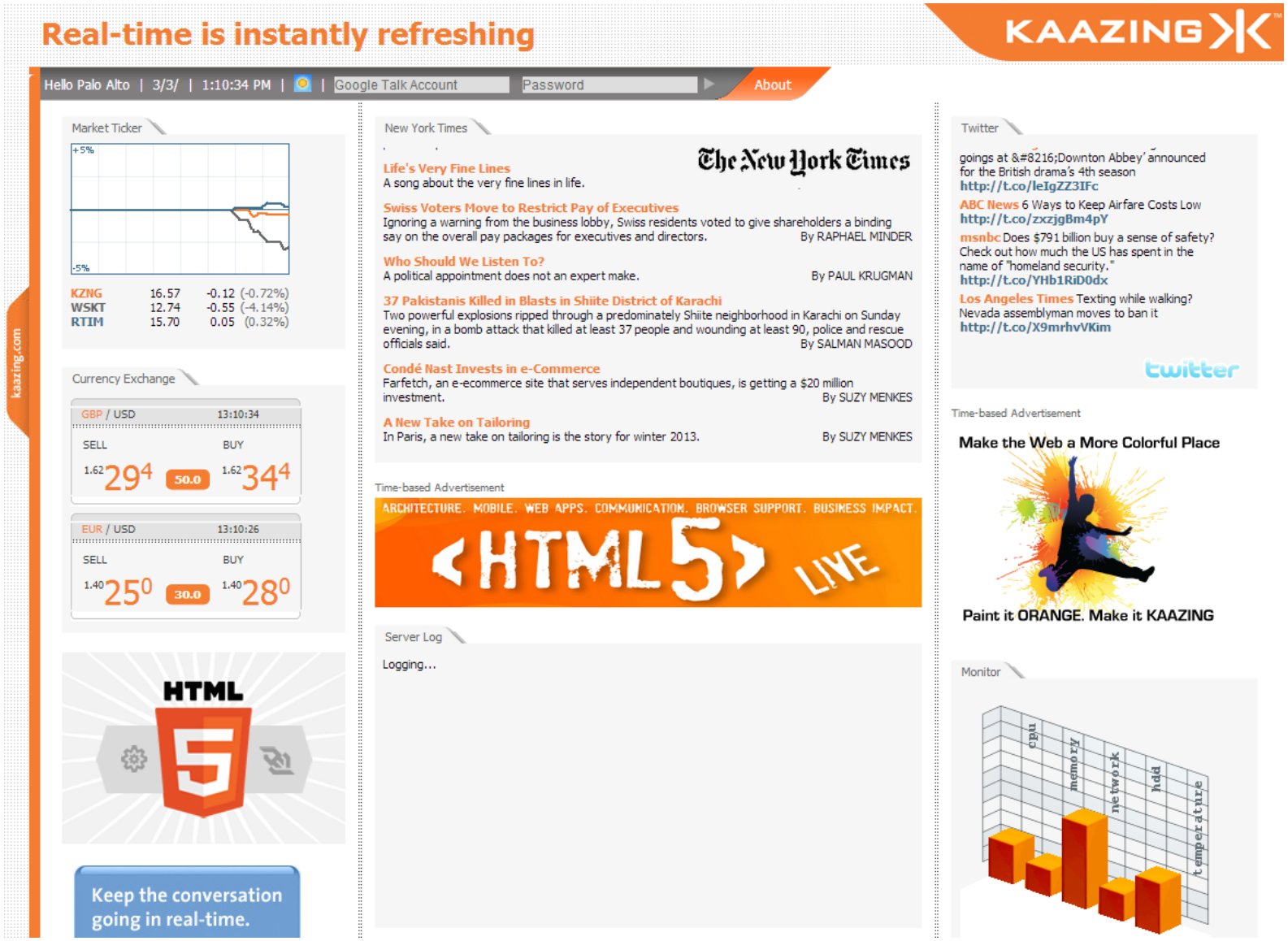
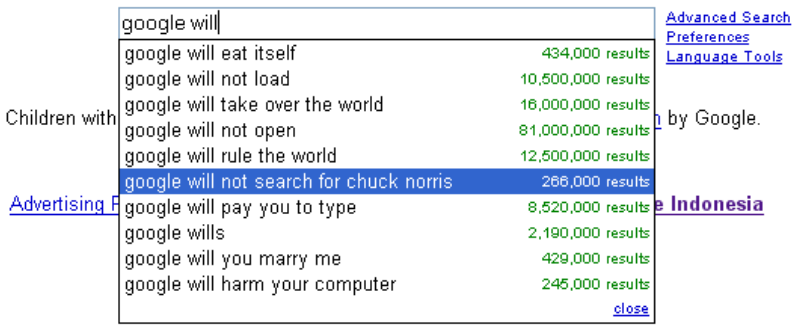
Server push and web sockets



http://kaazing.com

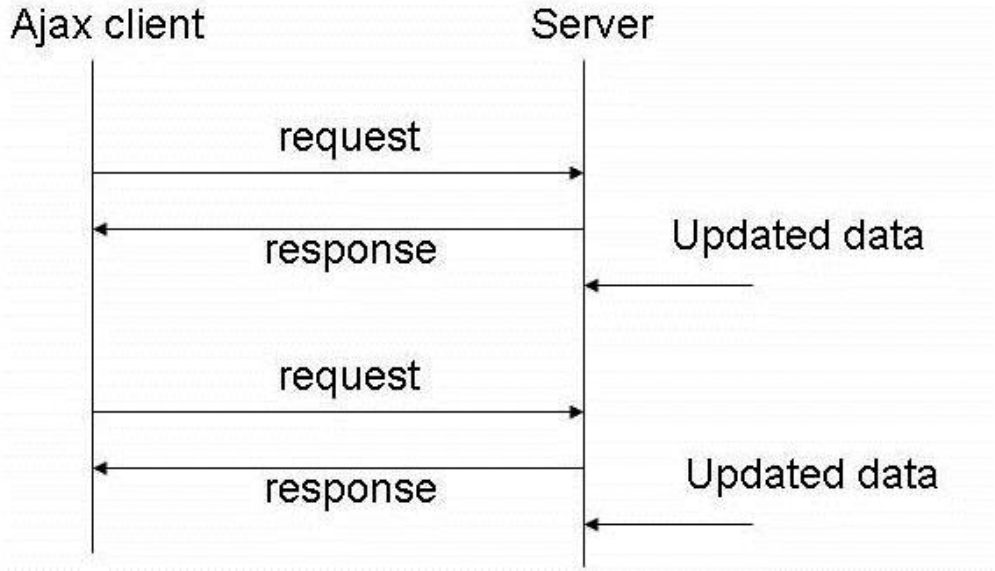
Responsive web apps, v1.0

- Problem: Client page needs info from server
- Solution: AJAX allows client to *pull* info
  - `XMLHttpRequest` makes asynchronous requests
    - Hacks to get around cross-domain restrictions
  - Uses standard HTTP request/response protocol
    - Small payload messages have high overhead
    - Latency introduced by HTTP processing



Responsive web apps, v2.0

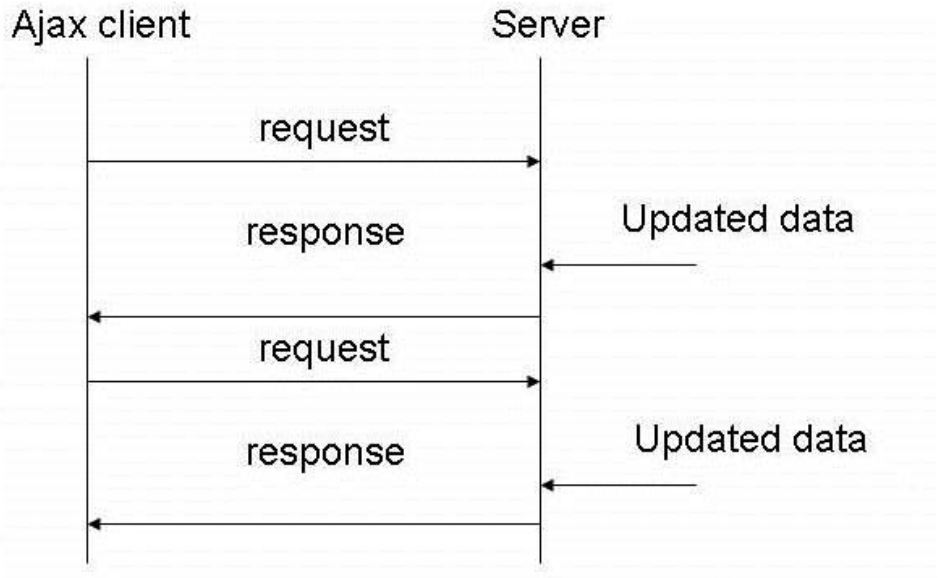
- Problem: Server needs to *push* info to client
  - e.g. update stock price, movement of players, etc.
- Possible solutions:
  - Polling: Client makes periodic AJAX requests
    - Works well if you know the correct polling interval
    - Otherwise wastes network/server resources



http://jfarcand.wordpress.com/2007/05/15/new-adventures-in-comet-polling-long-polling-or-http-streaming-with-ajax-which-one-to-choose/

Responsive web apps, v2.0

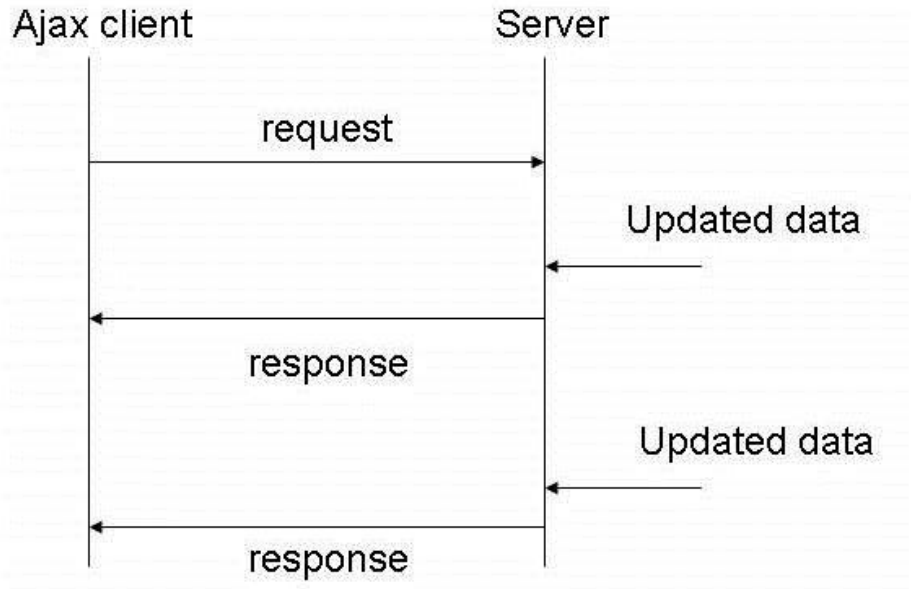
- Problem: Server needs to *push* info to client
  - e.g. update stock price, movement of players, etc.
- Possible solutions:
  - Long-polling: Client sends HTTP request, server waits until it has data to send in response
    - Hanging request may have high resource costs



http://jfarcand.wordpress.com/2007/05/15/new-adventures-in-comet-polling-long-polling-or-http-streaming-with-ajax-which-one-to-choose/

Responsive web apps, v2.0

- Problem: Server needs to *push* info to client
  - e.g. update stock price, movement of players, etc.
- Possible solutions:
  - Streaming: Server maintains open response continuously updated with push events
    - Subject to buffering by agents in network



http://jfarcand.wordpress.com/2007/05/15/new-adventures-in-comet-polling-long-polling-or-http-streaming-with-ajax-which-one-to-choose/

Streaming: HTTP response

- Response from server
  - Status line:
    - Protocol version, status code, status phrase
  - Response headers: extra info
  - Body: optional data

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Last-Modified: Wed, 14 Sep 2011 17:04:27 GMT
Content-Length: 285

<html> …
```

Code	Meaning	Examples
1xx	Information	100 = server agrees to handle client's request
2xx	Success	200 = request succeeded; 204 = no content present
3xx	Redirection	301 = page moved; 304 = cached page still valid
4xx	Client error	403 = forbidden page; 404 = page not found
5xx	Server error	500 = internal server error; 503 = try again later

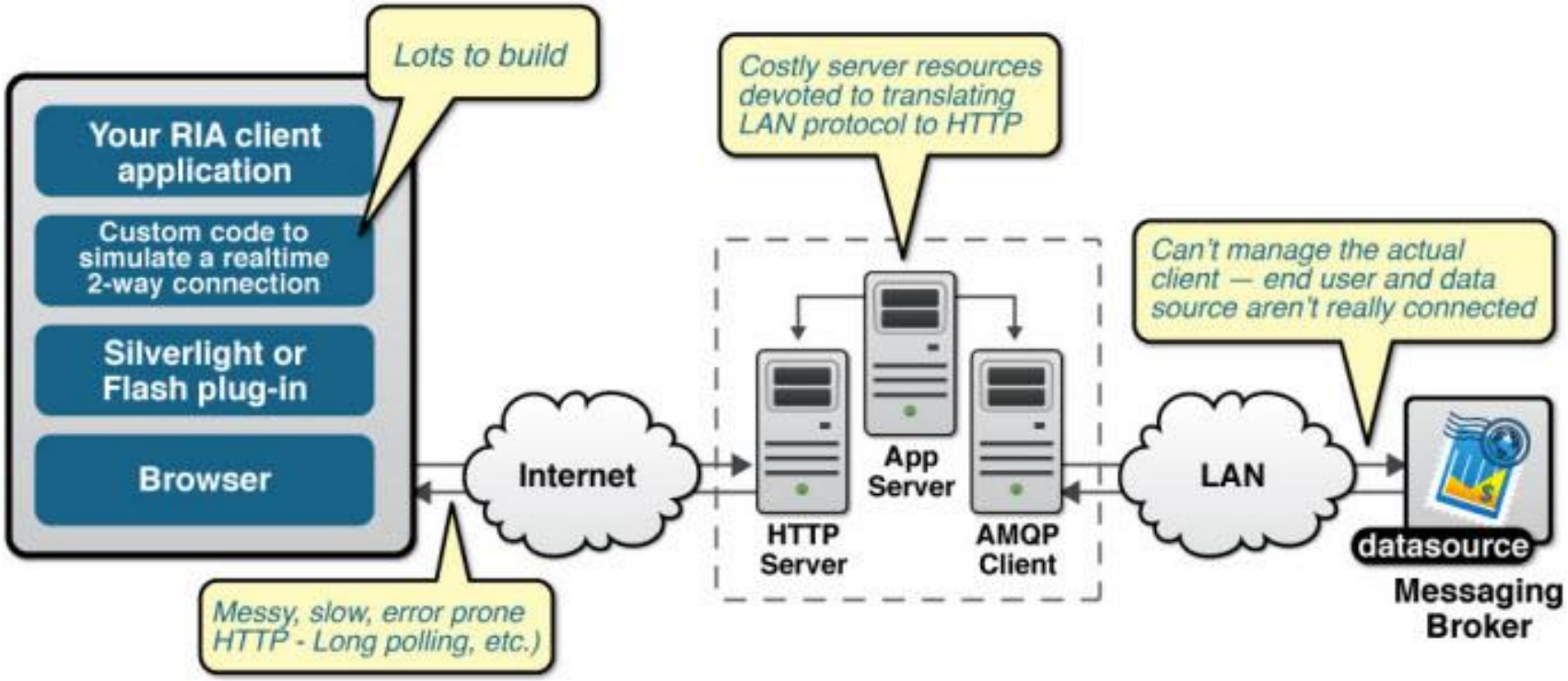
Streaming: HTTP response

- Chunked response
  - Each chunk specifies size in hex, last chunk = 0

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Last-Modified: Wed, 14 Sep 2011 17:04:27 GMT
Transfer-Encoding: chunked
29
<html><body><p>The file you requested is
5
3,400
23
bytes long and was last modified:
1d
Sat, 20 Mar 2004 21:12:00 GMT
13
.</p></body></html>
0
```

Comet

- Comet (via polling or streaming)
  - Simulate bi-directional communication
    - Using HTTP request/response protocol
    - Often 2 connections: 1 downstream, 1 upstream
    - Resource expensive and error prone to write

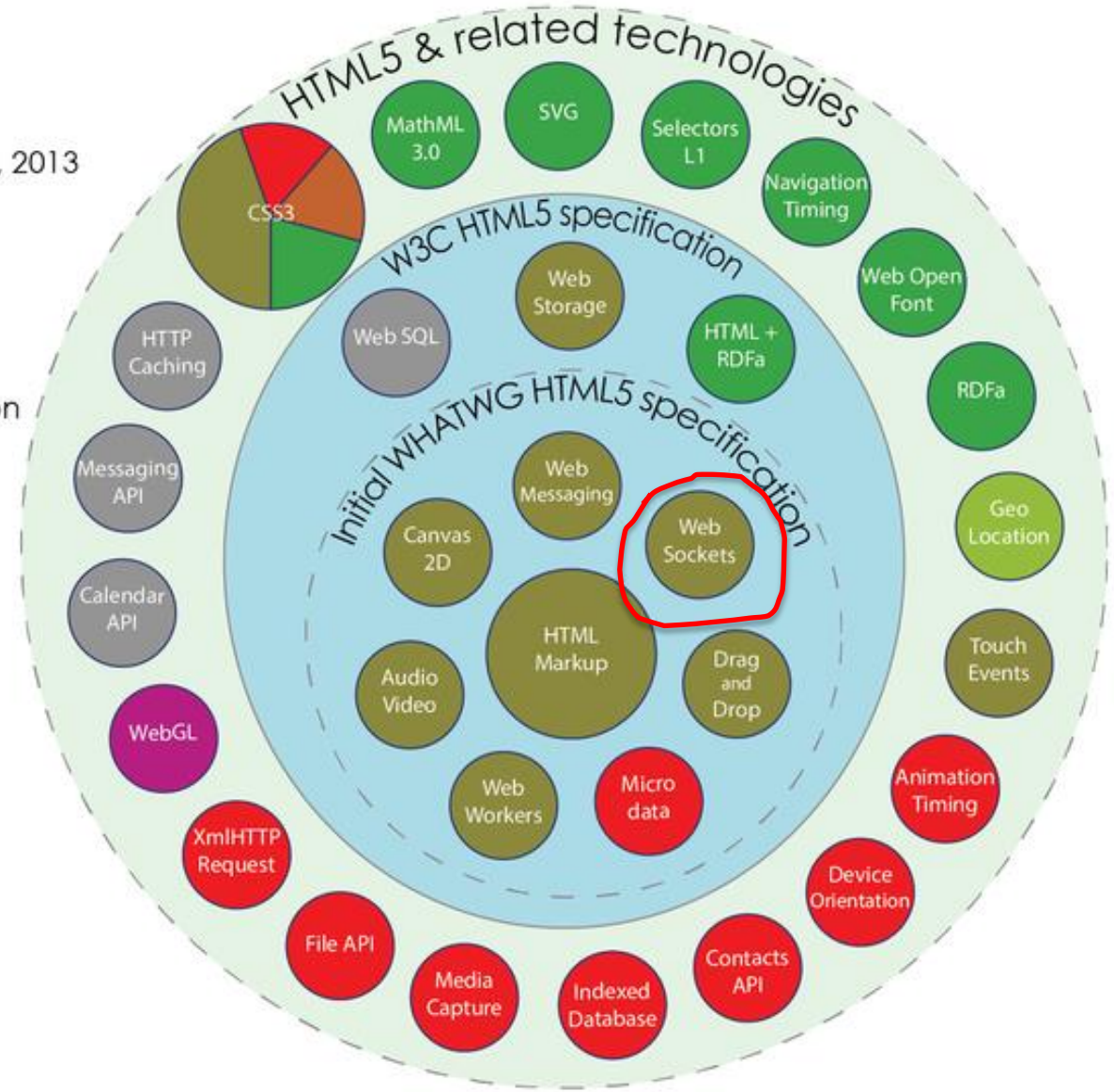


http://www.websocket.org/quantum.html

HTML5

Taxonomy & Status on January 20, 2013

- W3C Recommendation
- Proposed Recommendation
- Candidate Recommendation
- Last Call
- Working Draft
- Non-W3C Specifications
- Deprecated



Web Sockets - CR

Bidirectional communication technology for web apps

Global	85.22% + 1.3% = 86.51%
unprefixed:	85.22% + 1.18% = 86.39%

Current aligned | Usage relative | Show all

IE	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
		31						
		36						
		37					4.1	
8		38					4.3	
9		39					4.4	
10	35	40	7.1		7.1		4.4.4	
11	36	41	8	27	8.1	8	37	40
TP	37	42		28				
	38	43		29				
	39	44						

HTML5 Web Sockets

- Web sockets:
  - JavaScript interface for client-side
  - Full-duplex communication
    - Using a single object, send string or binary data
    - Low latency, low header overhead (strings = 2 bytes)
  - Initial handshake over HTTP
    - Upgraded to web socket protocol
      - Some proxies may not like and drop the connection
    - Runs on port 80 allowing it to traverse NATs

"Reducing kilobytes of data to 2 bytes…and reducing latency from 150ms to 50ms is far more than marginal. In fact, these two factors alone are enough to make Web Sockets seriously interesting to Google."

-Ian Hickson

Web socket protocol

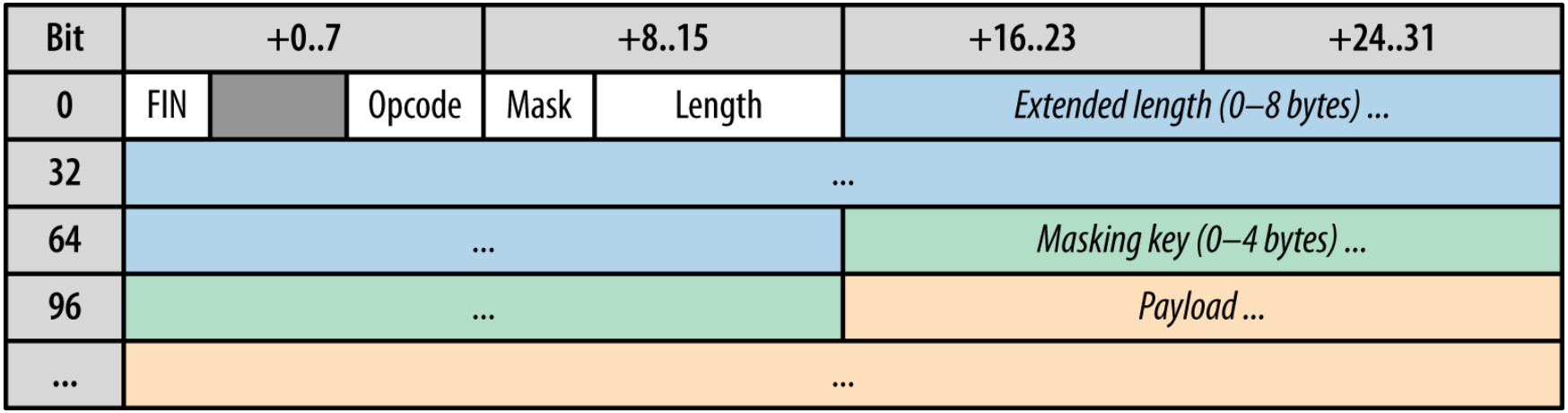
- URL prefix:
  - ws:// for normal connections, wss:// for secure
- HTTP-compatible handshake:

```
GET ws://echo.websocket.org/?encoding=text HTTP/1.1
Origin: http://websocket.org
Cookie: __utma=99as Connection: Upgrade
Host: echo.websocket.org
Sec-WebSocket-Key: uRovscZjNol/umbTt5uKmw==
Upgrade: websocket
Sec-WebSocket-Version: 13
```

```
HTTP/1.1 101 WebSocket Protocol Handshake
Date: Fri, 10 Feb 2012 17:38:18 GMT
Connection: Upgrade
Server: Kaazing Gateway
Upgrade: WebSocket
Access-Control-Allow-Origin: http://websocket.org
Access-Control-Allow-Credentials: true
Sec-WebSocket-Accept: rLHCkw/SKsO9GAH/ZSFhBATDKrU=
Access-Control-Allow-Headers: content-type
```

Web socket protocol

- After handshake:
  - HTTP connection broken down
  - Replaced by WebSocket connection
    - Over the same TCP/IP connection
    - Upgrade is one way, can't go back to HTTP
- Framing:

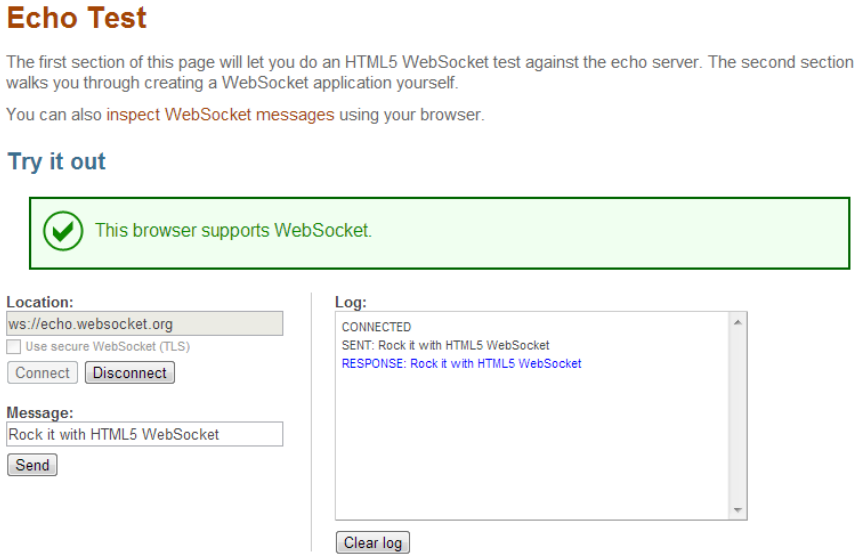


http://chimera.labs.oreilly.com/books/1230000000545/ch17.html#_websocket_protocol

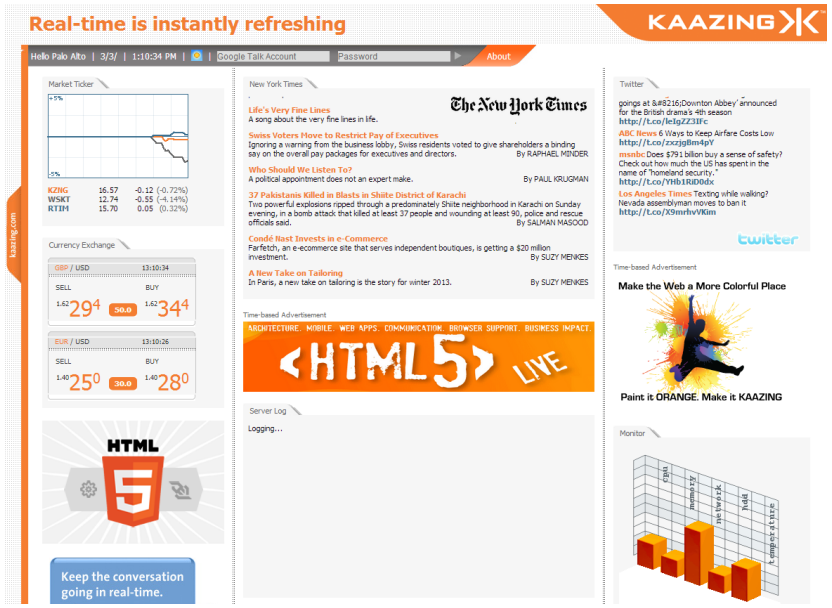
Example messages

- A single-frame unmasked text message
  - `0x81 0x05 0x48 0x65 0x6c 0x6c 0x6f` (contains "Hello")
- A fragmented unmasked text message
  - `0x01 0x03 0x48 0x65 0x6c` (contains "Hel")
  - `0x80 0x02 0x6c 0x6f` (contains "lo")
- Unmasked Ping request and masked Ping response
  - `0x89 0x05 0x48 0x65 0x6c 0x6c 0x6f` (contains a body of "Hello")
  - `0x8a 0x85 0x37 0xfa 0x21 0x3d 0x7f 0x9f 0x4d 0x51 0x58` (contains a body of "Hello", matching the body of the ping)
- 256 bytes binary message in a single unmasked frame
  - `0x82 0x7E 0x0100` [256 bytes of binary data]
- 64KiB binary message in a single unmasked frame
  - `0x82 0x7F 0x0000000000010000` [65536 bytes of binary data]

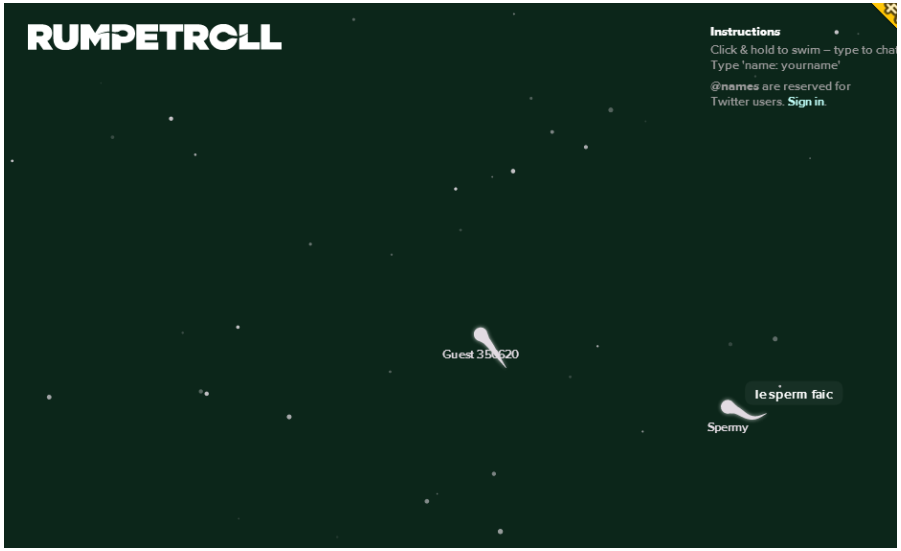
Web socket examples



http://www.websocket.org/echo.html



http://demo.kaazing.com/livefeed/



http://rumpetroll.com/

http://labs.dinahmoe.com/plink/

http://www.youtube.com/watch?v=64TcBiqmVko

http://www.html5rocks.com/en/tutorials/websockets/basics/

WebSocket interface

```
[Constructor(DOMString url, optional (DOMString or DOMString[]) protocols)]
interface WebSocket : EventTarget {
  readonly attribute DOMString url;

  // ready state
  const unsigned short CONNECTING = 0;
  const unsigned short OPEN = 1;
  const unsigned short CLOSING = 2;
  const unsigned short CLOSED = 3;
  readonly attribute unsigned short readyState;
  readonly attribute unsigned long bufferedAmount;

  // networking
           attribute EventHandler onopen;
           attribute EventHandler onerror;
           attribute EventHandler onclose;
  readonly attribute DOMString extensions;
  readonly attribute DOMString protocol;
  void close([Clamp] optional unsigned short code, optional DOMString reason);

  // messaging
           attribute EventHandler onmessage;
           attribute DOMString binaryType;
  void send(DOMString data);
  void send(Blob data);
  void send(ArrayBuffer data);
  void send(ArrayBufferView data);
};
```

Simple text echo client

```
<!DOCTYPE html>
<html>
<head>
<meta charset="utf-8" />
<script>
function init()
{
   websocket           = new WebSocket("wss://echo.websocket.org/");
   websocket.onopen    = function(e) { onOpen(e)    };
   websocket.onclose   = function(e) { onClose(e)   };
   websocket.onmessage = function(e) { onMessage(e) };
   websocket.onerror   = function(e) { onError(e)   };
}

function onOpen(e)
{
   writeToScreen("CONNECTED");
   message = "Hello world!";
   writeToScreen("SENT: " + message);
   websocket.send(message);
}

function onClose(e)
{
   writeToScreen("DISCONNECTED");
}

function onMessage(e)
{
   writeToScreen('RESPONSE: ' + e.data);
   websocket.close();
}

function onError(e)
{
   writeToScreen('ERROR: ' + e.data);
}

function writeToScreen(message)
{
   document.getElementById("output").innerHTML +=
      message + "<br />";
}
window.addEventListener("load", init, false);
</script>
</head>

<body>
<h2>WebSocket Test</h2>
<div id="output"></div>
</body>
</html>
```

Supported data types

- Send data as:
  - Text
  - ArrayBuffer
  - Blob

```
// Sending String
connection.send('your message');

// Sending canvas ImageData as ArrayBuffer
var img = canvas_context.getImageData(0, 0, 400, 320);
var binary = new Uint8Array(img.data.length);
for (var i = 0; i < img.data.length; i++)
{
   binary[i] = img.data[i];
}
connection.send(binary.buffer);

// Sending file as Blob
var file = document.querySelector('input[type="file"]').files[0];
connection.send(file);
```

```
// Setting binaryType to accept received binary as either 'blob' or 'arraybuffer'
connection.binaryType = 'arraybuffer';
connection.onmessage = function(e)
{
   console.log(e.data.byteLength); // ArrayBuffer object if binary
};
```

http://www.html5rocks.com/en/tutorials/websockets/basics/

Client programming in practice

- WebSockets relatively new
  - Browser support is now widespread
  - W3C candidate recommendation
  - Network proxies may mess things up
- Other techniques more mature
  - `XMLHttpRequest`
- Option: use a 3rd party client library
  - Library provides semantics of bi-directional communication, but encapsulates details
  - e.g. socketio, cometd, Hookbox, orbited

Web socket server

- The server side
  - You need server-side support!
    - Support a large # of open WebSocket Connections
    - Traditional stacks (e.g. LAMP) do not deal well with this
- Commercial: Kaazing, …
- Some free options:
  - apache-websocket: apache module
    - Develop your own module (in C) for app-specific details
  - pywebsocket: apache module / standalone server
    - Requires mod_python
  - Jetty WebSocketServlet

Other server options…

- C/C++
  - libwebsockets
  - Mongoose
  - POCO C++ Libraries
  - Tufão
  - Wslay
  - QtWebsocket
- Erlang
  - Yaws
- Go
  - go.net/websocket
  - webrocket
- Haskell
  - websockets
- Java
  - Apache Tomcat 7
  - Play Framework
  - Atmosphere
  - Bristleback
  - GlassFish 3.1, Grizzly
  - HLL WebSockets
  - JBoss 7
  - Jetty 7
  - jWebsocket
  - Netty 3.3
  - MigratoryData WebSocket Server
- .NET Framework
  - Internet Information Services (IIS) 8, ASP.NET 4.5
  - Windows Communication Foundation 4.5 through NetHttpBinding
  - Fleck
  - SuperWebSocket
  - XSockets.NET
- Clojure
  - http-kit
  - aleph
- Nginx
  - Proxy (since version 1.3.13)
  - Push Stream (3-rd party module)
- Node.js
  - Socket.IO
  - WebSocket-Node
- Objective-C
  - SocketRocket
  - BLWebSocketsServer
- Perl
  - Mojolicious
  - PocketIO
- PHP
  - php-websocket
  - Ratchet
- Python
  - WebSocket-for-Python
  - txWS
  - AutobahnPython
- Ruby
  - EM-WebSocket
- Other
  - apache-websocket
  - mod_websocket for lighttpd
  - nginx supports websocket since version 1.3

Summary

- Responsive interactive web apps
  - Often requires low latency bi-directional communication
  - Existing solutions:
    - Ajax polling, long polling, HTTP streaming
    - Really hacks working with an ill-suited HTTP request/response protocol
  - HTML5 web sockets:
    - Simple client-side API
    - Requires server supporting web sockets
    - You have to develop app-specific logic in some way
      - e.g. Apache module, Java servlet, …