Breaking Browsers: A Survey

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Genetic Programming

- Encode programs as “genes”
- Evaluate in objective function to get a numeric score
- Usually want to minimize objective function
- Use “crossover” and “mutation” to produce new genes
- Repeat until satisfied
- Usually programs encoded in Lisp-ish syntax
  - (sin (cos (+ x y)))

Stack Based GP

- Genes encoded as strings
- Evaluated in a stack based virtual machine
  - Forth, Postscript...
  - x y + cos sin
- Data held in stack
  - stack data is doubles, strings
- Data held in global state
  - in this case, HTML structure
    - elements, attributes, values...

Genes

- Gene string composed of tokens
- Tokens represent :
  - Strings
    - “foo”
  - Numbers (floating point)
    - (1.345)
  - Functions
    - <element>
- Tokens are atomic

Crossover, Mutation...

- Crossover done by selecting substrings of two genes and pasting together
- Mutation done by copying a gene and deleting, adding and mutating tokens
- Also operators for chopping off beginning and end of genes
- Genes can be generated with non-uniform probabilities for tokens

Evolution

- Start with population
- Evaluate all members of population
- Save best (“elitism”)
- Generate unique new genes by selecting genes favoring those that scored well and doing mutation and crossover
- Save a few good genes as a “genepool” to help maintain diversity in future

Project Goals

- Can GP be used to generate debugging data
  - flexible
  - naturally gives “regression testing”
  - but either too easy or too hard
- Originally to just crash browsers
- Used time as a measure
  - because it worked
- Then one page took 3+ hours to display
- Timing became interesting on its own

HTML data

- Always a “current element”
- New elements created with an “element” function
  - added as sub-elements to the current element
  - made current element
- Elements may be closed
  - <foo> .... </foo>
- or left unclosed
  - <foo> <bar> </foo>
- elements generated from list of valid HTML elements and from randomly generated strings

HTML Data...

- Attributes defined with an attribute function
- Names, values generated with random strings
  - usually syntactically valid (names may include non-valid characters)
  - but no guarantee
- Attribute values always given as strings
  - attribute=”value”
  - even when attribute name is sensible, value usually is not
- Mechanism to limit the length of the generated HTML

Evaluation

- Program runs a tiny “web server”
- Gets request and sends page generated by gene
- Records time sent and time next request received
  - elapsed time is used to compute score
- If browser fails, wrapper restarts requesting page “crash” so evaluator can use fixed time for crash
  - crash recovery time (which may require human intervention) is fixed
  - can be set to reward crashing or not
- Very short times scored the same

Mechanics

- Headers say content is HTML
- Request immediate reload
  - effectively happens after page loads and displays
- Headers also specify length of page (so browsers don't wait for end of malformed HTML)
- Elapsed time measured in milliseconds
- Any other requests generated get zero length responses (images, embedded objects....)
- Socket is closed after content sent

Problems

- Inconsistent browsers
  - some just hang instead of crashing or fetching next page
  - sometimes without using any CPU
  - sometimes pegging CPU at max utilization
  - involves user intervention
- Some browsers don't like being run from scripts
- Getting the headers right to consistently force reloads was involved
- Run “server” and browser on same machine or machines on same local network

Results

- Few browsers are trustworthy
- Most crash for some input – sometimes non-valid, often valid
- For most there is input that can be limited in length but that will cause the browser to take a long, long (long!) time to respond
- Crashing may be results of random search over input space (HTML)
- Clear that long response times are caused by GP engine learning what makes browser slow

Example Log File

- browser = internet-explorer
- normalizing = false
- crash time = 10000
- population = 1000
- generations = 10
- refresh = Refresh: 0;URL="http://146.187.130.103:5555/normal.html"
- truncation = 20000

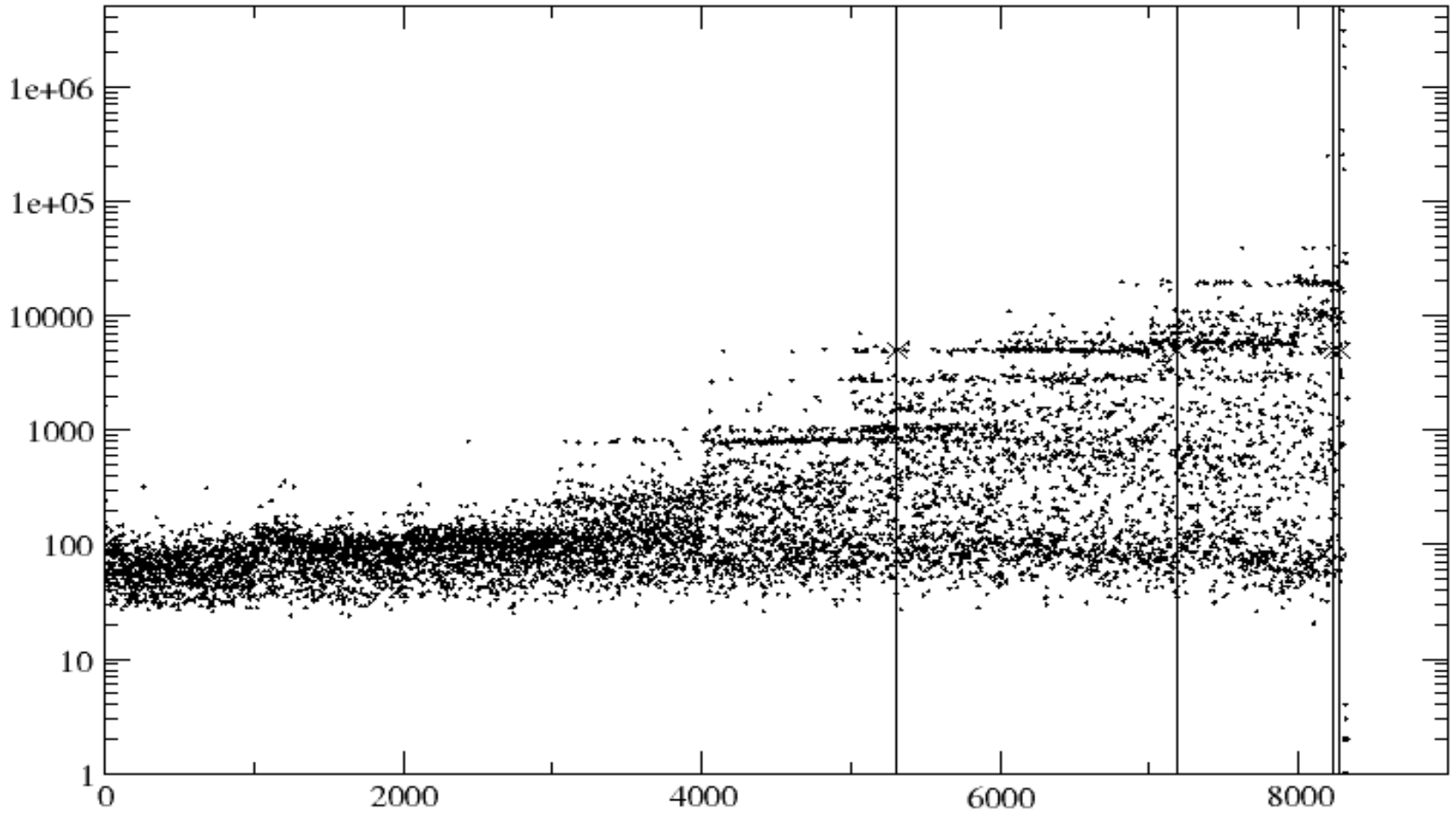
Example Log File ...

- eval=1043 time=5513 strlen=17133 score=0.01 crash
- eval=1044 time=1012 strlen=7392 score=0.1
- eval=1045 time=1305 strlen=11077 score=0.07692307692307693
- eval=1046 time=286 strlen=9213 score=0.5

IE

- Maximum time in plotted run
  - 4655902 milliseconds
  - 1.3 hours
- crashed at evaluations 5311,7192,8237,8280
- Another run crashed 54 times out of 5000 evaluations
- Crashes occurred in 4 of 6 runs done for this test
- page load times relatively fast until long loading pages dominate

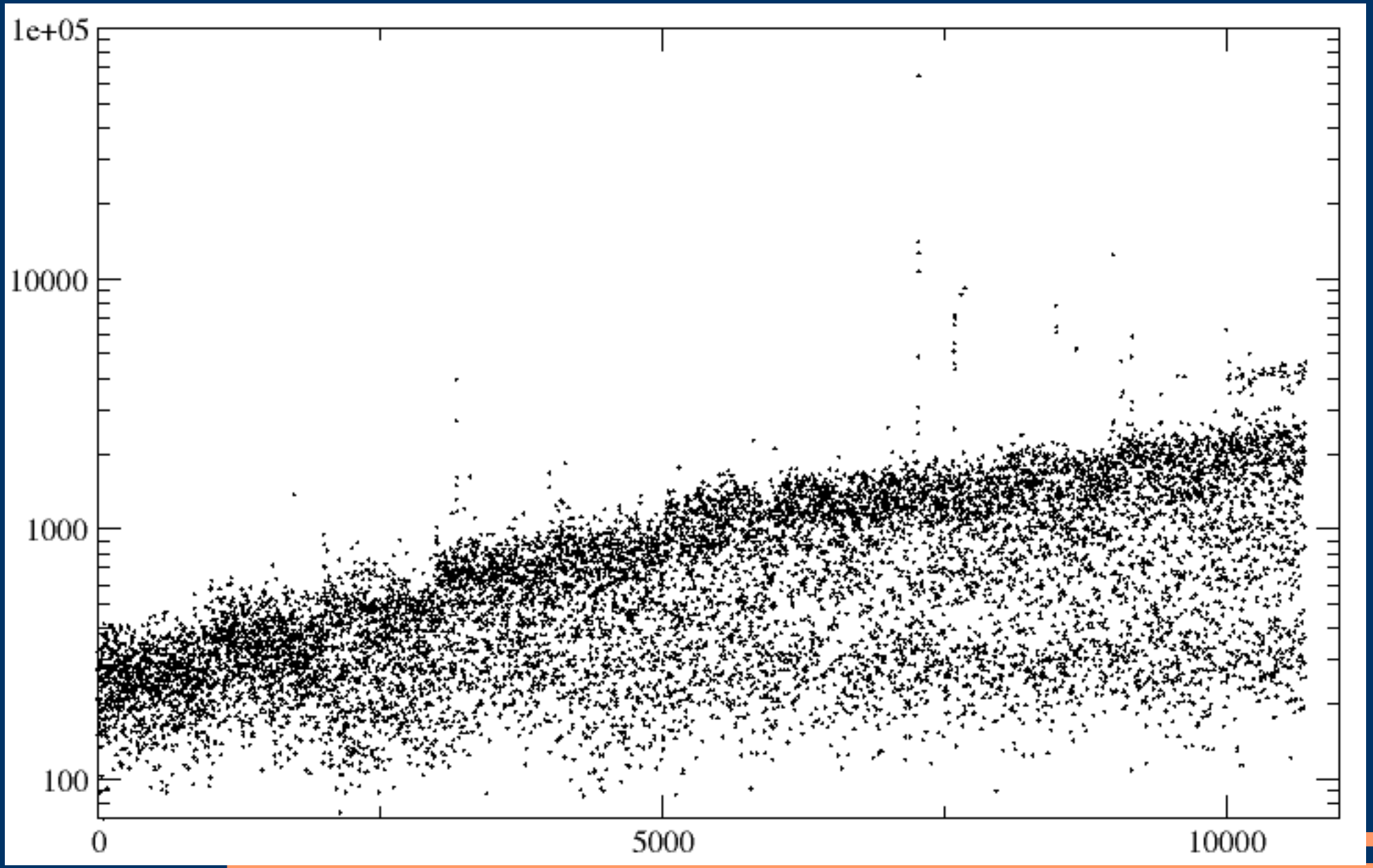
IE



Firefox

- Crashed in 4 of 9 runs
- In one run crashed eventually in 1 out of every four page loads
- Slower page loads
- One page load took 203 minutes to complete
- In one development run (not logged carefully), a single page load took 19 hours

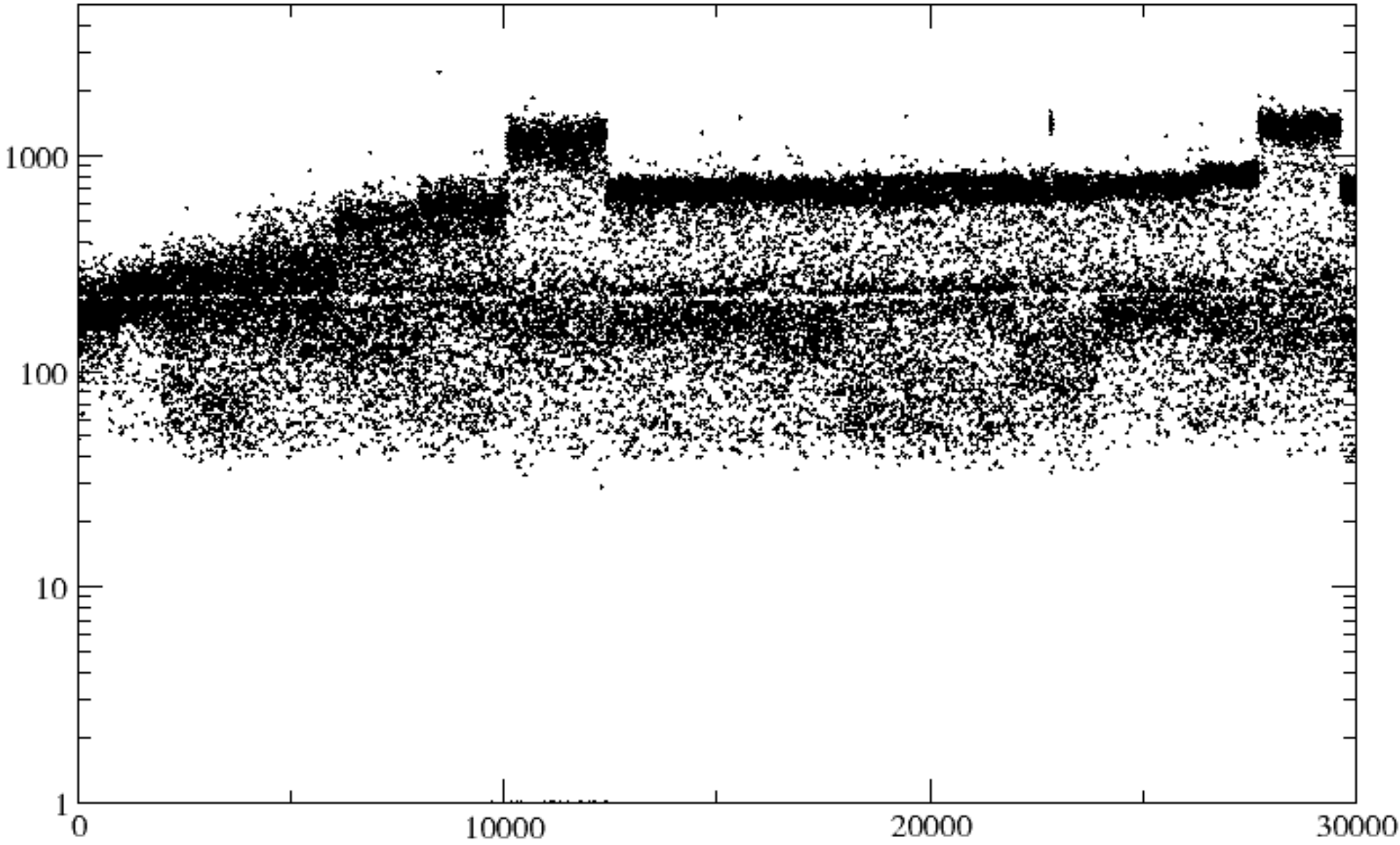
Firefox



Safari

- Load times started slower than IE
  - but remained faster
- Maximum page load time was under four seconds
- Reliable, robust, reasonably fast

Safari



Conclusions

- Genetic Programming has potential to be a debugging/probing tool
- Browsers are nowhere near as robust as they should be in the face of unknown web sites
- Its astonishingly easy to make most browsers run very, very slowly

Potential

- Generate XML according to some schema
  - easy to generate correct syntax
  - much harder to generate correct semantics
- Deserialize XML to objects in some programming language
  - use as part of a test regime
  - ensuring meaningful semantics as most OO code assumes good semantics on created objects